

**ROY G. PERRY COLLEGE OF ENGINEERING
CHEMICAL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**

COURSE BINDER COVER PAGE

**CHEG 2316-P01:
ETHICS AND CONDUCT OF
ENGINEERS**

FALL 2021 SEMESTER

NAME OF INSTRUCTOR: Dr. Sheena M. Reeves

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING
CHEG 2316-P01: ETHICS AND CONDUCT 2021**

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I. Course Description in ABET Format

CHEG 2316-P01: Ethics and Conduct of Engineers

1.	Course number and name:	CHEG 2316-P01: Ethics and Conduct of Engineers
2.	Credits and contact hours:	1 credit hours; 3 contact hours
3.	Instructor's or course coordinator's name:	Dr. Sheena M. Reeves
4.	Text book: Title:	Engineering Ethics
	Author:	Charles B. Fleddermann
	Publisher, Year & Edition:	Pearson, 4th Edition
	a. Other Supplemental material	1. Responsible Conduct of Research by Adil E. Shamoo and David B. Resnik, Oxford, 2nd Edition
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	An introductory view into how moral principles and standards are applied to the field of engineering. Students will learn how to analytically think about particular ethical problems. Topics include the responsibilities of an engineer, the code of conduct, ethical theories, ethics in the law, and case studies of engineering successes and failures.
	b. Prerequisites or Co-requisites	GNEG 1101, CHEG 1101, MCEG 1101, CVEG 1101 or equivalent
	c. *Indicate whether a required, elective, or selected elective (as per definition provided) course in the program	Required
6.	Specific goals for the course	Students will be able to :
	a. specific outcomes of instruction	1. Recognize ethical and professional responsibilities in engineering situations involving global, and societal contexts. 2. Make informed judgements on ethical and professional responsibilities in engineering while considering the impact of engineering solutions in global, economic, environmental, and societal contexts. 3. Articulate the social and ethical ramifications of the engineering practice and technology in an oral or written format.
	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.	This course addresses: Outcome 4 Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

7	Brief list of topics to be covered	Introduction to Ethics (3) Professionalism (3) Personal vs. Professional Ethics (3) Disaster Case Studies (9) Ethical Thoughts and Theories (6) Ethics and the Law (3) Codes of Ethics/Conduct (3) Whistleblowing (3) Ethics in Research (6) Professionalism (3) Negligence, Benefits, and Risk (3) Ethics around the World (6)

ABET COURSE OUTCOMES

Course Outcome 1: This outcome is the same as program outcome 4.

Students will have an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

1. Ability to recognize ethical and professional responsibilities in engineering situations involving global, and societal contexts.
 Given a problem, the student is able to:
 - (i) Review engineering case studies of engineering and identify the ethical and professional failures.
 - (ii) Determine breaches in ethical conduct given an engineering scenario.
 - (iii) Discuss professional codes of conducts of various entities and discuss differences in the codes.
 - (iv) Discuss the responsibility of an engineer when advancing technology.
 - (v) Discuss the relationship between engineering practice and basic moral values.
 - (vi) Distinguish between personal and professional values.
 - (vii) Explain the importance of engineering ethics.
2. Ability to make informed judgements on ethical and professional responsibilities in engineering while considering the impact of engineering solutions in global, economic, environmental, and societal contexts.
 Students are able to:
 - (i) Recognize the importance for safety and determine the risk associated with engineering designs.
 - (ii) Determine the responsible individual given a moral scenario.
 - (iii) Research the ethical duties of a practicing engineer.
 - (iv) Apply ethical problem solving techniques when given an ethical dilemma.
 - (v) Discuss the similarities between ethical problem solving and engineering design.
 - (vi) Discuss and distinguish between the different ethical theories and how they apply to engineering.
 - (vii) Utilize flow charting to solve ethical problems.
 - (viii) Define risk, safety, and negligence.
 - (ix) Determine methods of avoiding ethical problems.
3. Articulate the social and ethical ramifications of the engineering practice and technology in an oral or written format.
 Students are able to:
 - (i) Participate in discussion/debate with colleagues in a respectful manner.
 - (ii) Effectively communicate a point of view to an audience.
 - (iii) Compile a report detailing the successes and failures of a discussed case study.
 - (iv) Discuss the consequences of actions or inactions to the community.
 - (v) Identify ethical situations such as bribery, conflicts of interest, and whistleblowing.
 - (vi) Participate in the Order of the Engineer ring ceremony.

II ASSESSMENT RESULTS FOR CURRENT AND PAST FOUR ASSESSMENT PERIODS

Program Outcomes Assessed in this course

Outcome 4: An ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics.

Assessment Summary of Class Semester Averages for Outcomes: Fall 2021

Outcomes	4
Semester	Semester Class Average (%)
Fall 2021	86.9
Fall 2020	--
Fall 2019	--
	--
Comments on Data	Class average was above the expected for the first offering of the course.

*Expected Semester Class Average = 75%

End of Semester Course Assessment Reports FALL 2021 and Last Three Assessment Periods.

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer **NO**.

Table 2.1 END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CHEG 2316:P01 Ethics and Conduct of Engineers: Fall 2021 SEMESTER
Report Prepared by: Dr. Sheena M. Reeves Report Date: December 19, 2021

Report Prepared by: Dr. Virendra K. Khosla Date: December 18, 2021																		
Semester	Analysis Type	Number of Students	Outcome 4.1 Recognize ethical and professional responsibilities in engineering situations involving global, and societal contexts.				Outcome 4.2 Make informed judgements on ethical and professional responsibilities in engineering while considering the impact of engineering solutions in global, economic, environmental, and societal contexts.				Outcome 4.3 Articulate the social and ethical ramifications of the engineering practice and technology in an oral or written format.				Outcome 4 Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.			
			Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average	Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2021	Direct	10	75	70	89.4	100	75	70	81.6	80.0	75	70	89.6	100.0	75	70	86.9	100.0
Fall 2020	Direct		75	70			75	70			75	70			75	70		
Fall 2019	Direct		75	70			75	70			75	70			75	70		
Implementation Summary	Items implemented from previous report or after meeting previous instructor		*First time offering course.												*First time offering course.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them		Some students were not able to identify the difference between what is ethical vs. what is lawful.				Students copied information from a source and did not cite the source in the paper.				Students were very nervous when presenting. Some groups did a poor job of explaining their line-drawing or had incomplete flow diagrams.				The online learning platform limits the ability to gauge student understanding (blank screens). Assignments are the only measurement tool for making adjustments.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas		The instructor should share more examples of laws and how it applies to engineering.				Although the instructor used turnitin throughout the semester, the instructor should carefully check sources provided by the students.				The instructor should spend more time explaining the differences between line-drawing and flowcharting. The instructor should incorporate more examples.				Implement plans in sub-outcomes.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters		All measurements were met.				All measurements were met.				All measurements were met.				All measurements were met.			
Were Expectations Met?	Class Average $\geq 75\%$ and $\geq 70\%$ of Students Performed at or Above Expected Average.		YES				YES				YES				YES			

**CHEG 2316-P01: ETHICS AND CONDUCT OF ENGINEERS
FALL 2021 SEMESTER**

Title of Assignment: HOMEWORK 3

TOPICS COVERED IN HOMEWORK 3

HOMEWORK 3 covered the following topics:

1. Factual and Conceptual Issues
2. Bribery
3. Conflict of Interest
4. Ethical Design Making
5. Line-Drawing Technique
6. Flow Charting Technique

Homework 3

For this assignment, read Chapter 4 in the textbook. The chapter covers ethical problem-solving techniques. You will use information from this chapter to answer the following questions.

1. In your own words, what are conceptual issues? 10pts
2. Give 2 examples of bribery. 10 pts
3. What is the line-drawing technique? Give an example. 20 pts
4. Describe the process of flow charting. 10 pts

SOLUTION:

- 1. Conceptual issues are handled by agreeing upon the primary concepts that were violated. Conceptual issues are resolved by coming to an agreement over the proper definition or scope of a term.**
- 2. Bribery is the act of accepting a gift or benefits in exchange for favoritism or unfair services such as paying constituents for votes or paying someone to take an exam for you.**
- 3. Line drawing involves listing various example scenarios based on a hypothetical situation. At one end is a positive paradigm that is considered morally acceptable while the other end contains a negative paradigm that is completely unacceptable for the hypothetical situation.**
- 4. Flow charting is a decision making type of diagram consisting of yes/no type of questions. The process should lead to either a positive, negative, or general solution to the hypothetical situation.**

ABOVE AVERAGE

Carol Akpan

October 14, 2021

Dr. Reeves

Homework ethics

For this assignment, read Chapter 4 in the textbook. The chapter covers ethical problem-solving techniques. You will use information from this chapter to answer the following questions.

1. In your own words, what are conceptual issues?

Conceptual issues are the meaning of a idea and are resolved by making a utilitarian agreement on the meaning and appropriate decision whether the meaning pertains to every concept.

2. Give 2 examples of bribery.

Amy, the vice president of the production company is on the search to decide who will replace her job while she is on maternity leave. One of the workers, John, gives Amy two tickets to an NFL game that cost over \$800 and tells her to consider him for her replacement.

James works with a company and makes a huge mistake that could cost him his job. He is aware that only one other person in his company is aware of his mistake, and gives him a large sum of money to keep quiet.

3. What is the line-drawing technique? Give an example.

The line-drawing technique shows the possibilities of positive and negative paradigm followed by a list of hypothetical examples for consideration. The considerations are marked on the line depending on which side it goes under on the scale of positive and negative paradigm. The letter "P" is set on the line which shows exactly where the problem first relative to the entries.

Example:

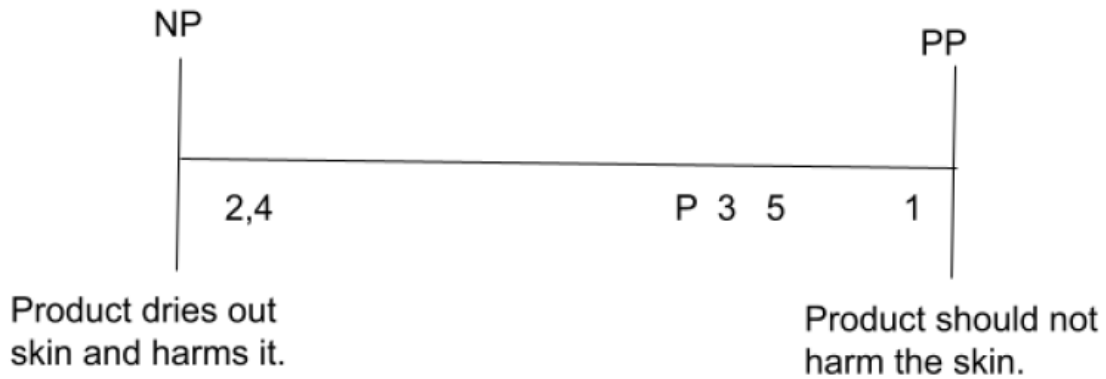
Problem: A cosmetics company made a product that will cause dry skin if applied more than the recommended amount.

Positive paradigm (PP): The product should not harm the skin.

Negative paradigm (NP): The product dries out the skin and harms it.

1. The company adds a dry skin warning label on the bottle of the product.
2. The effects of too much product will produce dry skin and can lead to permanent damages

3. The company add a label telling consumers the recommended amount to avoid dry skin.
4. The product will cause more damage to the skin if applied before direct sunlight exposure.
5. The company adds a label to inform consumers to apply the product at night to avoid sun exposure.



4. Describe the process of flowcharting.

Flowcharting is a visual process that describes the basic procedures in a flow chart with symbols that lead to the final product. They offer a set of choices (yes/no) that lead to different alternative routes. Helps one to look over the entire chart and be able to navigate to the end of the chart with an answer. A rectangle is a process or action, ovals are the start or end, diamond is the decisions or approvals, and arrows show direction.

References;

FLEDDERMANN, CHARLES B. "Professional Responsibilities and Professional Rights ." *Engineering Ethics*, edited by Marcia J Horton, 4th ed., Pearson Education, University of New Mexico, 2012, pp. 56-70.

AVERAGE

45/50 Student did not label the questions.

Conceptual issues are issues that deal with how something affects an outcome or how something influences a decision. The issues involve the difference between a gift and a bribe, because one can be seen as a friendly thought and the other an unfair advantage. Bribery is seen as the main idea of a conceptual issue because bribery has always had influence on business decisions that are supposed to be fair and legal. One example of bribery would be a student offering their teacher \$100 to raise their grade from a 79 to a 90. Another example of bribery would be multiple math online programs presenting to a Superintendent why he should purchase their program for his school. Out of the 3 programs presented the owner of one of them offers the Superintendent \$10,000 to use their program, the acceptance of the \$10,000 would be bribery. The line-drawing technique is drawing a horizontal line to judge how morally or immorally acceptable something is. The more to the left that action is placed the more negative and immoral that action is, while the more to the right that action is placed the more positive and moral that action is. An action that would be placed on the negative side of the line would be dumping waste and trash into a lake, and an action that would be placed on the right side of the line would be keeping the water in the lake safe and clean. The process of flow charting would be visually describing the concept of an activity, such as building a plant, and planning how to move ahead throughout the flow chart. The flow chart also has options for if the activity is not ready to move ahead and has an action ready for every decision of the road.

BELOW AVERAGE

40/50 Student did not provide a full example of line-drawing with PP and NP

1. In my own words conceptual issues would be just questioning an idea of one's actions as it pertains to morals and ethics.
2. 2 examples of bribery would be paying a judge off for lesser sentencing and a seller giving a potential client high value gifts in exchange for the project.
3. Line -drawing technique is used to resolve moral issues by drawing a line with hypothetical examples near either end the line positive paradigm and negative paradigm this method makes it easier to decide on whether the situation is unethical or ethical.
An example to use the line drawing technique would be putting cell phone towers in low income communities.
4. The process of flow charting is used to take a decision and see how it flows to each consequence as it applies to ethics. The flowchart process starts with an idea; it then flows to a question that pertains to the ideas guidelines, a yes that leads to a statement with further instruction or a no with another question or statement

**CHEG 2316-P01: ETHICS AND CONDUCT OF ENGINEERS
FALL 2021 SEMESTER**

Title of Assignment: FINAL REPORT

TOPICS COVERED IN FINAL REPORT

FINAL REPORT covered the following topics:

1. Trendlines/Correlations
2. Molecular Weight
3. Composition
4. Volume
5. Unit Conversions
6. Mass and Moles
7. Significant figures
8. Mean, median, mode, standard deviation

CHEG 2316-P01: ETHICS AND CONDUCT OF ENGINEERS

FALL 2021 SEMESTER

Each student is required to upload a case study report about their engineering disaster. The report will follow the same format as the case study report (updated for reports 3 and 4) with the following additions.

- **A longer Background section which includes information regarding details about the disaster, its impact on society and the impact.**
- **A discussion of any legal actions as a result of the disaster.**
- **A line-drawing or flow chart created by the group (must explain the reasoning of the diagram and why the paths are written such as P point)**

Submit the finalized report as a PDF file by **Monday, December 6, 2021 at 10 p.m.** You will have access to the Turnitin link to check your report for plagiarism multiple times before the deadline. Final reports must contain less than 3% plagiarism. ***[NOTE: Obvious instances of plagiarism such as subsequent copied lines of text will result in negative points even if the overall paper reviews less than 3% plagiarism.]***

Case Report Rubric

Criteria	Ratings						Pts
This criterion is linked to a Learning OutcomeFormat 5-7 pages, 1 inch margins, correct sections, 12 pt. Times New Roman, double spaced, APA							3 pts
	3 pts Full Marks all criteria met	2 pts Very Good Most criteria met	1 pts Poor Missing several criteria		0 pts No Marks		
This criterion is linked to a Learning OutcomeGrammar Grammatically correct with new paragraphs as new main topic is mentioned; does NOT use I, me, we, us, they, he, she, his or her.							5 pts
	5 pts Full Marks Meets all of the criteria	4 pts Very Good Meets most of the criteria	3 pts Good Meets some of the criteria	2 pts Fair Struggles to meet criteria	1 pts Poor Does not understand or meet criteria	0 pts No Marks	

Case Report Rubric

Criteria	Ratings						Pts
This criterion is linked to a Learning OutcomeIntroduction Introduce your topic to the reader. Be sure to include the state of current research and where you plan to develop the current state of knowledge. You may want to include an interesting fact to reinforce the importance of your work and to develop an interest in your hypothesis. Finish off with a thesis statement that you'll focus on your workaround.							5 pts
	5 pts Full Marks Meets all of the criteria	4 pts Very Good Meets most of the criteria	3 pts Good Meets some of the criteria	2 pts Fair Struggles to meet criteria	1 pts Poor Does not understand or meet criteria	0 pts No Marks	
This criterion is linked to a Learning OutcomeAims In this section, you answer the questions regarding why you are conducting your research and any questions you'll explore. Avid case study writer recommends focusing your questions around your thesis.							5 pts
	5 pts Full Marks Meets all of the criteria	4 pts Very Good Meets most of the criteria	3 pts Good Meets some of the criteria	2 pts Fair Struggles to meet criteria	1 pts Poor Does not understand or meet criteria	0 pts No Marks	

Case Report Rubric

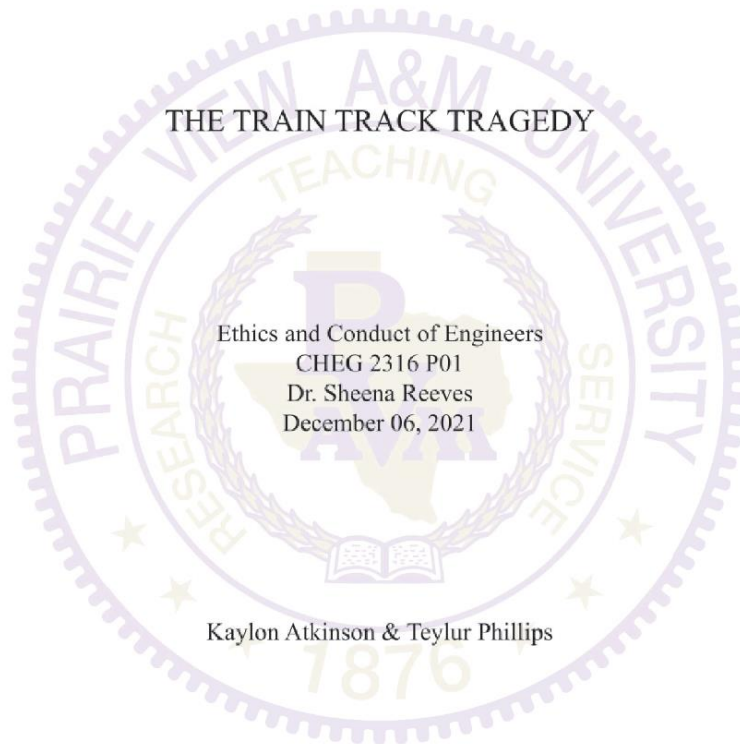
Criteria	Ratings						Pts
This criterion is linked to a Learning OutcomeResults/Discussion In this section, you will discuss the outcome of the scenario using ethical thinking and ethical reasoning. List any factual, conceptual, or moral issues and provide possible solution techniques including flowcharting and line-drawing.							12 pts
	12 pts Full Marks Meets all of the criteria	10 pts Very Good Meets most of the criteria	7 pts Good Meets some of the criteria	5 pts Fair Struggles to meet criteria	2 pts Poor Does not understand or meet criteria	0 pts No Marks	
This criterion is linked to a Learning OutcomePlagiarism No direct quotes are allowed in technical reports. Turnitin reports less than 3% plagiarized.							10 pts
	10 pts Full Marks Meets all of the criteria		5 pts Good plagiarism is less than 5%		0 pts Plagiarized Greater than 5%		

Case Report Rubric								
Criteria	Ratings						Pts	
This criterion is linked to a Learning OutcomeConclusion/Recommendations advise stating any knowledge gaps in your work as well as any unanswered or new questions that you had found in the process; how can society move forward? further issues to discuss in the area? is the matter settled?	5 pts Full Marks Meets all of the criteria	4 pts Very Good Meets most of the criteria	3 pts Good Meets some of the criteria	2 pts Fair Struggles to meet criteria	1 pts Poor Does not understand or meet criteria	0 pts No Marks	5 pts	
This criterion is linked to a Learning OutcomeReferences uses credible sources, APA format, references statements in the text that are not common knowledge. [1] (Reeves, 2021) (DOL.Gov, 2008)	5 pts Full Marks Meets all of the criteria	4 pts Very Good Meets most of the criteria	3 pts Good Meets some of the criteria	2 pts Fair Struggles to meet criteria	1 pts Poor Does not understand or meet criteria	0 pts No Marks	5 pts	
Total Points: 50								

Total Points: 50

ABOVE AVERAGE

Case Report Rubric	
Criteria	Ratings
Format view longer description	Full Marks all criteria met 3 / 3 pts
Grammar view longer description	Very Good Meets most of the criteria 4 / 5 pts
Introduction view longer description	Full Marks Meets all of the criteria 5 / 5 pts
Aims view longer description	Good Meets some of the criteria 3 / 5 pts
Results/Discussion view longer description	Very Good Meets most of the criteria 10 / 12 pts
Plagiarism view longer description	Full Marks Meets all of the criteria 10 / 10 pts
Conclusion/Recommendations view longer description	Full Marks Meets all of the criteria 5 / 5 pts
References view longer description	Full Marks Meets all of the criteria 5 / 5 pts
Total Points: 45	

**Introduction**

Life is extremely valuable and once it's gone, there's no going back. This is why when there is a threat towards the people that someone cares about, they will most likely do anything in that person's power to protect them. Wars are shown on a global scale of this same instance happening. Countries go to war to either defend the people living there, or to help defend their allies from countries that are a threat to their society. WW1 originally occurred due to Germany ignoring France's Treaty of London that gave Belgium its independence of being a neutral state since 1839, and declared war on them (Holden, 2020). Germany thought of the treaty as just a scrap of paper and with no hesitation Britain stepped in. Britain tried to stop Germany by giving them an ultimatum, in which Germany refused and caused WW1. Britain's government did everything in their power to help their allies fight against Germany including transporting their soldiers through the fastest routes possible. At that time the quickest way of transportation was through trains. Britain's focus became more set on using as much money to get the 7th Battalion to the war grounds that their engineering focus was pushed aside (Fascinating Horror, 2020). Thus the worst train collision in Britain's history was formed, which killed hundreds of soldiers before they ever made it to the warfield.

Train Track Tragedy Aims

Britain will never forget the tragic event that occurred early May 22 in 1915 (Fascinating Horror, 2020). Britain was in the shock of their lives when they got news of a horrible three way train collision which involved the death of their soldiers. Britain controlled the majority of the railways in order to transport their soldiers of the 7th Battalion from Scotland to Liverpool where they could then climb aboard ships that would lead them to Gallipoli where they could help fight

the Ottomans (Fascinating Horror, 2020). The soldiers were transported in low priced, quickly trains so that more money could go towards other resources needed for the war.

At every train junction a signal box was placed so that the signalman inside could direct the flow of train crossing by pulling levers and signaling to the train engineers. This specific signal box was called Quintinshill and it was located near Gretna Green in Scotland (Fascinating Horror, 2020). On the night shift of the accident George Meakin worked the night shift until did his job of keeping track of the incoming and outgoing of the various trains until James Tinsley arrived to relieve him (Fascinating Horror, 2020). James Tinsley was scheduled for the day shift, however he made his appearance at 6:30am. This timing is important due to James Tinsley originally supposed to arrive at 6:00am, however he arrived 30 minutes later. This act was common in signal man so that the day signalman could have more time to sleep before they had to get up for their shifts (Fascinating Horror, 2020). Each signalman was expected to arrive on time, because their handwriting had to be printed in their data entry notes the times the trains passed by to ensure everything happened successfully.

George Meakin stayed in the signal box even after James Tinsley was there so that he could read the newspaper while James Tinsley could copy the train details into the data entries for the 30 minute time interval he was not there. Afterwards James Tinsley got back to work. George Meakin had already reversed a local train into the upward line towards Carlisle so that an express train could pass on the downward line towards Glasgow since it was traveling at a faster rate (Fascinating Horror, 2020). James Tinsley accidentally sent a troop train through the upline, forgetting that the local train was on that line. This caused a terrible crash collision amongst the two trains, to where they derailed into the downline and many were injured. Shortly following an express train going 80 miles per hour, which signaled that everything was clear, went through the



Figure 1: The Three Train Collision at Quintinshill

(Fascinating Horror, 2020). An artist recreated this moment through his painting as shown in figure 1. Other casualties consisted of the troop train and local train being destroyed due to the collision and fire (*Quintinshill Rail Disaster Genealogy Project*). As a result of the tragedy the Caledonian Railway closed for only a short period to time and reopened with debris still surrounding the railway (*Quintinshill Rail Disaster Genealogy Project*). With so many casualties under review the subject of whom to blame followed; the public deemed James Tinsley and George Meakin solely responsible for the disaster. This was because as a signalman their job was to properly signal trains movements in effort to get each train to its promised destination (Ellis, 2021).

According to the findings made in court James Tinsley and George Meakin weren't following correct procedures as instructed to. It was revealed that James Tinsley had been arriving to work 30 mins late in hopes to rest in while George Meakin overstayed his intended shift and assisted James Tinsley by doing his data entry work (Fascinating Horror, 2020). These everyday actions were to be the fault of both men as it was an underlying factor of the disaster.

downline and hit the local and troop trains (Fascinating Horror, 2020).

Results

With a great disaster comes great action. The Gretna Green rail disaster killed 225 people and of those were 215 soldiers

By arriving 30mins late daily James Tinsley had no choice but to falsify George Meakins data entries to cover their trail of unethical behavior (Fascinating Horror, 2020). However, during this process James Tinsley became distracted and forgot to do his actual job at the moment which was to signal the trains on the railway which resulted in local trains colliding into a troop train waiting for a signal (Fascinating Horror, 2020).

With these findings presented in court James Tinsley and George Meakin were assumed to be guilty. Lieutenant Colonel E. Druitt furthered the proceedings of the case with his inspection adding that the firemen onboard the express train were in the sleeping chambers (Fascinating Horror, 2020). Also the train wasn't equipped with the proper amount of emergency essentials, the train didn't have water buckets which would have prevented the spread of the fire (Fascinating Horror, 2020). Also cross examined was the misuse of rule 55, a procedure followed if a train has been stopped on the railway for longer than 3 minutes (Fascinating Horror, 2020). During this act a crew member is supposed to communicate the train's status with the signalman and make sure that the proper procedures are being carried out. But, when the crew member went to the signal box to gather an updated status of the train (Fascinating Horror, 2020). With all factors presented in court the verdict determined both James Tinsley and George Meakin guilty of manslaughter, Meakin serving 18 months and Tinsley 1 year and hard labor; but both only serving their original time (Railway Department et al., 1915). Surprisingly after being released both were hired back at the Caledonian Railway; James Tinsley as a lampman and George Meakin as a goods train guard (Railway Department et al., 1915).

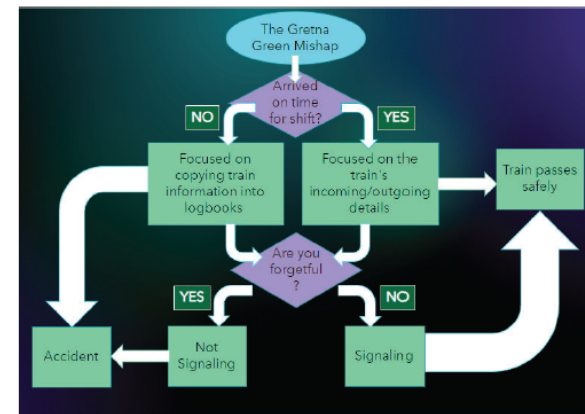


Figure 2: Flow Chart Diagram based off the Gretna Green Mishap

Figure 2 displays the Gretna Green mishap as it pertains to the signalman. Following this diagram you'll be able to follow the decisions that could be made ignored to have successfully train passing versus an accident occurring as resulted in the Gretna Green rail disaster. As stated in the report a key factor in the disaster was the improper procedures being followed by both signalmen. One being James Tinsley arriving at his shift 30 minutes later than scheduled resulting in error of signaling. This leads us into the first question on the diagram asking if they arrived on time for their shift. If they did not then the next question would be to ask if they were focused on copying train information into the log books. This will result in the signalmen not paying attention so an accident is most likely to occur. James Tinsley had a mental disorder to where he would sometimes be forgetful, therefore the question comes into play that if the signalmen is forgetful, they might forget to signal for the incoming trains. Not signaling may result in an accident. On the contrary, if the signalmen, specifically James Tinsley, did arrive on time for their shift they would be focused on the train details instead of copying from George

Meakins notes. Resulting in the flow to move towards the outcome of the trains passing through their junctions safely. Again due to the status of this signalman job, the question proceeds to ask if they are forgetful. If the signalmen aren't forgetful, they will be better qualified for the job and have a higher chance at a successful train passing as well.

Discussion

Safety should always be the main concern for an engineer. The government should not have forced the engineers to build a train out of cheap wood. Even worse is that the troop train was lit by lanterns that ran on gas. This was very unethical and put all those soldiers' lives at risk. Even if that troop train and local train did not crash that day, there was still an extremely large chance of an accident happening. The gas for the lanterns got on the surface of the fast made perimeter of the train which was made out of wood and caught on fire due to the wind. It is understandable for Britain wanting all of their troops to be at Liverpool within a certain amount of time to help fight for Belgium. However, there is no point if the soldiers die before they even have the chance to help fight in the war.

James Tinsley is the signalman known to be the person who caused this horrible disaster to occur. If the signalman arrived in a decent amount of time for their jobs, there would have been a smaller percentage of an accident even occurring. James Tinsley spent a good amount of time falsifying information into the data entries nevertheless if James Tinsley came on time he would have actually moved the local train to the upline himself and had an idea of what was going on. James Tinsley's focus was more so on copying George Meakin's notes so that their managers could look at the sheets and think that James Tinsley was there on time doing his job.

There was also information given that James Tinsley had a mental disorder that causes him to forget things sometimes, and this was one of those times. James Tinsley rode to work on the local train. The same local train that George Meaking had to reverse into the upline to allow the express train to pass. George Meakin had no choice but to signal the local train into the upline from the downline, because there was already a goods train waiting in the siding on the downline. George Meakin was supposed to put a safety collar on the signal that the local train was on so the troop train physically could not be able to continue going. Within each engineering role there are strict qualifications that a person must have in order to do their job efficiently without affecting anyone around them negatively. James Tinsley should not have been hired for this role even though they were short staffed due to majority males going to war. Memory and close attention to details are important in that industry.

Arguments we made about the officers at the scene of the tragedy in which civilians saw their loved ones shot to death. The officers decided that they didn't want their soldiers to suffer an even horrible death experience as they were trapped under train debris and were starting to burn alive. It was a process of duty ethics vs having a utilitarianism mindset. The officers duty was to make sure that the soldiers of the 7th Battalion of the Royal Scots were transported to their ships so that they could make it to the fighting grounds. The officers chose to maintain a utilitarian mindset and thought of both the good and bad possibilities and how it would affect everyone. Which is why they shot the trapped troops so that they would be out of their misery, instead of pulling them out knowing that they would not be able to live long due to their severe injuries and forcing them to finish what they've started.

Conclusion/ Recommendations

With every story there are loopholes and questions. As stated in the report Britain controlled the railways during World War I and used any train they could get their hands on, old or new (Fascinating Horror, 2020). This action resulted in safety error, being that there would be a mix of old and new trains transporting goods and people to locations. Also the troop train carriages was a wood material which then ignited in claims causing three trains to be engulfed with flames (Railway Department et al., 1915). If the train carriages were made out of steel rather than wood then the material would've burned slower.

Furthermore if the material wasn't changed, there is a possibility that with fire extinguishers and tools such as hammers, saws, crowbars and axes; they could've had less casualties (Railway Department et al., 1915). In the inspection made by Lieutenant Colonel E. Duritt, a number of the tools were there but was only accounted for in small amounts (Railway Department et al., 1915).

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AVERAGE

Case Report Rubric	
Criteria	Ratings
Format view longer description	Full Marks all criteria met 3 / 3 pts
Grammar view longer description	Very Good Meets most of the criteria 4 / 5 pts
Introduction view longer description	Very Good Meets most of the criteria 4 / 5 pts
Aims view longer description	Good Meets some of the criteria 3 / 5 pts
Results/Discussion view longer description	Good Meets some of the criteria 7 / 12 pts
Plagiarism view longer description	Full Marks Meets all of the criteria 10 / 10 pts
Conclusion/Recommendations view longer description	Good Meets some of the criteria 3 / 5 pts
References view longer description	Full Marks Meets all of the criteria 5 / 5 pts
Total Points: 39	

Prairie View A&M University
Dr. Reeves
Ethics and Conducts for Engineers
Final Group Report
The Oppau Explosion
December 6, 2021
Carol Akpan and Kaitlin Newcost

Introduction

One of the world's most catastrophic explosions happened in Europe on September 21, 1921, when a nitrogen fixation explosion set off at a BASF chemical factory in Oppau containing four thousand-five hundred tons of ammonium sulfate nitrate. This devastating event occurred under the watch of the explosive expert named Herman Humppa, who was the explosion expert on-site on the day of the accident. *Figure 1* shows a photograph taken of the entire factory after the explosion. This report will show the background leading up to this catastrophic event and why the chemical fertilizer plant blew up and who was held at fault. The report will also discuss the ethical thinking that occurred in the event also the possible ways future and existing chemical plants should learn from the Oppau explosion.



Figure 1: Photograph of the aftermath in Oppau showing the entire chemical fertilizer factory and the crater formed at the silo days after the explosion.

Citation: Gyenes, Z., Dr. (2016). Oppau – The consequences of the explosion [Photograph found in BASF plant, Oppau, 1921]. Retrieved 2021, from https://minerva.jrc.ec.europa.eu/en/shorturl/minerva/lpb251_article_fertiliserspdf

Amis

The fault of Oppau Ammonium nitrate sulfate was blamed on the chief explosion expert Herman Humppa. However, Herman has been using the same method that blew up the plant that day before many times at the site for years. Therefore, it is hard to pinpoint him as this sole issue because of people's lack of technology and knowledge in the 1920s. However, Herman was to blame because he was not aware of the change in the chemical compound he was dealing with that particular day. It is understandable to see why this event occurred because he uses the same method on the same material every day. Therefore, he gave almost little thought as to why the fertilizer would change to a new chemical compound. The ethical thinking in this debate proves how important it is before installing a chemical plant to review the safety and go in-depth into what the plant will be producing the storage conditions of the particular chemical being used. In this case, Herman and his workers worked based on past experience and were unaware that the chemical they were dealing with could change its chemical compound with time and extreme amounts of settlement. Therefore, Hermans crew were unaware that the new chemical compound would react in a catastrophic way when being ignited. The background of this discussion will be further discussed in the results of this report.

Results

Wednesday, September 21, 1921, Southwest of Germany, was just a typical average day when BASF owned Germany's most extensive chemical factory fertilizer plant. The chemical plant ran for eight years producing nitrates for synthetic fertilizer. The plant produces different types of fertilizer, all with an ammonium base; however, fertilizer is only needed at certain seasons.

Therefore, they store their fertilizers in Silos, holding up to fifty-thousand tons of fertilizer (Triffo, 2017). However, when you store ammonium fertilizer and pile it up to the ceiling, the bottom layers will start to compact and form a rock-hard base when stored for long periods. Back then, the only way to get through the compact rock ammonium fertilizer was to use pickaxes and shovels to break down the base (Horchner, 2016). However, if this took up too much time there, the factory workers decided to use explosives to break the compact fertilizer in the Silos. The explosives they used only gave off a small explosion, resulting in the ammonium fertilizer being broken down into smaller 30 cm chunks (Triffo, 2017). Herman Humppa, an expert explosives factory worker, and a team of his experts often used these explosives to break up the settlement in the Silos and never experienced any problems. Therefore they were convinced that the small explosions method was utterly safe to break up the settlement. On Wednesday, September 21, 1921, at 7:30 AM inside silo number 110, Herman and his team were on the mission to loosen over four thousand tons of fertilizer for bagging and shipping (Triffo, 2017). Herman over-seed its placement of the dynamite. Unfortunately, The fertilizer and that silo have slowly changed their chemical composition into something very deadly over time. Herman and his team were unaware of this newly formed fertilizer they were dealing with that day and thought it was another day of setting off explosions. Unfortunately, that morning Herman and his workers set off their small explosives within the compound of the new chemical fertilizer. Within seconds the entire factory was caught in black smoke as an explosion spread across the city. Since it was 1921, the architectural buildings in place were based on bricks; therefore, the explosion's impact was so strong that the pressure created by the blast was strong enough to push all of the walls in and toppled nearby houses like a domino effect. Many of the villagers thought the explosion was an earthquake and proceeded to take cover within their homes; however, this was an explosion,

and they were not trained nor prepared for this catastrophic event. In the aftermath of the explosion, people tried to dig a bulk of the debris and bricks scattered and piled upon family members in search of hope for their loved ones. Try to rescue the dead and save the injured. The force of the explosion was so strong, but it left nearly 7500 people homeless in 1921 injured in about 561 total deaths (Bariyah, 2020). One hundred seventy-seven of the deaths were from the employees at the factory site, while the other 384 deaths were from the residence in Oppau (Triffo, 2017). At the site of the silo, The explosion created an enormous crater that was about 20 meters deep and 90 meters wide, and about 125 meters long (Triffo, 2017). This explosion was so detrimental in our history because the explosion back then could not have been prevented, and the entire scene happened within seconds, leaving cities broken and lives lost. After the explosion, the remaining members of families who lost their loved ones until the explosion began to rally and riot at The home of BASF explosives chief Humppa. The people were distraught because Humppa was to blame since he claimed to be the expert. The crowd began to throw things and break down Humppa's house, including threats of lynching to their families who were still inside their house with the rioters outside. After the explosion that wiped away nearly seventy-five percent of the buildings and homes within Oppau were insured by a news agency that helped the homeless get money to rebuild their houses. *Figure 2* shows the illustration of the aftermath of the factory explosion on the streets of Oppau, which left many homeless. The factory company BASF also contributed money to support those who lost their houses and were injured by the explosion (Triffo, 2017). However, BASF refused to take responsibility for the disaster. After all, they claimed that whatever caused the explosion could not be explained because their science could not prove what happened. Inspectors concluded that the fertilizer within that silo must have changed its chemical composition and physical

properties. Today the BASF fertilizer plant company has been running since the 1950s. They were able to create a method that can prevent the fertilizer from compacting into a rock and stopping the chemical composition from changing within the silo to remove the blasting method.



Figure 2: Photograph from the Oppau streets of the remaining houses and buildings left scattered.

Cite: Conradt, S. (2013). *The Oppau Explosion, 1921* [Photograph found in 7 Other Ammonium Nitrate Disasters, DOWNTOWNROSEBURG.ORG]. Retrieved 2021, from <https://www.mentalfloss.com/article/50229/7-other-ammonium-nitrate-disasters>

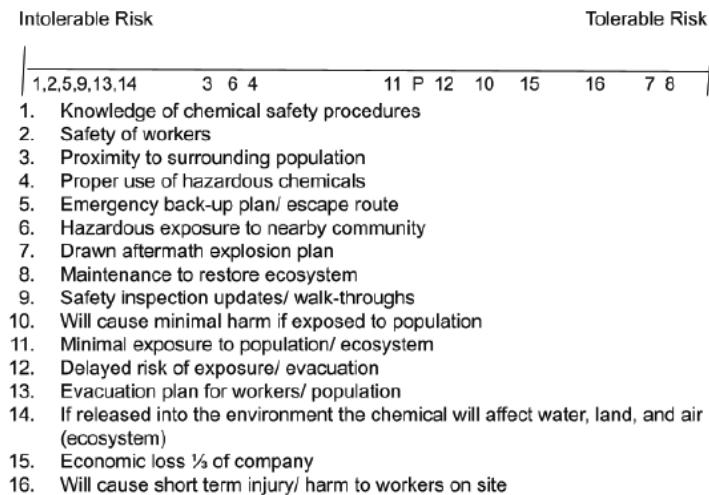


Figure 3: Line drawing

Discussion

Figure 3 above represents how factories and plants should prioritize procedures throughout facilities to avoid mass tragedies/ explosions, such as the Oppau explosion. The P point in Figure 3 illustrates the importance and balance between the safety of the people and workers. As a plant, factory, or company, the importance of prioritizing safety and the people should always be something that is never questioned. If not, one of the outcomes can result in an intolerable risk, which is a risk that the company can not afford or should never think about challenging. The unacceptable risk could result in serious harm to workers and people, which then could result in outrage, which was displayed in the Oppau explosion disaster. Although the tragedy was a pure accident, the methods and procedures used were unethical and easily

preventable. The company portrayed pure negligence and recklessness from the lack of knowledge on the chemicals used and how to handle the chemicals properly. The company showed a lack of attentiveness and awareness when dealing with dangerous chemicals, such as following proper inspections and protocols to monitor chemical levels. The factory's dynamite method for clearing build-up had worked all the other times wonderfully when the process was used, which is why the factory relied so heavily on this method (Triffo, 2017). The factory became too comfortable with the explosive technique, and instead of producing other ways to clear the build-up, the factory continuously relied on the explosive approach. As dangerous as the explosive method was, if the proper safety measurements had been put into place, the explosive method could have still been very effective. Trained experts, such as Herman Humppa, in explosives, were in charge of the factory's process. When dealing with such dangerous chemicals and products, it is crucial that everything is inspected and properly checked. Just because something occurs the exact one hundred times does not necessarily mean that something will not change once when reaching one hundred and one. The way the factory was managed and the procedures BASF followed were very unethical regarding the safety of the workers and people residing in nearby communities. At BASF, there were two shifts; the night shift's job was to report to the day shift coming in what went on or what to look out for (Triffo, 2017). If the night crew had measured or paid any attention to the levels of ammonium nitrate in the product, the night crew would have realized the levels were much higher than usual. The report made to the Day shift by the night crew resulted in the day shift doing the routine procedures that were always done (Triffo, 2017). By the night crew, glimpsing over the tiny details of the level of ammonium nitrate caused many innocent lives in the factory and nearby communities to be lost. The factory was built very close to many communities; if the company

had put how close the villages and nearby communities were into consideration it could have also prevented much devastation. Especially with a company like BASF, when dealing with dangerous chemicals like ammonium nitrate and handling explosions, putting the people's safety first is always best. The event's aftermath caused the families of the workers within the company and many civilians to go into outrage demanding answers to how a regular morning turned into one of the most traumatic events to occur in Oppau.

Conclusion and Recommendations

The Oppau disaster impacted Oppau; the tragedy forever changed how the company operated. Although the incident was settled and all was restored years later, the families still cannot get back the lives that were lost due to the tragedy. To help assist the people affected by the disaster, an agency funded money and shelter to people without homes and those who suffered damage from the incident (Triffo, 2017). BASF contributed to the agency by giving compensation to the family and loved ones that were lost due to the tragedy (Triffo, 2017). The factory now uses a different and much safer method for making fertilizer. Even though BASF has changed the way the company produces fertilizer, has BASF implicated safety plans, evacuation routes, and funds to prepare for such events? Does the company carefully measure chemicals and look for a change in the product since the last incident? The disaster now serves as a lesson to all other plants and factories of how necessary implicating safety procedures and practices are. The Oppau disaster shows the severity and tragedy caused by one simple mistake that was made. As an engineer, the fate and safety of the people reside in what is done and how it is done. One simple mistake could affect thousands of lives in just one second. Further issues to discuss in similar situations would be planning the locations of the plants and factories in the future. Also,

the procedures and inspections put into place to make sure the factory or plant is up to safety standards could potentially prevent more tragedies as such from occurring.

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BELOW AVERAGE

Case Report Rubric	
Criteria	Ratings
Format view longer description	Full Marks all criteria met 3 / 3 pts
Grammar view longer description	Very Good Meets most of the criteria 4 / 5 pts
Introduction view longer description	Very Good Meets most of the criteria 4 / 5 pts
Aims view longer description	Full Marks Meets all of the criteria 5 / 5 pts
Results/Discussion view longer description	Good Meets some of the criteria 7 / 12 pts
Plagiarism view longer description	Plagiarized Greater than 5% 0 / 10 pts
Conclusion/Recommendations view longer description	Good Meets some of the criteria 3 / 5 pts
References view longer description	Good Meets some of the criteria 3 / 5 pts
Total Points: 29	

Case Study Report Collapse Of The Tacoma Narrows Bridge

Emily Castro and Sharon Shusi

Engineering Department, Prairie View A&M University

CHEG 2316: Ethics and Conduct of Engineers

Dr. Sheena Reeves

6 December 2021

1

Introduction:

The Tacoma Narrows Bridge was constructed in the 1930s for military use. The bridge's purpose was to link McChord Air Field south of Tacoma and the Puget Sound Navy Shipyard in Bremerton. The bridge was completed in July 1940. At that time the Tacoma bridge became known as the third-longest spanned bridge in the world at a 2,800 span (Farquharson, 1940). Before the bridge was officially open there was a fact that the deck of the bridge was very flexible. Even the construction workers were told to chew on lemon so construction workers do not become extremely nauseous while working (Farquharson, 1940). Despite the very visible flaws as the bridge was not stable at all, The engineers assured the people, letting the people know that there was nothing to worry about since the bridge was also held with checking cables.

On November 7, 1940, the Tacoma Narrows Bridge, which had also been nicknamed "Galloping Gertie" because of how the bridge would bounce, collapsed because of high winds going at about 42 miles per hour (history.com, 2009). The first reported incident was around 11 a.m. with the breaking of concrete, and a few minutes later 600 feet of the bridge broke. The investigators later found that the bridge could not handle the wind vibrations created (history.com, 2009). The narrow two-lane roadway allowed the flexibility of the bridge, while the plate girders did not absorb the wind gusts (Britannica, 2021). The bridge did not take any lives because at the moment the bridge had been closed to the public half an hour before the collapse (Voss, 2016). The bridge was replaced in 1950 with four lanes westbound (Britannica, 2021).

The bridge collapsed in a matter of four months. The bridge was originally designed by engineer Clark Elridge, but the bridge was an \$11 million cost to build. To this

problem engineer Leon Misseff created a new design that only had a cost of \$8 million. Although Leon Misseff had a cheaper alternative the design provided had less resistance to twisting and bending (Voss, 2016).

On a regular bridge, the wind should pass through due to the incorporation of the trusses (Harish, 2021). ¹ In the case of the Tacoma Narrows Bridge, the wind was going above and below the bridge causing the bridge to move (Fig1). Leon Misseff argued that the aerodynamic forces would push the bridge sideways instead of up and down making the structure of the bridgeless unstabilized. The bridge would move with moderate wind conditions while being built and shortly after being opened the people experienced vibrations of the bridge. To try and solve the problem an engineering professor, Frederick Farquharson was brought to perform wind tunnel studies (Voss, 2016).

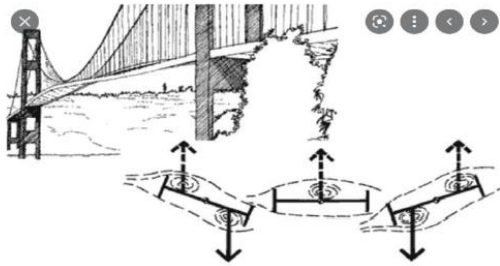


Fig.1: The following picture shows how the wind caused the movement of the bridge.

When Frederick Farquharson noticed that the models would begin twisting Farquharson let reporters know that the bridge would not survive the twisting type of movements

(Voss, 2016). The morning of the collapse the reporter, Leonard Coatsworth, headed onto the bridge and was halfway through the bridge when a bounce moved the car. After the sudden bounce, the reporter tried to get off the bridge as soon as possible and the only damage found were a couple of scratches and bruises on the body (Voss, 2016). According to the report Farquharson released ten years later, the reason for the collapse was the twisting motion seen on the models created for the tunnel studies (Voss, 2016).

Aims:

There are many ethical issues discussed when the case report ² collapse of the Tacoma Narrows Bridge is brought up. The engineers predicted that the bridge would not be able to handle high wind velocities without having some sort of damage. A couple of questions will be discussed throughout the paper: Should the bridge have been built with engineer Clark Elridge's design? Can anyone be blamed for the collapse of the bridge? What consequences did the bridge bring to engineers? Who was affected by this case? Was anyone being unethical? Was there a different approach than the company could have taken?

Discussion:

Naturally, the thought was to look back and figure out if there were any warning signs before the collapse. Also if any concerns were voiced out by anyone. Back then the Narrows Bridge was one of a kind because of how narrow the roadway was. During those times bridges such as the George Washington Bridge had a ³ length to width ratio of in the '30s. The Tacoma Narrows Bridge had a ⁴ length-to-width ratio of 72, which was far more than any other bridge had ever been during that time (Farquharson, 1940).

Various concerns raised questions and uncertainty within the septuagenarian consulting engineer, Theodore L. Condon, whose job was to make sure that the design of the

bridge was feasible and achievable (Farquharson, 1940). Theodore quickly concluded that the narrowness of the deck of the bridge allowed for excessive flexibility (Farquharson, 1940). Theodore then consulted the other engineers who were part of the project for their opinion as well.

Ultimately went with the expertise and the advice of the authoritative figures that have been worked with and for. The experience that Condron went through can be considered prevalent in each of the cases that have been researched. The idea of someone, having genuine concerns, going to their proposed superior for further clarifications and being told that everything is okay is a theme. The discussion is how different factors can affect the way a person views something even when the responsibility falls on the person to make sure that an overall project is productive as well as safe. The case was interesting as well as concerning that although there were many signs of things possibly not being right the decision was made to continue with the bridge and allow for the general public to have access as well.



Figure 2: The illustration above is a cartoon-like drawing but also an accurate representation of just how unstable the first version of the Tacoma Narrows Bridge was. The picture shows a ripple effect throughout the bridge. This also supports the fact that many people say that the bridge felt like they were on the waves in the sea as it was going up and down as they were on the bridge.

The engineering of the bridge had a lot of negligence involved. If the bridge had not been closed people's safety would be at immediate risk. Although no deaths occurred there was a delayed risk present as long as the bridge was open to the public. People could predict the collapse of the bridge because of the sudden vibrations the bridge had during the building process and before the collapse.

The professor that conducted the tunnel studies had an obligation, to be honest with the results found from the studies. Farquharson was externally whistleblower by letting the reporters know that the findings showed the bridge was unsafe when the high wind was present. Farquharson was not discrete with the findings of the study because of the duty present as an engineer to keep people safe. After this information went public people would voluntarily risk their lives when the citizens continued using the bridge as a route to take.

Most of the steps taken by the engineers present were ethical and legal. The reporters and engineers gave out information as the information was found to keep people safe. Aside from these actions the bridge was also closed right before the bridge began collapsing and shaking. This specific action helped keep people from falling and hurting each other and themselves. All of the actions helped keep people from any deathly harm. Although one reporter did have a few injuries no major incident happened.

Although most of the precautions taken were good and ethical the engineers could have also gone with other options. The engineers could have analyzed the options better if the options were presented on a line drawing. Some of the options the engineers could have considered are the following: (1) Built the \$11 million bridge design, (2) Close the bridge completely until the bridge was finally stable, (3) The bridge should not have been built until the bridge was safe, (4) Let the bridge collapse, (5) Ask other engineers to step in with fixing the bridge.



The options the engineers could have taken were very different and could have had different outcomes. The 'p' point represents the problem fitting into entries. The 'p' was placed between the options of asking other engineers and closing the bridge until the bridge was stable because the best option to keep the bridge from collapsing completely was to close the bridge and focus on stabilizing the bridge. The options after the 'p' were allowing the risk of the bridge collapsing and risking people's safety.

Conclusion:

⁵ The Collapse of the Tacoma Narrows Bridge was caught on film, which also makes the most infamous bridge failure in history. An Investigative committee was assigned to figure out what exactly caused the bridge to collapse in the way that the bridge did. Their findings were that the aerodynamic forces were not taken into account when the design was underway. These types of things were rarely taken into account or seen as a big deal before the collapse so no engineer was charged for any wrongdoings. Instead, this was a lesson for engineers and future designs for bridges. This also resulted in there being a pause on bridge building in the 1940s. Despite that, there was still research being conducted on the cause of the failure. One of the prominent bridge engineers who studied wind and how the wind affects bridges, specifically the Tacoma Narrows Bridge, was David B Steinman (Petroski, 1993).

In 1954 Steinman published a paper about how wind affected bridges in *American Scientist*. To be able to look at the situation from an engineering standpoint more closely (Petroski, 1993). At the end of the day, the bridge was completely demolished, the building and the structure by mid-1943. By then the discussion had begun into what had to be done to make sure that this costly disaster did not occur again. The construction of the replacement bridge began in 1948 and by 1950 the bridge was completed. The bridge had many tests due to there being several storms. The winds reached about 75 miles per hour. Since the first bridge collapsed after 42 miles per hour of winds this was an indication of a better design that was able to withstand harsh winds (Gunns, 1981). With the expansion of the bridge, there was space for more stability and many people were pleased with the new design. The bridge became very busy with traffic as well as servicing the needs of the general public. Whether the people went for vacations, or for regular commute. The bridge generated toll revenue and was extremely

profitable as the loans that were used to build the bridge were paid back . With that, the tolls were removed from the Tacoma Narrows Bridge in 1965 (Gunns,1981).

Recommendations:

The responsibility fell on the Engineers and everyone on board with the construction of the Tacoma Narrows Bridge to make sure things were done right the second time around. So in fact the Engineers investigated each area that went wrong and had a list of things that needed to be changed which included:

1. Making sure that the deck of the bridge was stiff enough to not twist and turn in the wind. There had to be stability. (Petroski,2001)
2. Steadiness would be achieved by making sure that the structure of the deck of the new bridge was wider and deeper. (Petroski,2001)
3. Having the new bridge to have four lanes instead of two, thus combating the narrowness of the first bridge.(Petroski,2001)
4. Using a more conventional stiffening truss. This allowed for the length and the depth ratio to be much smaller and more in line with how other bridges were constructed during that time as well.(Petroski,2001)

All of these things were crucial in creating a design that worked and was able to stand the test of time. It was unfortunate that care was not taken the first time but commendable that they were able to learn from their previous mistakes and create a plan that allowed them to be more successful with their second attempt.

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2	www.britannica.com Internet Source	1%
3	history.com Internet Source	1%
4	www.coursehero.com Internet Source	1%
5	espace.library.uq.edu.au Internet Source	1%
6	guides.library.ubc.ca Internet Source	1%
7	byt-baj.fun Internet Source	1%
8	coffeewithjeff.com Internet Source	1%
9	YM Wan, MS Raven, EE Inameti, BG Murray. "YBCO thin film device fabrication using lithographic techniques", Vacuum, 1992	1%

Publication

10	"Selected Bibliography", Elsevier BV, 2015 Publication	<1%
11	portfolio.vvsu.ru Internet Source	<1%

Exclude quotes Off Exclude matches < 2 words
Exclude bibliography Off

**CHEG 2316-P01: ETHICS AND CONDUCT OF ENGINEERS
FALL 2021 SEMESTER**

Title of Assignment: FINAL PRESENTATION

TOPICS COVERED IN FINAL PRESENTATION

FINAL PRESENTATION covered the following topics:

1. Engineering Disaster
2. Contracts/Liability
3. Ethics and the Law
4. Line Drawing
5. Flow Diagram
6. Ethical Reasoning

CHEG 2316-P01: ETHICS AND CONDUCT OF ENGINEERS

FALL 2021 SEMESTER

Each student is required to upload a PDF file of your PowerPoint slides by **Monday, December 6, 2021 by 10 p.m.** The presentation should include the following.

- **Presentation Overview**
- **Disaster Background**
- **Ethical Engineering Focus**
- **Line-Drawing or Flow Chart designed by the group**
- **Results/Summary**

The presentation is 15 minutes with a maximum of 12 slides in the presentation. You are required to cite all content, tables, and images on each slide. The use of videos is allowed; however, you cannot show more than 1 minute of footage.

ABOVE AVERAGE

Nathan W.
Mariah H.

Social & Behavioral Sciences Core Component Sample Rubric

Group Score

	Capstone 5	Milestones 4	3	Benchmark 2	Lack of Proficiency 1
CRITICAL 28					
Evidence 	Information is taken from source(s) with enough critical evaluation to develop a clear, comprehensive analysis. Viewpoints of experts are questioned thoroughly. Provides full understanding of an issue.	Information is taken from credible, relevant source(s) with enough critical evaluation to develop a coherent analysis. Viewpoints of experts are subject to questioning. Provides solid understanding of an issue with	Information is taken from source(s) with some evaluation, but not enough to develop a coherent analysis. Viewpoints of experts are taken as mostly fact, with little questioning. Provides good understanding of an issue with several omissions.	Information is taken from source(s) without any real evaluation. Viewpoints of experts are taken as fact, without question. Provides a limited or one-sided understanding of an issue.	Information is severely lacking or incorrect. Viewpoints of experts are taken as fact, without question, or may even be misrepresented. Provides an inadequate understanding of an issue.
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COMMUNICATION 18					
Organization 	Specific introduction and conclusion, sequenced body material, and transitions are clear and consistent. Skillful and cohesive organization.	Specific introduction and conclusion, sequenced body material, and transitions are clear and consistent. Some minor lapses in cohesive organization.	Specific introduction and conclusion, sequenced body material, and transitions are mostly clear but occasionally inconsistent or formulaic. Some lack of cohesion in	Specific introduction and conclusion, sequenced body material, and transitions have been attempted but may be confusing and/or inconsistent. Weak	Lack of specific introduction and conclusion, sequenced body material, and transitions. Highly confusing and inconsistent. No real cohesion.

Group: 20/20 → showed favoritism to a certain company
 Critical Thinking: 28/30
 Communication: 18/20
 Social: 40/40

96

Control of Language 	Uses graceful language that skillfully communicates meaning to the audience with clarity and fluency, and is virtually error-free.	Uses straightforward language that generally conveys meaning to the audience. The language has few errors.	Uses language that generally conveys meaning to the audience with clarity, although it may include some errors (slang, incorrect verb forms)	Uses language that sometimes impedes meaning because of errors in usage.	Uses language that consistently impedes meaning because of errors in syntax, grammar, and mechanics, including punctuation, capitalization,
SOCIAL 40 Discipline Knowledge 	5	4	3	2	1
Social Knowledge Analysis 	Demonstrates sophisticated understanding of the complexity of elements important in the course, whether sociology, social work, psychology, criminal justice, human development,	Demonstrates adequate understanding of the complexity of elements important in the social science course.	Demonstrates partial understanding of the complexity of elements important in the social science course.	Demonstrates surface understanding of the elements important in the social science course.	Demonstrates no clear understanding of the complexity of elements important in the social science course.
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	Demonstrates evidence of adjustment in own attitudes and beliefs because of working within and learning from diversity of communities and cultures. Promotes others' engagement with diversity.	Reflects on how own attitudes and beliefs are different from those of other cultures and communities. Exhibits curiosity about what can be learned from diversity of communities and cultures.	Has awareness that own attitudes and beliefs are different from those of other cultures and communities. Exhibits little curiosity about what can be learned from diversity of communities and	Expresses attitudes and beliefs as an individual, from a one-sided view. Is indifferent or resistant to what can be learned from diversity of communities and cultures.	Expresses unclear individual attitudes or is derogatory towards what can be learned from diversity of communities and cultures.

- Suggested work stop; arrogant
- Lini drawing of individuals
- Good flow chart?!
- Hilarious line drawing

Good answers to

Case Study: Collapse of the Quebec Bridge



Whittem, James M. "A Bridge with Two Tingles." *Liquor Magazine*. 7 Dec. 2012. <https://liquormagazine.com/en/2008/11/a-bridge-with-two-tingles/>

Nathan Warren and Mariah Hart

Background



Morrison-Webster. (n.d.). The history of 'true' Morrison-Webster. Retrieved December 6, 2021, from <https://www.morrison-webster.com/words-at-play/the-history-of-the-world-train>

Era of Growth:

- Industrial Revolution boosted growth
- Rapid development of surrounding areas due to the railway system

Location Requirements:

- Quebec City is the capital of the province of Quebec
- Geographic barrier (St. Lawrence River)

Introduction

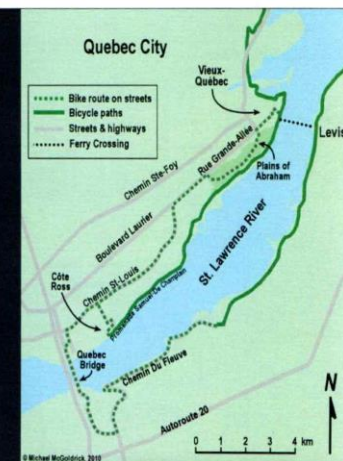
- Quebec, Canada
- First Collapse in 1907
- Second Collapse in 1916



Structurae. (n.d.). *Quebec Bridge (Quebec, 1917)*. Structurae. Retrieved December 6, 2021, from <https://structurae.net/en/structures/quebec-bridge-1917>

Drafting the Project

- Bridge necessity determined
- Selection of Theodore Cooper as leading engineer
- Recommendation of Cantilever Bridge design (submitted by Phoenix Bridge Company)
- Design finalization and project start



Quebec City. Bicycle Map - Quebec City / Levis. (n.d.). Retrieved December 6, 2021, from <https://gobiking.ca/bicy-maps/quebec-city-map.html>

The First Fall

- Cooper's design change
- Continuous construction from 1904 to 1907
- Warping of girders and supports begin to show in summer of 1907
- Head engineer John Dean ignores warping issues presented by inspector Norman McClure
- McClure is sent to inform Cooper in NY
- Cooper and McClure order cease of construction via telegram
- Dean does not relay information to workers
- The Quebec Bridge collapsed 9/29/1907



Quebec Bridge Disaster. The Canadian Encyclopedia. (n.d.). Retrieved December 6, 2021, from <https://www.thecanadianencyclopedia.ca/en/article/quebec-bridge-disaster-feature>

The Second Setback

Changes:

- Bridge design change
- St. Lawrence Bridge Company
- New engineering team
- Cleared debris from river for 2 years before construction

Construction:

- Started construction in 1912
- 1916 the two ends were completed
- Central span was floated down river
- Hydraulic pumps lifted span
- Jack failed, and central span crashed into river

Results of the First

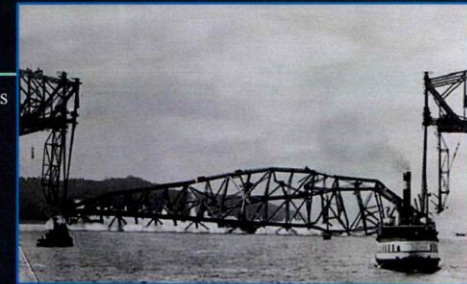
- 70 million tons of steel fell into the river
- 75/86 laborers died
- Royal Commission assigned blame to Theodore Cooper, Quebec Bridge Company, and Phoenix Bridge Company
- Theodore Cooper passed in 1919
- Quebec Bridge Company and Phoenix Bridge Company end



A community's loss: A Community's Loss - Canada's History. (n.d.). Retrieved December 6, 2021, from <https://www.canadahistory.ca/episode/first-collapse/our-memorial-a-communitys-loss>

Results of the Second

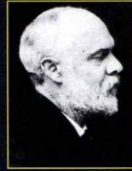
- People fell with bridge; 13 casualties
- St. Lawrence Bridge Company announced their plans to continue construction
- St. Lawrence Bridge Company assumed all responsibility and compensated families of the victims
- A year later, the second attempt was successful



Viglin, Y. (2020, November 1). A Shocking Accident. viglin. Retrieved December 6, 2021, from <https://www.viglin.com/2020/11/a-shocking-accident-occurred-on-the-quebec-bridge-1900-tons-of-steel-fell-the-river-and-75-people-shanty-were-perished>

Ethical Considerations

- ❑ **Theodore Cooper:** wanted a record breaking bridge to end his career, so he altered the design
- ❑ **John Dean:** accused the supplier of giving warped supplies, lied to working staff and inspector, and ignored the order to cease construction
- ❑ **Norman McClure:** held regular inspections, advised to consider stressed material, and met with Cooper to convince him of the dangers of the stress



Cooper, Theodore - jpm.com - portraits - find a historical
December 16, 2021, from
<https://www.jpm.com/portraits>



Conclusion

The first of the two collapses had much more ethical influence, as the motivations of different individuals lead to disaster.

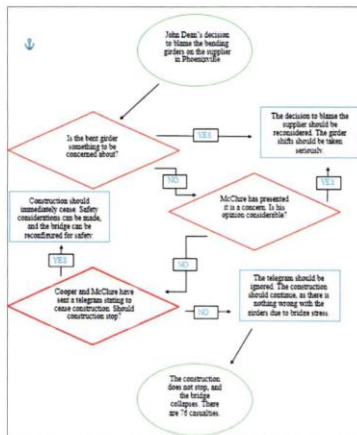
Lessons Learned:

- As engineers, we must be extremely careful in the design process
- Never leave a project of large magnitude in the hands of one person



Dean, C. (2020, May 14). What is active learning? and why it matters.
VirtuSonic Library. Retrieved December 6, 2021, from
<https://www.virtuSonic.com/library/education/active-learning-matters>

<https://www.youtube.com/watch?v=OcfqDPay7zc>



John Dean's Flowchart

- Depicts the possibilities of other options he could have chosen
- Outlines the main choices he made
- Reflects how each of his choices contributed to the fall of the bridge

References

- Whalen, James M. "A Bridge with Two Tragedies." Legion Magazine, 7 Dec. 2012, <https://legionmagazine.com/en/2000/11/a-bridge-with-two-tragedies/>.
- Disasters of the Century. Bad Day HQ. September 21, 2016. Youtube.Com, 2021. <https://www.youtube.com/watch?v=xk1xEtDK0k>. Accessed 5 Dec 2021.

AVERAGE

Kaylan A.
Teylor P.

Quintin Train Derubment
Shill

Social & Behavioral Sciences Core Component Sample Rubric

Group Score
100%

	Capstone 5	Milestones 4 3		Benchmark 2	Lack of Proficiency 1
CRITICAL 24					
Evidence 	Information is taken from source(s) with enough critical evaluation to develop a clear, comprehensive analysis. Viewpoints of experts are questioned thoroughly. Provides full understanding of an issue.	Information is taken from credible, relevant source(s) with enough critical evaluation to develop a coherent analysis. Viewpoints of experts are subject to questioning. Provides solid understanding of an issue with	Information is taken from source(s) with some evaluation, but not enough to develop a coherent analysis. Viewpoints of experts are taken as mostly fact, with little questioning. Provides good understanding of an issue with several omissions.	Information is taken from source(s) without any real evaluation. Viewpoints of experts are taken as fact, without question. Provides a limited or one-sided understanding of an issue.	Information is severely lacking or incorrect. Viewpoints of experts are taken as fact, without question, or may even be misrepresented. Provides an inadequate understanding of an issue.
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COMMUNICATION 16	5	4	3	2	1
Organization 	Specific introduction and conclusion, sequenced body material, and transitions are clear and consistent. Skillful and cohesive organization.	Specific introduction and conclusion, sequenced body material, and transitions are clear and consistent. Some minor lapses in cohesive organization.	Specific introduction and conclusion, sequenced body material, and transitions are mostly clear but occasionally inconsistent or formulaic. Some lack of cohesion in	Specific introduction and conclusion, sequenced body material, and transitions have been attempted but may be confusing and/or inconsistent. Weak	Lack of specific introduction and conclusion, sequenced body material, and transitions. Highly confusing and inconsistent. No real cohesion.

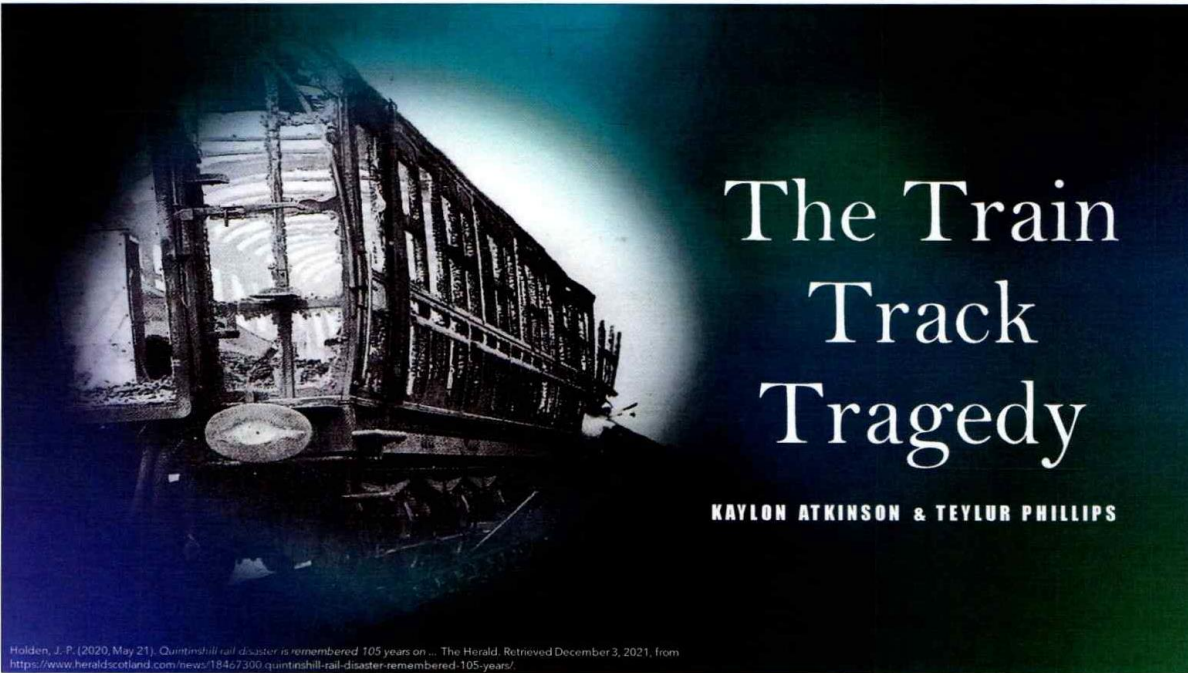
Group: 20/20
Critical Thinking: 24/30
Communication: 16/20
Social: 38/40

88

- 2 trains collides
- Blame the signalman and materials

Control of Language 	Uses graceful language that skillfully communicates meaning to the audience with clarity and fluency, and is virtually error-free.	Uses straightforward language that generally conveys meaning to the audience. The language has few errors.	Uses language that generally conveys meaning to the audience with clarity, although it may include some errors (slang, incorrect verb forms)	Uses language that sometimes impedes meaning because of errors in usage.	Uses language that consistently impedes meaning because of errors in syntax, grammar, and mechanics, including punctuation, capitalization,
SOCIAL 38 Discipline Knowledge 	5	4	3	2	1
Social Knowledge Analysis 	Demonstrates sophisticated understanding of the complexity of elements important in the course, whether sociology, social work, psychology, criminal justice, human development,	Demonstrates adequate understanding of the complexity of elements important in the social science course.	Demonstrates partial understanding of the complexity of elements important in the social science course.	Demonstrates surface understanding of the elements important in the social science course.	Demonstrates no clear understanding of the complexity of elements important in the social science course.
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- Explained 3 minute wait limit for trains.
- Flow chart only contained 2 questions
- What new Technology currently exists to prevent this incident from occurring now?
- You mention that the train should not be built of flammable material?



Overview

Where: Quintin Shill stop

When: May 22nd, 1915, at 6:49am

What: Train crash and fire ; due to negligence of the signalmen and train cars material

People involved: George Meakin , James Tinsley – signalman

Casualties: 226 died and 215 were soldiers

Background

Germany vs Belgium



World War 1 started in 1914

Britain was in control over majority of the railways

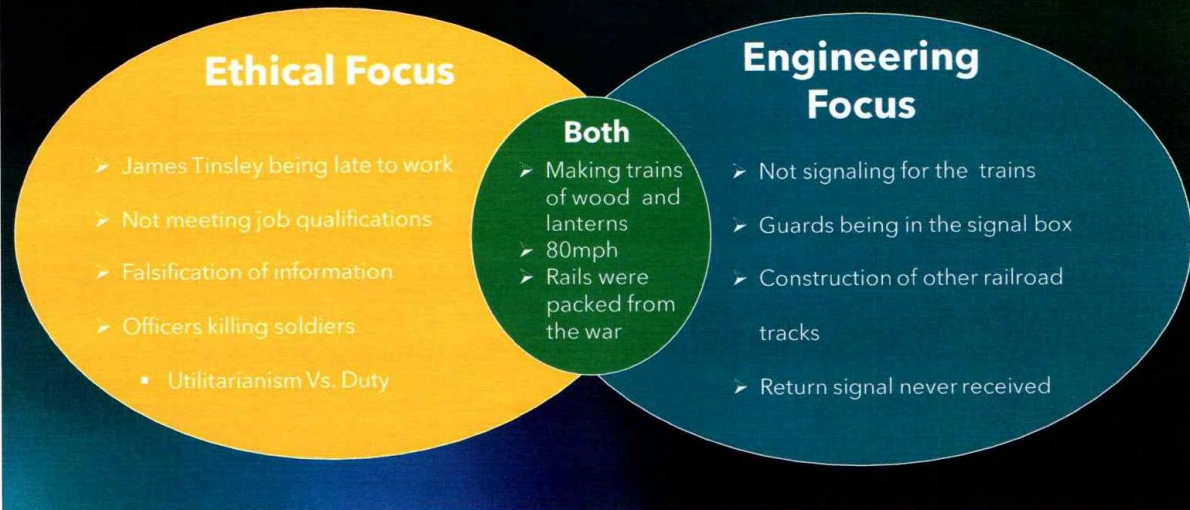
Fastest form of transportation was trains

Britain declares war--Daily Mail Aug 5, 1914.jpg. wikipedia. (2018, September 10). Retrieved December 3, 2021, from https://www.wikipedia.org/wiki/File:Britain_declares_war--Daily_Mail_Aug_5,_1914.jpg.

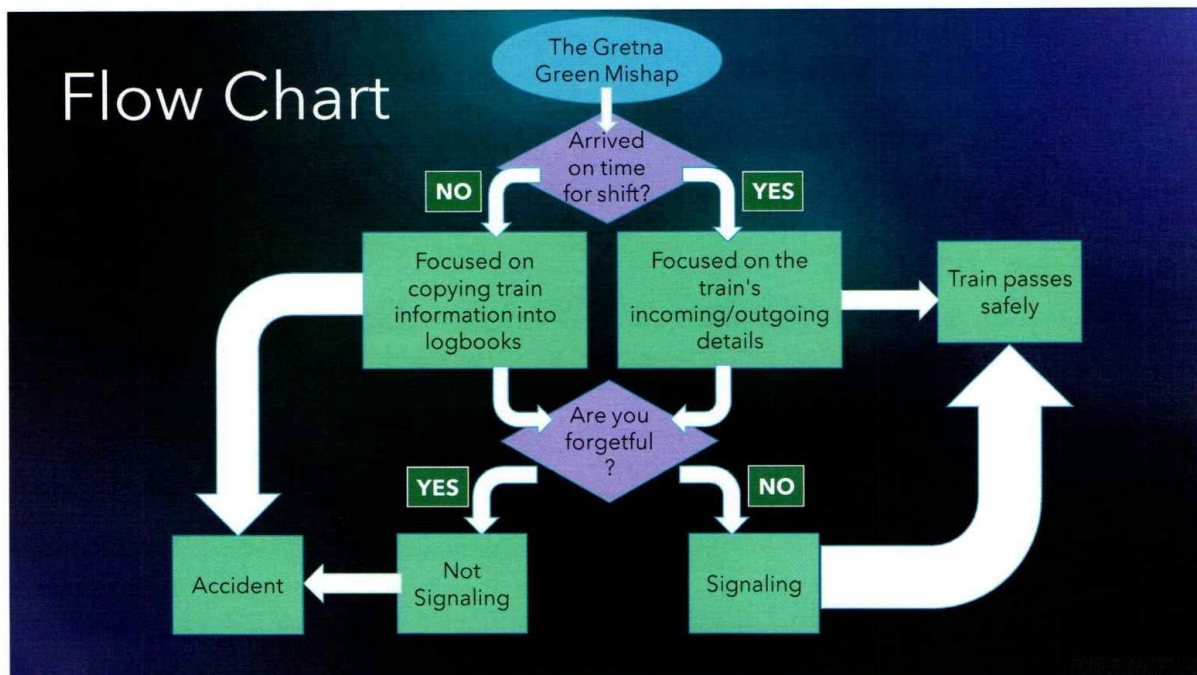


<https://youtu.be/k-b83WX3Xms?t=300>

Ethical Engineering Focus



Flow Chart





Results

- ❖ Signal men were convicted
- ❖ 226 people were killed
- ❖ The train cars were either retired or restored
- ❖ Railway reopened May 25th

Conspiracy theories

- ❖ Was it all a cover up
- ❖ The Caledonian rehired James Tinsley and George Meakin
- ❖ Caledonian railway helping George Meakin while in prison



Fledderman, C. B., & Sanadhya, S. K. (2014). *Engineering ethics*. Pearson. The Quintin Shill Conspiracy : The shocking True Story Behind Britains Worst Rail Disaster

Summary

- ❖ Sometimes doing good things comes at a price
- ❖ Job qualifications are important
- ❖ Engineer like an engineer
- ❖ Safety first

*THE REST
IS
HISTORY*

BELOW AVERAGE

Kaitlin N. Carol A.

Uppan 2000

Social & Behavioral Sciences Core Component Sample Rubric

Group Score

100%

	Capstone 5	Milestones 4 3		Benchmark 2	Lack of Proficiency 1
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Group: 20/20
Critical: 20/30
Communication: 16/20
Social: 34/40

80

Control of Language <i>with</i>	Uses graceful language that skillfully communicates meaning to the audience with clarity and fluency, and is virtually error-free.	Uses straightforward language that generally conveys meaning to the audience. The language has few errors.	Uses language that generally conveys meaning to the audience with clarity, although it may include some errors (slang, incorrect verb forms)	Uses language that sometimes impedes meaning because of errors in usage.	Uses language that consistently impedes meaning because of errors in syntax, grammar, and mechanics, including punctuation, capitalization,
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Attitudes <i>with</i> <i>Worker wasn't knowledgeable about the chemical in silo</i>	Demonstrates evidence of adjustment in own attitudes and beliefs because of working within and learning from diversity of communities and cultures. Promotes others' engagement with diversity.	Reflects on how own attitudes and beliefs are different from those of other cultures and communities. Exhibits curiosity about what can be learned from diversity of communities and cultures.	Has awareness that own attitudes and beliefs are different from those of other cultures and communities. Exhibits little curiosity about what can be learned from diversity of communities and	Expresses attitudes and beliefs as an individual, from a one-sided view. Is indifferent or resistant to what can be learned from diversity of communities and cultures.	Expresses unclear individual attitudes or is derogatory towards what can be learned from diversity of communities and cultures.

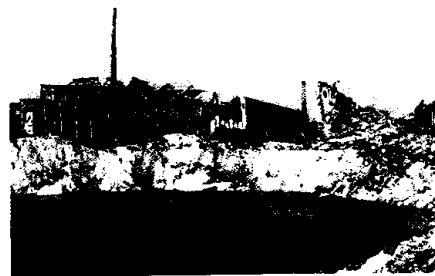
- Explain #2? #9*
- 1) What new technology was developed as a result of this incident? Not sure*
 - 2) How did you determine Intolerable vs. Tolerable? Mixed responses.*



Disaster Background & Brief Summary

What happened?

- On September 21, 1921 a nitrogen fixation explosion set off at an Oppau BASF factory containing 4,500 tons of ammonium sulphate nitrate. The explosion resulted in 561 deaths, 1,952 injured, and left over 7,500 nearby residents homeless.
- The purpose of the manufacturing factory was to produce nitrogen fertilizers. Unfortunately, due to a lack of knowledge the ammonium sulfate nitrate mixture of two salts: ammonium nitrate (which is explosive) and ammonium sulfate were combined to an unequal ratio and resulted in an explosion. A sprinkler system was not implaced
- After the accident revealed physical parameters such as particle size, density, water content, homogeneity of crystal structure influenced the scene.



Source: Horcher, U. (2016). Oppau 1921: Old Facts Revisited. Chemical Engineering Transactions . Retrieved 2021, from <https://www.aidic.it/cet/16/48/125.pdf>

Source: Horcher, U. (2016). Oppau 1921: Old Facts Revisited. Chemical Engineering Transactions . Retrieved 2021, from <https://www.aidic.it/cet/16/48/125.pdf>.

Who was responsible?

- Herman Humppa's lack of knowledge, unsafe proximity to the community, and safety equipment.
- The Silo drying/storage was made of wood back in the 1920's with a concrete foundation and contained both salts.

Source: Horcher, U. (2016). Oppau 1921: Old Facts Revisited. Chemical Engineering Transactions . Retrieved 2021, from <https://www.aidic.it/cet/16/48/125.pdf>.

Table 1: Results of the explosion tests of "Chemisch-Technische Reichsanstalt Berlin"

Parameter	Influence of Parameter on sensitivity to detonation impact	Influence of spray process on parameter
Particle Size	Increased by smaller particle size	Particle Size is smaller
Density	Increased by lower density	Density is lower
Strength of Confinement	Increased with increasing strength of confinement	No influence
Brisance of booster charge	Increased with increasing strength of booster charge	No influence (the same cartridges were used as before the process change)
Water content of mixed salt	Increased with decreasing water content	Water content is lower (4 % before vs. 2 % after process change)



<https://oldimagesrystone.blogspot.com/2013/09/cement-silos-k-andos-pre-1921.html>

Timeline of Events:

- Before the WWI, a German chemical plant company called BASF created the first nitrogen Fertilizer factory constructed on May 19, 1916 and began to run on April 1917.
- 1914- Ammonium nitrate started to be added into a factories repertoire. It was key for explosives in the German war.
- Build up was created from the product they produced. Dynamite was used to clear build up as it could not be cleaned manually.
- Before the accident about 20,000 blasting operations were carried out without any notable incidents.
- In mid-1921
- 1921- The morning of September 21 the same method used for clearing build the build created a mass tragedy. They assumed the dynamite set off one of the mixtures that had a higher concentration of ammonium nitrate.

Video:

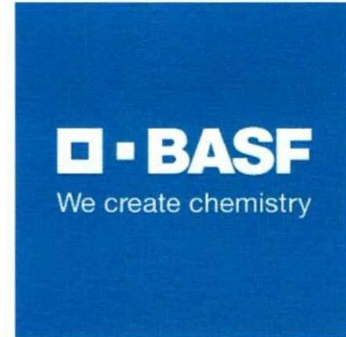


Resources:

<https://devastatingdisasters.co>
<https://devastatingdisasters.com/oppau-explosionm/oppauxplosion>
<https://youtu.be/56NKS9RzhU0>

Ethical Reasons

- The BASF plant in Oppau portrayed recklessness and negligence.
- The factory used an unsafe method to clear build up from products.
- The lack of attention of the measurement of the ammonium nitrate levels throughout the plant resulted into the explosion which caused this mass tragedy.



<https://mobile.twitter.com/basf>

Ethical Reasons

- Negligence by the operating team failure to provide proper care/ awareness to safety protocols.
- Company BASF refusing to take responsibility of the incident, but gave money to aid the houses and lives lost.



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Line drawing of the Intolerable/ Tolerable Risks involved in the Oppau Explosion

- Risks to take to prevent explosions in chemical plants?

Intolerable Risk											Tolerable Risk				
1,2,5,9,13,14				3 6 4			11 P 12 10 15 16 7 8								
1.	Knowledge of chemical safety procedures														
2.	Safety of workers														
3.	Proximity to surrounding population														
4.	Proper use of hazardous chemicals														
5.	Emergency back-up plan/ escape route														
6.	Hazardous exposure to nearby community														
7.	Drawn aftermath explosion plan														
8.	Maintenance to restore ecosystem														
9.	Safety inspection updates/ walk-throughs														
10.	Will cause minimal harm if exposed to population														
11.	Minimal exposure to population/ ecosystem														
12.	Delayed risk of exposure/ evacuation														
13.	Evacuation plan for workers/ population														
14.	If released into the environment the chemical will affect water, land, and air (ecosystem)														
15.	Economic loss 1/2 of company														
16.	Will cause short term injury/ harm to workers on site														

Line Drawing Explanation

Tolerable risks

- There is a set plan for restoring the land and housing loss for when an explosion takes place.
- Only minimal damage will happen to the company losses, health of the people population, and the effect it has on the environment.

Tolerable Risk					
12	10	15	16	7	8

P

- Only allowing minimal damage to the surrounding area that can be restored within a decade.

Intolerable

- Ensuring proper safety procedures of the people, workers, and ecosystem.

Intolerable Risk

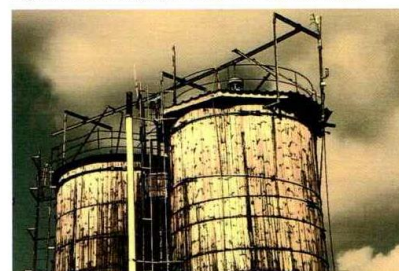
1,2,5,9,13,14	3	6	4
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Ethical Results from Explosion Aftermath

- Know the chemicals in the chemical plant
- Ensure safety and PPE for everyone within the plant
- Ensure everyone in the plant has knowledge of the chemicals and how to properly handle them
- Have emergency routes and plans for restoring the environment/ people if a catastrophic event were to occur
- Ensure chemicals are dealt with accordingly to their physical properties
- For toxic and large quantities of chemicals, ensure the plant is located far away from nearby communities



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.reddit.com%2F%2FMilitaryForm%2Fcomments%2F2n4dz%2Fspanish_civil_war_land_mine_explosion_at_the_ca%2F&imgref=ACvVaw36CCMLUK87dfo0BMWVv87Z&ust=1538910553666000&source=images&cd=vfe&ved=0CAsQJRxqFwoTCOU-5KI0PQCFQAAAAAAdAAAAAD



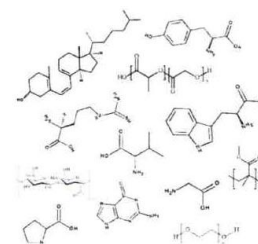
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Final Summary

- Our ethical conclusion shows that the entire incident could have been avoided if the explosives manager Herman had a better understanding of the chemical composition of ammonium sulfate and nitrate.
- If Herman had enough research about the changes involved with ammonium if it is stored by the tons, then he would have known not to ignite the settlement and avoid the entire explosion.
- Advice to future and existing chemical plants is to insure before any production that the entire engineering and management staff, etc. knows in depth about the chemicals they are working with.
- For example: the storage conditions, temperatures, quantity, density, volume, chemical changes, packaging, etc.



<https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.outpost.co.uk%2Fstock-photos%2Fwarning-explosive-symbol-sign-image-122162.html&imgref=ACvVaw36CCMLUK87dfo0BMWVv87Z&ust=1538910553666000&source=images&cd=vfe&ved=0CAsQJRxqFwoTCOU-5KI0PQCFQAAAAAAdAAAAAD>



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