What Actions Can We Take to Avoid Catastrophes        Qingyang Su

The most important canon of Engineering Ethics, according to what I learned in the Engineering Problem Solving I class, is try our best to protect the safety, health and welfare of the public. However, as Henry Petroski wrote in his article “Failure Is Always an Option”, all inventions could be full of failures, which means engineers have to consider many kinds of potential catastrophes that may or may not happen. Unfortunately, these tragedies happen from time to time and serve as warnings to engineers to be more cautious of every detail. As I learned in the Engineering First Year Seminar, the most likely reason for the failure of engineers is their overconfidence.

On August 1st, 2007, one of the busiest bridge roads in Minneapolis, Minnesota collapsed, and the middle section of the bridge fell into the river, which caused 111 cars on the bridge to drop into the river from the broken bridge. Thirteen people died and 145 people were injured from the accident (National Transportation Safety Board, 2007). This great disaster caused shock all over America and warned, not only engineers, but also people from all career areas. This accident was a tragedy from which we can learn important engineering lessons. We need to learn from this event to prevent us from repeating the same mistake of sacrificing quality work for a lower cost.

After the investigation, the National Transportation Safety Board came to a conclusion that it was the original bridge design that caused the tragedy (National Transportation Safety Board, 2007). They pointed that the gusset plate, which is a thick metal plate that is used to fixed several beams and trusses at a joint point so that the joint will not move and can hold more weight, was too thin to withstand the weight on the bridge, and after the metal plate was destroyed because of the overload, the bridge collapsed (Iowa Dot, n.d.). As we know from Newton's third law, the force that the vehicles exert on the bridge and the supportive force that the bridge supports to the vehicles are a group of action and reaction forces. These are mathematically equal to the total weight of the cars on the bridge because the forces are in equilibrium, meaning the bridge is not in motion. The weight of the vehicles on the bridge is referred to as the gravitational force $G_v$ and the supportive force from bridge is normal force N, shown in the free body diagram in Figure 1. When the gravitational force outweighed the normal force, the bridge collapsed.

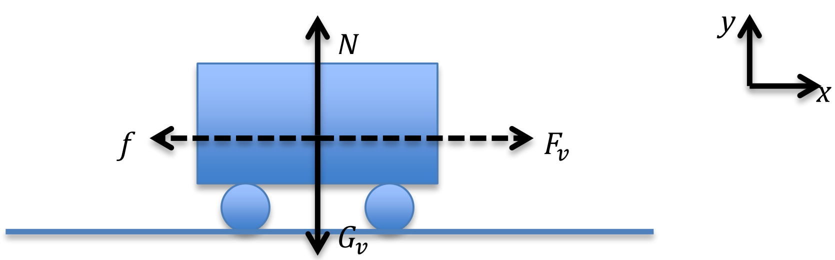


Figure 1: the free body diagram of the force acting on one vehicle

In this analysis, only the vertical forces, the y components, are taken into consideration. In order to keep the bridge in a stable state, all forces in the y direction need to be equivalent. As a result, the force that the vehicles act on the bridge should equal to the normal force of the bridge. And when the weight of the vehicles is bigger than the normal force the bridge can support, the bridge will collapse.

For this particular case, the bridge collapsed because the gusset plate was too thin to hold the weight of the bridge and weight of cars on the bridge. As shown in Figure 2, the pin was subjected to too much pressure from the weight of the bridge and the cars, causing the pin to split into two parts. Without the support of the pin, the gusset plate was bent and could no longer support the extra weight of cars and the bridge that used to be supported by that pin, and the weight being supported was applied to the rest of the bridge, which caused the bridge to fail.

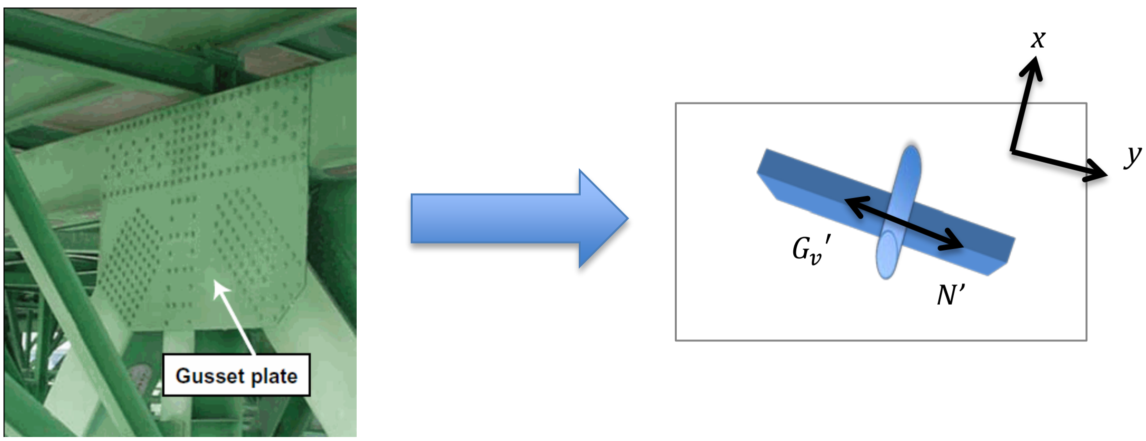


Figure 2: the gusset plate of the old Minneapolis I-35W Bridge
(National Transportation Safety Board, 2007)
And the side view of the plate and one of the pins

Similar to the analysis above, only the forces on the y component are taken into account since the perpendicular forces on the x component have nothing to do with the plate. The force $G_v$ is distributed to several small pins on the gusset plate. Suppose that the force that each pin applies to the gusset plate is $G_v'$ and the force that the gusset plate applies to the pin is N. In this case, the pressure that the plate withstands is equal to the force $G_v'$

divided by the contact surface area between the plate and the pin (call it S). If the engineers who designed this bridge had chosen a thicker plate, which would mean that the area S would become larger, it could have resulted in less pressure acting on the plates with the same force and a big disaster might have been avoided.

Alternately, if the engineers had chosen a larger gusset plate so that more pins could distribute the total force $G_v$ so that $G_v'$ became smaller, the tragedy might have been avoided. In this case, when computing the pressure exerted on the gusset plate, $G_v{}'$ divided by the contact surface area S, the pressure becomes smaller, and this pressure might have been small enough to be held by the gusset plate. Another possibility that could have avoided this failure would have been if the design engineer had chosen another different but more solid material for the pin. In this case, though the pin would still have the same relatively big pressure from the gusset plate, by using a more solid pin, the pin would be strong enough to hold the big pressure from the gusset plate. Any of these improvements could have been made to save thirteen lives.

Since we now have discussed three alternative methods to improve the bridge, it seems like it would have been very simple to prevent the failure. Therefore, when we look deeper into this issue, the statics design error is not the only reason the tragedy happened. The URS Corporation, the company that was responsible for building the bridge, failed to examine the bridge regularly and used thinner gusset plates to save costs; this is probably the main reason that directly caused the tragedy (Karnowski, 2009). What surprised me is that there is a photo post on the MPR news website taken in 2003, four years before the bridge collapsed, which showed that the gusset plate was bent. However, none of the maintenance or precautions were taken even after the URS Corporation held an internal meeting in 2005. The only conclusion they drew was that there would be no danger to the bridge even though the gusset plate was bent (Karnowski, 2009). I do not know why they came to this decision, but it is obviously questionable. I felt so shocked about what an engineering company did to save money. They used thin gusset plates but did not check them regularly. They figured out the problem, but did not require any changes just because they thought it would cost too much to fix it. If they had had a little conscientiousness or a sense of social responsibility, they would never have let it happen.

As far as I am concerned, the more powerful a person or corporate entity is the more responsibility that person or entity has to society. Society can only develop stably if the people who have strong knowledge are willing to contribute to the wellbeing of the public. Had the engineers in the bridge company who took charge of the bridge been more concerned with the safety of the public, they would have used thicker gusset plates instead of the thinner ones; had they hired people to inspect the bridge as other bridge companies usually do or stopped the cars from passing through and repaired the bridge, the tragedy would never have happened. I hope everyone, not only engineers but also people in all kinds of careers, no matter whether they are managers or staff in a small company, can learn something from this event, and I wish similar disasters would never happen. Only if everyone makes his own effort and uses conscientiousness to treat society well instead of focusing on money and reputation, can my wish come true.

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