Bridges are important to our nation’s roadway network. They can connect two places together that would otherwise be set apart by a large depression in the earth. Bridges require an extensive set of calculations to ensure that a failure will not occur. Unfortunately, these failures sometimes occur, and when innocent lives are lost, the engineer is responsible. Although bridges are designed to be safe, failures can occur due to design flaws, live wind loads, and manufacturing defects.

Poor design of a bridge can lead to an unexpected collapse. An example of a faulty design leading to a catastrophic collapse occurred on August 1, 2007, when the Interstate 35-W Bridge fell into the Mississippi River in Minneapolis, MN. The failure occurred in the main span of the deck truss around 6:05 p.m., and as a result, a 1000-ft long section of the truss collapsed, killing thirteen people and injuring 145 others. The National Transportation Safety Board concluded that the most probable cause of the collapse was an inadequate load capacity. This was due to a design error of the gusset plates at the U10 nodes. These plates failed due to increased weight of the bridge from previous modifications, as well as concentrated live loads from construction and traffic on the day of the collapse. The picture below shows the main deck truss about two hours after the collapse:
Also contributing to the collapse were quality control procedures that failed to give adequate attention to the gusset plates. The gusset plates were not checked for distortion, and the plates were not used in analyzing load ratings.

Wind loads are causes of bridge collapses, even if the wind is not very strong. The most famous example of a bridge collapsing due to wind in the United States is the original Tacoma Narrows Bridge in Tacoma, Washington. The bridge was a suspension bridge and was known as the most advanced suspension bridge at that time. The bridge collapsed on November 7, 1940, just four months after it was opened. Turbulent winds of 40 miles per hour were the cause of the failure. Further investigation showed that the bridge had too much flexibility. The deck was too light and too narrow, and the side spans were too long compared to the center span. The bridge started moving in vertical waves, but then it started to move in a twisting, torsional motion. The cable band on the north cable slipped at mid-span, which caused the north cable to split into two unequal lengths. This transferred to the light girders, which started to twist and cause failure moments later. The picture below shows the bridge collapsing:

![Bridge Collapse](image)

The investigation showed that the bridge had poor aerodynamics, and engineers needed to better understand aerodynamics in the future design of long suspension bridges.

Manufacturing defects have been known to create some of the largest bridge collapses in United States history. Most of the time, a defect is not found until the actual collapse takes place. One of the most famous examples of manufacturing defects in a bridge was found in the Silver Bridge over the Ohio River on December 15, 1967. The bridge was located near Huntington, West Virginia and was the major bridge connecting the city to Ohio. The collapse occurred during rush hour, around 5:00 p.m., killing 46 people and injuring nine others. A fracture in one of the eyebars that held up the bridge occurred when a substantial amount of traffic was stopped on the bridge. The fracture was a result of stress corrosion and fatigue, which were two problems not known when the bridge was constructed in 1927. Stress corrosion is corrosion that occurs internally.
The steel used in the bridge was carbon steel, which had a tendency to crack. The crack in the eyebar was only 0.1 inches deep, and it broke in a brittle fashion. The load was transferred to the other side of the eyebar, which failed because of too much load. Even if the bridge were around today, the flaw still would not have been detected unless the bridge was completely taken apart and tested. The picture below shows the bridge after it collapsed:

![Bridge Collapse](image)

The result of the collapse was the creation of more intensive inspection methods and the replacement of bridges similar to this one. The St. Mary's bridge, which was located just upstream from the Silver Bridge, was designed in a similar fashion and was later demolished.

Bridges are designed to have a high safety factor to prevent unexpected collapses from occurring. Although much time and resources are put into the design of bridges, failures still occur. It is up to the engineers to find new methods of bridge design that eliminate flaws, increase resistance to wind, and ensure that the problem is addressed in the parts manufacturing stage instead of the construction stage.
List of References

