The Failure of the Schoharie Creek Bridge

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The Schoharie Creek Bridge was built in the early 1950s as part of a new superhighway spanning the entire state of New York. The bridge was constructed of five spans supported by four piers, each composed of two columns that rested on lightly reinforced plinths—larger rectangular sections of concrete that acted as a stronger base for the structure— which were placed on shallow spread footings that were intended to be reinforced by loose stone, called riprap. Unlike piers two and three, piers one and four were on the banks of the creek, where the water didn't reach and couldn't cause scour—the washing away of loose ground or material—around their bases. Piers two and three were placed in the creek itself, exposing them to the greatest force of the flowing water (see Figure 1). About thirty years after the bridge was finished, in the fall of 1987, most of the bridge collapsed during a large flood, killing ten people (Storey, 2003). Pier three fell first, bringing down spans three and four of the bridge and triggering a change in water flow that, when combined with the bridge's other structural problems, brought down pier two only half an hour later (Barker, 2013). The tragedy caught the attention of many news sources and investigations were conducted to determine what had caused the bridge to fall. Through these investigations, flaws were found within the initial design of the bridge, the construction of the bridge, and the maintenance of the bridge over its thirty years of use (Storey, 2003). The presence of any one of these problems alone in a structure is enough to make it unstable, but when all three of them are added together, as seen in the Schoharie Creek Bridge, the results can be catastrophic. Engineers can learn from these catastrophes to better prepare for the effects that nature, especially erosion due to water flow, will have on their designs.

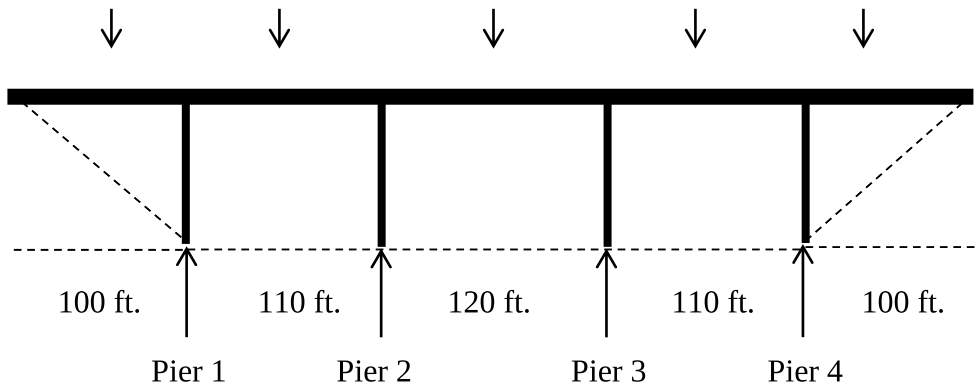

Figure 1. The original structure of the Schoharie Creek Bridge.

The designers' primary failure was in their prediction of the magnitude of the effects water flow would have on the base of the bridge, leaving it vulnerable to the scour that eventually compromised the integrity of the foundation. The design called for footings to be buried in a deep layer of stone and covered by metal sheeting and riprap. However, when the design was executed, the plinths were very shallow and the foundation was filled primarily with erodible soil instead. Also, the sheeting was never put in place (O'Brian, 2012). Because the builders of the bridge chose to deviate from the original plan, whether due to time or monetary constraints, there was very poor protection of the bridge's foundation, which allowed flood waters to easily wash away the loose soil (Storey, 2003). As erosion occurred under the piers of the bridge, the amount of force pushing downward on the pier became more than the amount of pressure that the foundation was able to exert upwards, causing the concrete base to sink down and crack. This uneven sinking movement shifted the spans above off of their supports, crashing them down into the water, further displacing the original piers (Bell, 2008) (see Figure 2).

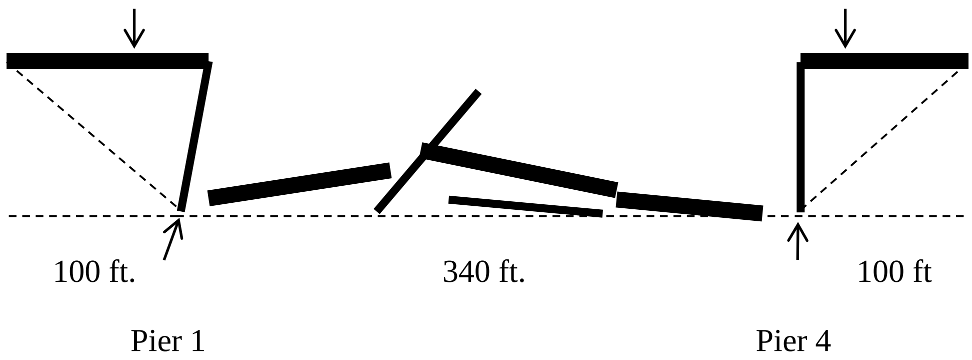

Figure 2. The Schoharie Creek Bridge structure after its collapse after the 1987 collapse.

In addition to the problems that existed with foundation of the structure, there also appeared to be issues with the initial version of the plinths that supported the piers. Soon after the bridge opened, nearly vertical cracks began to form in the concrete of the plinths. These cracks were attributed to high tensile stresses, which are stresses that tend to elongate the body along the direction of the applied force, within the plinths due to their inability to resist bending stresses between the columns that they supported. These bending stresses are internal stresses developed in response to curvature of the beam caused by the application of external force. A fairly basic reinforcement was placed on the lower plinths, using dowels as studs to transfer the bending stresses to the reinforcements instead of the plinths themselves. Unfortunately, as the reinforcement did not continue into the columns, it did little to increase the strength of the structure (Swenson, 1991). In order to make a more effective reinforcement and to avoid the cracking of the plinths that added to the failure of the bridge, they would have needed to extend the supports up into the columns and potentially provide support at the top of the columns. In fact, the poor anchoring of the reinforcement that was placed may have actually caused the plinths to become more fragile (Storey, 2003).

The flaws within the initial planning and construction of the Schoharie Creek Bridge were not the only things that contributed to the failure of the structure. The National Transportation Safety Board determined that the New York State Thruway Authority had failed to maintain an adequate amount of riprap around the foundation of the bridge over the years, allowing the soil to be washed away and the foundation to become compromised (National Transportation Safety Board, 1987). Furthermore, a massive flood had occurred back in 1955, washing away some of the riprap only a year after the bridge had been constructed. An engineering firm consulted in 1977 advised that this riprap should be replaced in order to maintain the strength of the structure, but it never was. However, the inspections of the bridge by engineering firms that occurred in the following years showed it to be in good condition. This was clearly not the case as, if it were, the bridge should not have collapsed during a flood that was of lower magnitude than the one that had occurred earlier. There was, and there still remains, some speculation as to the quality of the inspectors that oversaw the bridge back then (Barker, 2013). If the inspectors had been of higher caliber, perhaps the problems with the design of the foundation would have been uncovered earlier and the tragedy never would have transpired.

It is not the responsibility of engineers to perfectly predict the different events and variables that may affect and threaten their creations, like perfectly predicting the amount of scour that would occur during two oddly severe floods. It is, however, the responsibility of engineers to make reasonable predictions based on the data that they have to minimize the effects of those events and variables on their creations and make assessments after the fact in order to combat and learn from them. Engineers were responsible for the designing, building, and inspections of the Schoharie Creek Bridge and yet the structure failed. While this event was disastrous, causing the loss of ten lives, it provided an opportunity for engineers to learn from their mistakes and make steps forward in the construction of more effective and structurally sound bridges. When the bridge collapsed back in 1987, the engineers that had constructed and inspected the bridge were confused, insisting that it should have withheld the flood (O'Brian, 2012). Only after inspecting the wreckage did they discover all of the flaws in design, construction, and maintenance that had occurred (Highway Accident Report, 1987). As stated by Petroski in his article, this is often the case, where engineers must act like scientists to uncover the flaws within their own blueprints after their failure (Petroski, 2003). This isn't meant to excuse the errors that were made, but rather to improve upon them so that the designers of the future may not make the same mistakes. Through these investigations, different suggestions were made as to the most effective way to combat the issues that had brought down the bridge, like scour and tensile stresses, helping to improve future bridge designs.

There is a lot of pressure on engineers to get things right, both by themselves and those around them. Overall, engineers did not fail in the creation of the Schoharie Creek Bridge, but they did fail to maintain and improve it when inspectors and physical cracks in the bridge warned that improvements needed to be made. By doing so, they let down themselves and those who came into contact with the bridge. To avoid tragedies like this in the future, there need to be proper channels of communication between inspectors and engineers so that both parties may confirm the safety of buildings and similar constructions before their use by the public. Nevertheless, if similar disasters do occur, the engineers who had a hand in the creation and maintenance of the structures should be held responsible for their role in the occurrence of flaws that may have led to their failure and should work to make amends, both by analyzing what went wrong and by making strides to correct their errors.

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