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I-35W bridge was doomed from the start

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Original designers of the Interstate 35W bridge in Minneapolis likely neglected to calculate the size of key gusset plates that eventually failed, a human mistake that culminated 40 years later when 13 people died after the span collapsed, federal safety investigators have found.

They also have determined that corrosion of certain gusset plates, extreme heat and shifting piers did not contribute to the bridge's collapse on Aug. 1, 2007, according to sources with direct knowledge of the probe. In three weeks, investigators will present their findings to the National Transportation Safety Board (NTSB), which will publicly review the draft report in a hearing Nov. 13 at the board's Washington headquarters. After that, the board will use the draft as the basis for its final report on the probable cause of the collapse and recommendations for preventing future disasters.

Had key steel gusset plates been designed properly -- they were one-half inch thick instead of an inch -- the bridge would have been able to withstand tons of concrete and steel added in two renovation projects as well as the 287-ton construction load on the bridge the day it collapsed, sources said.

In January, NTSB Chairman Mark Rosenker was criticized by U.S. Rep. Jim Oberstar, D-Minn., and others for placing too much early emphasis on gusset plate failure as the potential cause. But the investigators' findings appear to validate Rosenker's early stance.

The safety investigators found records showing that the bridge designers knew how to calculate the thickness of gusset plates, but probably did not perform that task for the bridge's center portion, where the initial failure occurred. Investigators leave open the possibility that the design firm, Sverdrup & Parcel, carried out the calculations but erred. That assessment is based on a review of the original work papers of the St. Louis-based firm, which was later acquired by Jacobs Engineering of San Francisco.

In January, a little-noticed research paper by the Federal Highway Administration concluded that the so-called U-10 gusset plate connections -- the same joints that investigators say were the first to fail -- were the only gusset plates on the bridge that were undersized.

In that report, government engineers recalculated the correct thicknesses required for each gusset plate. The comparison to the actual thicknesses showed that the U-10 gussett plates were the only plates on the bridge that were "Inadequate -- No Good."

Gusset plates are crucial in fracture-critical bridges such as the I-35W bridge that spanned the Mississippi River because they join together load-carrying beams that intersect at different angles. In fracture-critical bridges, a failure in one beam or gusset plate can cause a complete collapse.

On Jan. 15, Rosenker provided an update on the investigation of the collapse. At that time he said: "There was a breakdown in the design review procedures that allowed a serious design error to be incorporated into the construction of the I-35W bridge ... Because of this design error, the riveted gusset plates became the weakest members of this fracture critical bridge, whereas normally gusset plates are expected to be stronger than the beams they connect."

Now investigators are expected to tell board members that nothing could have prevented the collapse short of an engineer noticing the design deficiency and correcting it, sources said.

Gusset guidelines lacking

The chances of that discovery were diminished, investigators found, because the U.S. bridge industry's practice was to accept original designs without question. Also, before the bridge collapse, government and industry lacked guidelines and training for inspectors and supervisors to detect subsequent weakness in gusset plates.

In January, federal authorities issued an emergency set of corrective orders after the NTSB first discovered the lack of scrutiny.

Under previous standards, there weren't even protocols for designers and engineers to recalculate the capacity of gusset plates when tons of structural weight were added to a bridge, investigators found. For that reason, the Minnesota Department of Transportation, as well as federal transportation authorities, did not adequately scrutinize gusset plates on the bridge when another layer of concrete decking, median barriers and railings were added in 1977 and 1998, sources said.

At least four years before the collapse, the ill-fated gusset plates in the bridge's center span were visibly bowed or bent, investigators are expected to tell the board. MnDOT consultants photographed the distortions, and those images were filed in the MnDOT Bridge Office without triggering any correction. The sources said the bowing resulted from plates that were too thin and increasing weight loads.

Industry-standard protocols that lacked specific references to gusset plates limited the quality of inspections on the bridge, even though it received more inspections than required by law, sources said. The safety board will likely be asked to make recommendations for new controls to be developed through the American Association of State Highway and Transportation Officials, a standards group affiliated with the federal government and all 50 states.

The investigators' findings eliminated several areas of concern as likely causes. On the day of the collapse, much of the construction load, including tons of sand, gravel and repaving equipment, was located on the center of the bridge -- above the gusset plate connections that were the first to give way, investigators found. The investigators are expected to tell safety board members that the collapse was triggered when the U-10 gussets plates -- likely U-10 West -- gave way above the river's west bank, sources said.

Corrosion on gusset L-11

Just below the U-10 gusset plate connections, a connection known as L-11 had been badly corroded since at least 1993 and no repairs were ever made, according to MnDOT inspection reports. But safety investigators have ruled out the corrosion damage at L-11 as a contributing cause to the collapse, the sources said.

Likewise, investigators are expected to tell the board that the collapse had nothing to do with physical conditions that had earned the bridge a rating of "structurally deficient." Those conditions included corrosion, deteriorated roller bearings, cracks in the approach spans, tilted piers and missing or broken bolts.

Over the years, MnDOT had paid consultants to study the physical integrity of the bridge, partly because the department's bridge engineers were worried about possible cracking in fatigued metal. Finally, during the winter of 2006-2007, MnDOT seriously considered a plan to retrofit the bridge by bolting steel plates to its beams. But the plan was scrapped because it was believed that drilling thousands of holes in the beams to add reinforcement plates could actually weaken the structure.

The sources said investigators are expected to recommend new inspection, training and design review standards focused on gusset plates. The most commonly used bridge management system in the United States, including Minnesota, doesn't include gusset plates as a separate bridge inspection element.

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