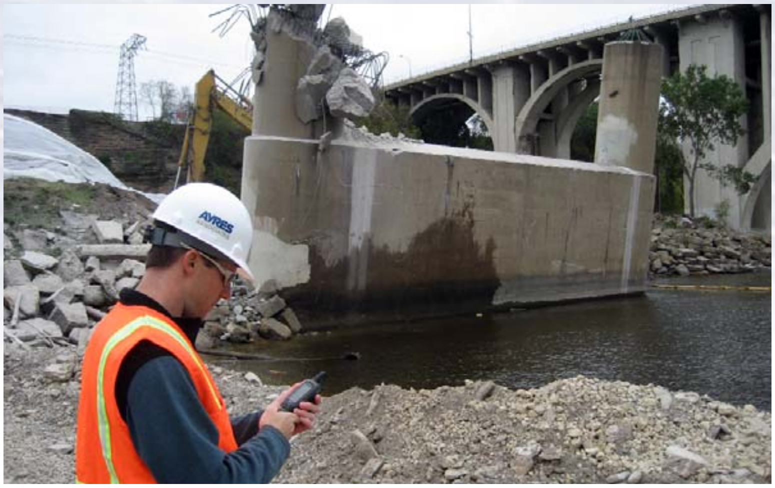
Calming the Waters:

Hydraulic analysis marks start of rebuilding after bridge collapse

By Tawny Quast

The remains of the I-35W Bridge shortly after the collapse.



On August 1, 2007, the I-35W bridge over the Mississippi River in Minneapolis, Minnesota, catastrophically failed, killing 13 people and severing a vital link in the Minneapolis-St. Paul transportation network. As cleanup was under way and investigators searched for the cause of the collapse, the Minnesota Department of Transportation (Mn/DOT) quickly began to focus on rebuilding, knowing how critical it was that traffic flowed smoothly as soon as possible.

Toward this goal, Mn/DOT selected the design-build team of FIGG and Flatiron-Manson Joint Venture for this task. Ayres Associates joined the team as a subconsultant to conduct a hydraulic and scour analysis and provide support during construction. Facing intense public scrutiny, Mn/DOT set an aggressive timeline of December 24, 2008, to have the bridge completed and open to motorists.

Typically a bridge of this magnitude would take years to design and build, said Alan Phipps, senior vice president for FIGG. But time was of the essence. “It was critically important to the transportation system to get the bridge in place and functioning as soon as possible,” Phipps said. In the end, the design-build team surpassed expectations, and the bridge opened on September 18, 2008, three months ahead of schedule and just 11 months after construction began.

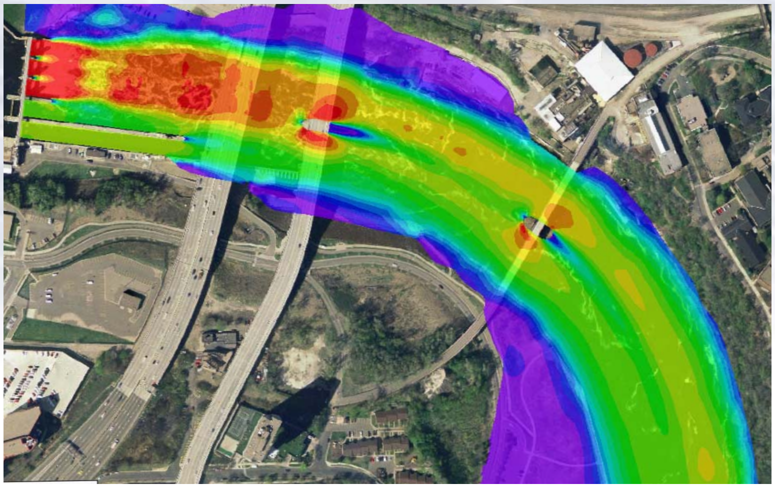
All members of the design-build team contributed to this achievement, including Ayres Associates, whose role in the hydraulic and scour analysis was an essential early component of the project. “The hydraulic analysis was a critical schedule element,” Phipps said. “We needed to complete the design quickly, and this was one of the earliest phases.”

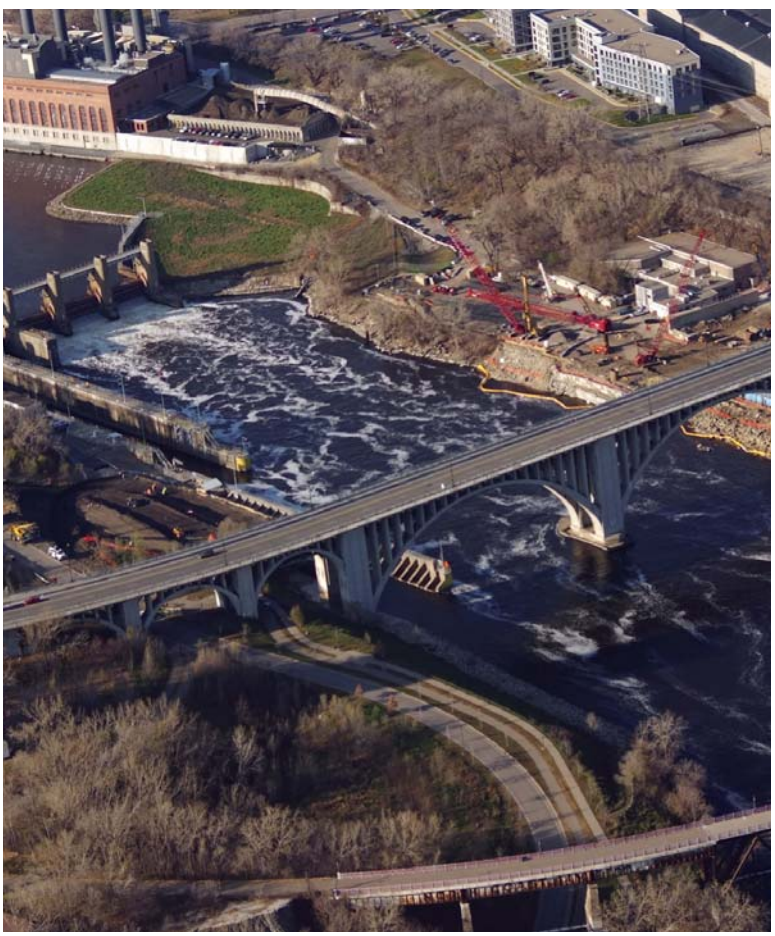
Ayres Associates has a history of working with FIGG on major bridge projects, including the Great River Bridge feasibility study over the Mississippi River upstream of Memphis, Tennessee, and the Fourth Street Bridge over the Arkansas River in Pueblo, Colorado. Phipps said when his firm was building a team for the I-35W Bridge project, there was no doubt it wanted Ayres Associates on board. “We knew we needed hydraulic analysis for this job, so we called Ayres Associates. They have an excellent national reputation,” he said.

The hydraulic analysis was necessary for several reasons. First, the analysis determined if the new bridge would cause a rise in the water surface during a 100-year flood. The design team also

Water resources engineer Dusty Robinson evaluates the conditions of the collapsed bridge, examining the bridge’s old pier, which was being removed.

The new bridge provided much-needed relief to the Minneapolis traffic system.





needed to demonstrate that the I-35W Bridge would not have negative impacts on nearby structures, including the downstream 10th Avenue Bridge, a nearby storm tunnel, or the adjacent U.S. Army Corps of Engineers (USACE) lock and dam facility. Finally, it provided information that was used in the scour analysis performed by Ayres Associates.

Ayres Associates engineers used HEC-RAS modeling, a 1-dimensional computer modeling program, to determine the bridge's impact on the water surface, said Lyle Zevenbergen, manager of river engineering in Ayres Associates' Fort Collins, Colorado, office. To perform this modeling, engineers modified the HEC-RAS model previously prepared for this section of the river by adding the new bridge.

Staff engineer Dusty Robinson used detailed survey and land use data to develop a complex 2-dimensional computer model, which gave an accurate depiction of the flow velocity and flow depth throughout the area. Ayres Associates relied heavily on data provided by Mn/DOT and the USACE, St. Paul District, to assist with the modeling effort, including the existing HEC-RAS model, mapping, survey data, and bridge plans from the failed bridge. "Without this data provided by the Corps and Mn/DOT, it would not have been possible to get this modeling done as quickly as we did," Zevenbergen said.

Ayres Associates then conducted a scour analysis for the new bridge. Bridge scour occurs when water flowing past a pier or abutment washes away sand, gravel, and the weak sandstone bedrock, leaving what are called scour holes, which can compromise the integrity of the bridge. The scour analysis determines how deep the scour will get, which in turn tells designers how deep the bridge's foundation needs to be, Zevenbergen explained. The scour depth is affected by the pier size and geometry, flow depth, and the velocity magnitude and direction.

"Many factors added to the complexity of this particular scour analysis," Zevenbergen said. "For one thing, the old bridge pier was only going to be partially removed, and keeping this in place contributes to scour." The more of the old pier that

Top: Ayres Associates used 2-D modeling to show flow velocity of the water surrounding the bridge location. The red color represents high velocity. Bottom: The hydraulic analysis showed that the new bridge would not adversely impact the adjacent lock and dam facility, middle, or the 10th Avenue Bridge, bottom.

was removed, the less scour, but designers did not want to remove more than was necessary. The scour analysis allowed the designers to determine how much of the old pier needed to be removed without causing too much scour on the new bridge pier.

Additionally, one of Mn/DOT's requirements was that the downstream 10th Avenue Bridge pier, which is in the middle of the river just downstream of I-35W, would not be harmed by the new bridge. "The 10th Avenue Bridge is scour critical," said Andrea Hendrickson, state hydraulics engineer for Mn/DOT. "We were very concerned about negatively impacting that bridge." The scour analysis was able to show that the velocity of flow impacting the pier and the potential scour would not change based on the new bridge.

Phipps said he was impressed by how quickly Ayres Associates was able to gain consensus among all stakeholders on the hydraulic and scour analysis, something he said is a testament to Zevenbergen's attention to detail and professionalism. Close coordination was required with Mn/DOT and the Federal Highway Administration to be sure everyone agreed on all the parameters of the analysis.

"Lyle did a great job," Phipps said. "He got the report in, provided technical support during meetings, provided backup information, and was able to get agreement quickly so we could get the foundation in place." In fact, the first test shaft, or foundation, was drilled just 24 days after the design started, a step that is typically being done a year or more after the design begins, Phipps said.

Hendrickson said she was impressed with Ayres Associates' technical ability. "I thought Ayres Associates did an excellent job with a very complex situation," she said. "This was a very high profile bridge, and we couldn't afford to take any risks. Ayres Associates did a very thorough analysis, and we were pleased with the results." ■

Top: Pier No. 2 on the south bank by the lock and dam facility. Middle: A storm tunnel near the new pier increased the complexity of the hydraulic analysis. Bottom: Construction crews put the finishing touches on the new I-35W Bridge, which opened to traffic on September 18, 2008, 11 months after construction began.