

Restoration Project to Preserve, Strengthen Minneapolis' Iconic Stone Arch Bridge

Collins Engineers Inc. Uses Innovative Reality Modeling Technology to Determine Necessary Repairs

Spanning the Mississippi River in downtown Minneapolis, Minnesota, the Stone Arch Bridge is a former railroad bridge-crossing recognized as a National Civil Engineering Landmark. The structure remains an emblematic architectural feature of the cityscape and is one of the most visited destinations in Minnesota. A landmark of the historic milling center of Minneapolis, the Stone Arch Bridge is celebrated as an intrinsic part of the city's heritage.

The bridge accommodated rail trains until the mid-to-late 1970s. In the early 1990s, the bridge passed ownership to the Minnesota Department of Transportation (MnDOT), which converted the 2,100-foot-long bridge into a pedestrian and bicycle pathway. MnDOT hired Collins Engineers, Inc. to assess and restore the structural integrity of the bridge to ensure the viaduct continues to remain a valuable public asset.

"The Stone Arch bridge is 140 years old and requires significant work to ensure the bridge performs well for many years to come," Barritt Lovelace, director of unmanned aircraft systems (UAS), artificial intelligence (AI), and reality modeling at Collins Engineers, said.

A Symbol of Prosperity

The Stone Arch Bridge is located near St. Anthony's Falls, the only natural waterfall on the Mississippi River. Beginning in the early 19th century, the flow from the falls powered many flour milling plants in Minneapolis, quickly turning the Twin Cities into a milling epicenter of the Midwest. But it was the railroad operations brought to Minneapolis via the Stone Arch Bridge that contributed to a further boom in the milling industry.

"The Stone Arch Bridge is a historical icon representing an era of tremendous growth and prosperity in Minneapolis," Lovelace said.

In 1883, railroad tycoon James J. Hill financed the construction of the bridge as a part of the Empire Builder route of the Great Northern Railway, which ran from St. Paul, Minnesota to Seattle, Washington. Grain from the Northern Plains was quickly transported by rail lines into the city for milling, and milled flour was swiftly carried out, heading south and east for domestic distribution and exporting.

In addition to carrying freight, the railway line also transported passengers to Minneapolis, enabling the public to travel from St. Paul to Minneapolis in under 10 minutes.

An Innovative Design

The original bridge design was prepared by Charles Smith, and the proposed bridge schematic was considered innovative in the late 1800s. Smith ensured that the structure accommodated the sandstone geology and the surrounding topography of the natural falls with an arched design. The sinking sandstone in the area near the waterfall would not accommodate the weight of an iron bridge. Therefore, Smith's multi-piered bridge was constructed out of masonry stone, consisting of locally sourced granite and magnesium limestone. They erected the bridge downstream from St. Anthony's Falls and positioned it at a diagonal to meet the rail tracks on the other side that would lead into the proposed Minneapolis Union Depot. The one-of-a-kind curved 22-span bridge was designated a National Civil Engineering Landmark by the American Society of Civil Engineers in 1974.

Smile!

The bowed angle and location just below the waterfall offered an incredible vantage point of both the natural waterfall and the Minneapolis skyline for the rail passengers who crossed the bridge. Today, the public continues to admire the view of St. Anthony's Falls and the city as the bridge was converted to a pedestrian and bicycle bridge in 1994.

"The bridge continues to serve as an important connection over the Mississippi River and is a popular setting for senior high, engagement, and wedding photos," Lovelace said.

The St. Anthony Falls Historic District, which includes the Stone Arch Bridge, was added to the National Register of Historic Places in 1971. The district's heavily trafficked 1.8-mile loop along the Minneapolis riverfront includes the Stone Arch Bridge, which is touted as the city trail's signature feature. The St. Anthony Falls Historic District is also the only urban section of the 72-mile Mississippi National River and Recreation Area (MNRRA), which is a narrow, protected stretch of land on both sides of the river that is managed by the National Park Service.

Once the industrial hub of the flour mills of Minneapolis, the Historic District has retained some of its original architectural character and charm. Milling ultimately left the city when fossil fuel burning became the standard energy provider, and hydropower was no longer needed to run the mills. Consequently, less trains came across the Stone Arch Bridge and the negative environmental impact from coal-burning locomotives lessened in the city. Yet, the loss of industry led to vacant buildings and poverty. Urban renewal in this section of the city has been underway since the 1970s, with millions invested in restoring polluted industrial land, new

construction, and the renovation of old mills into luxury loft condominiums and offices. The creation of Central Mississippi Riverfront Regional Park has established natural green spaces around the river for city residents to explore.

Rehabilitation Project

The Stone Arch Bridge Rehabilitation project is the structure's first significant restoration to be carried out in decades. Currently in the final design phase, construction is slated to begin in spring 2022. The rehabilitation project includes refurbishing or replacing all damaged stone on the arches, embankments, piers, and underwater foundations. In addition, all mortar joints, drainage weeps, and metal tie rods will undergo reparation. Scour and breakwater protection will also be installed at the pier bases to mitigate sediment erosion. Ensuring that fast-flowing water does not carry away the soil surrounding the foundational piers will abate bridge failure.

"There is no immediate worry the bridge would collapse, but without the proposed repairs the risk of collapse could become more worrisome," Lovelace explained. "Repairing the bridge now ensures there will not be a more significant repair project in the near future."

Accurate information regarding the condition of the masonry and mortar joints was required to develop precise repair plans and calculate costs. In addition to undergoing a traditional inspection process, Collins Engineers used Bentley System's reality modeling software to create a high-fidelity 3D model of the Stone Arch Bridge from over 13,000 images taken from unmanned aerial vehicles. Analysis of the 3D model pinpoints the areas in need of repair. Supplementing traditional inspections with reality modeling increased and enhanced the data collected on the bridge's structural condition. Detailed information allowed for more accurate construction bids, which will save the taxpayers 10% to 15% on construction costs.

Using advanced technologies to survey the pedestrian bridge allowed Collins Engineers to shorten the time the bridge was out of service during inspection, enabling them to only close the pathway for four days.

"While performing UAS inspections in the field we had numerous individuals from the public show interest in our work," said Lovelace. "Their feedback was always positive, they appreciated the high-tech approach to such a historical structure, and they also appreciated that utilizing UAS and modeling reduced the impact to the public by being a less intrusive method of collecting inspection data."

Likewise, engineers will reference the 3D model during construction so repairs can be made confidently and quickly to limit the time the bridge is unavailable for public use. After the project's completion, the data and digital twin are anticipated to be linked to the bridge's

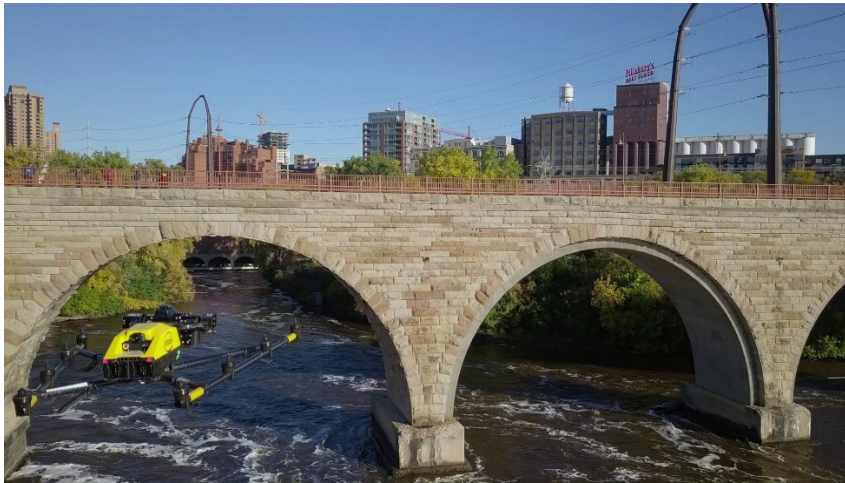
inspection record and used for the lifecycle of the Stone Arch Bridge. Through this capability, engineers can base their planning and maintenance decisions on up-to-date structural integrity information.

“Rehabilitation of the Stone Arch Bridge will ensure this public asset will continue to serve as a historical icon for the City of Minneapolis and as an important pedestrian link for many decades to come,” Lovelace said.

For more information, contact Christine Byrne at christine.byrne@bentley.com, or +1 203-805-0432.

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[Image 1:](#)



Caption: The Stone Arch Bridge Rehabilitation Project was initiated to identify deficiencies and repair a historic bridge.

Image courtesy of Collins Engineers

[Image 2](#)



Caption: The Stone Arch Bridge Rehabilitation Project utilized unmanned aircraft system (UAS) inspection, digital twins and mixed reality.
Image courtesy of Collins Engineers

[Image 3:](#)



Caption: Collins Engineers utilized an unmanned aircraft system (UAS) on the Stone Arch Bridge Rehabilitation Project.
Image courtesy of Collins Engineers

[Image 4:](#)



Caption: Reality modeling was utilized throughout the planning and design phase of the project.
Image courtesy of Collins Engineers