ACCESSING THE ARCH

By Remo Capolino, RRC, PE; and Christine Freisinger, SE, PE

Location: St. Louis, Missouri
Client: National Park Service

The 630-foot-tall stainless steel Gateway Arch in St. Louis, Missouri, was designed in 1947 by architect Eero Saarinen to commemorate the city's role in westward expansion. Since its official dedication in 1968, this National Historic Landmark has captivated over one-hundred million visitors. As the tallest man-made monument in America and the largest catenary structure ever built, the Gateway Arch stands as a gleaming model of architectural and engineering innovation. After observing increasing discoloration, streaking, and surface irregularity of the stainless steel exterior, as well as interior corrosion, the National Park Service sought an expert assessment of the structure to determine the source of the apparent corrosion and staining of the stainless steel; establish repair recommendations based on the structure's historical context; and develop a plan for long-term, sustainable protection.

During several phases, from 2005 to 2015, the history and conditions of the

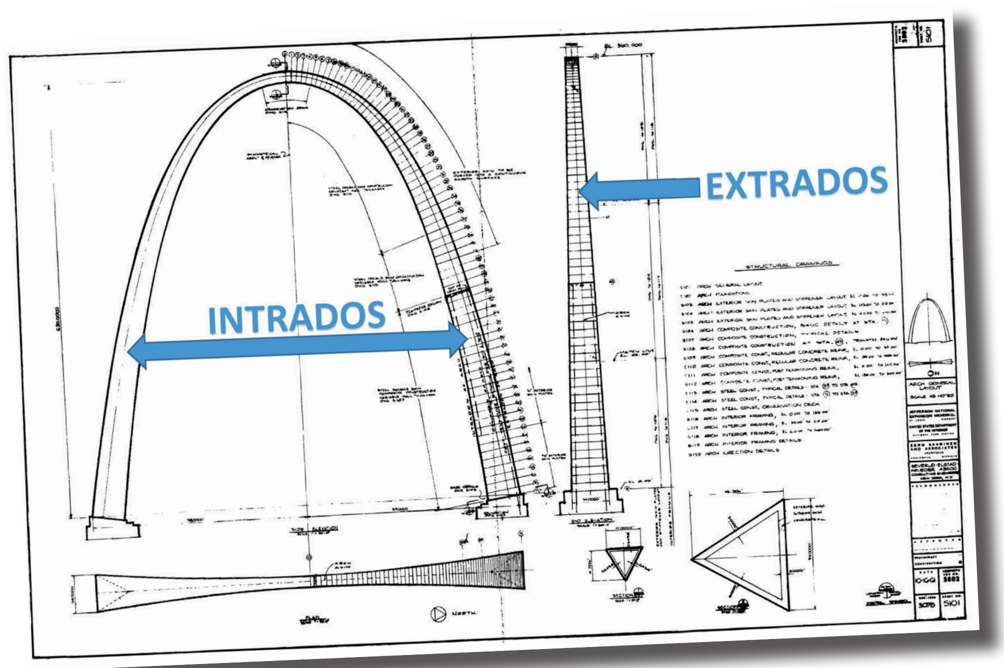
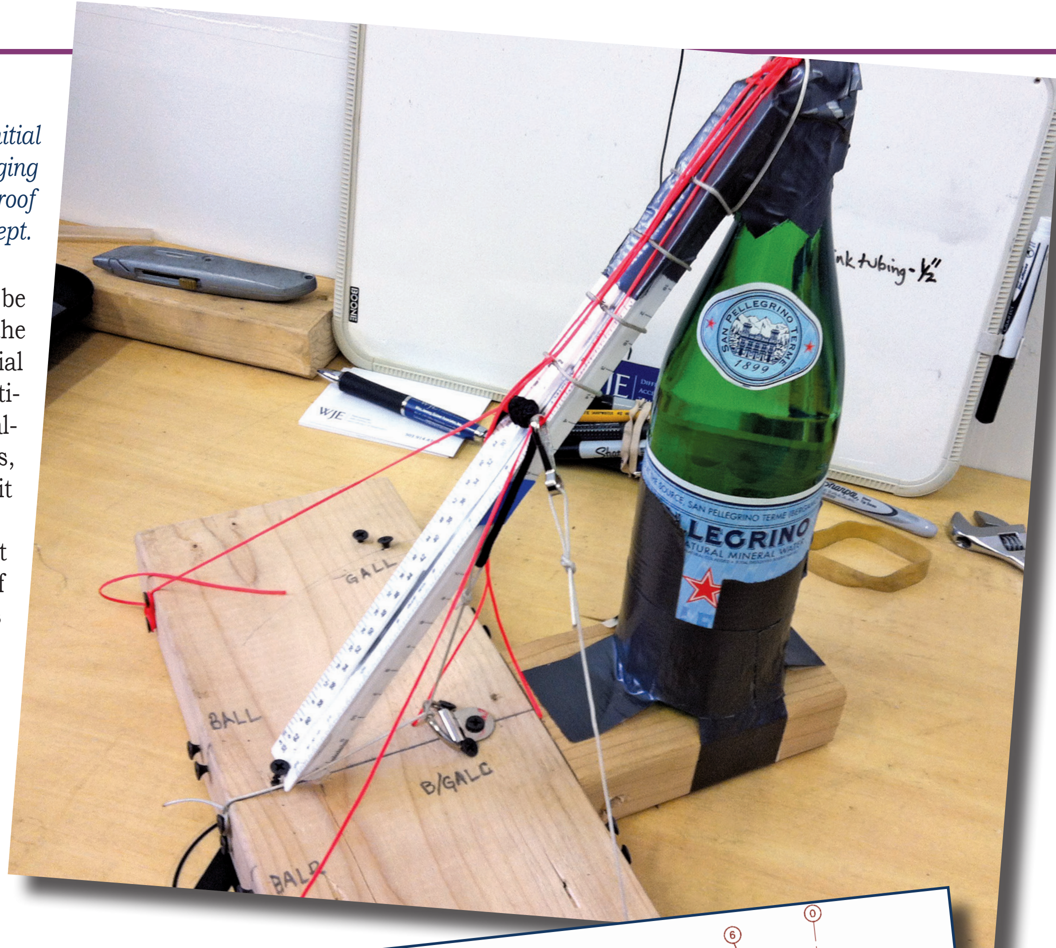


Figure 1 – Plan of arch with section.

Gateway Arch were investigated. During the final phase, which began in the fall of 2014, areas of stainless steel that appeared from grade to be discolored were examined close-up for the first time using aerial lifts and industrial rope access techniques. During the investigation, members of the project team visually inspected the stainless steel and welds, removed weld samples, collected deposit samples, and performed cleaning trials.



Figures 2 – Initial mock-up of rigging concept and proof of concept.

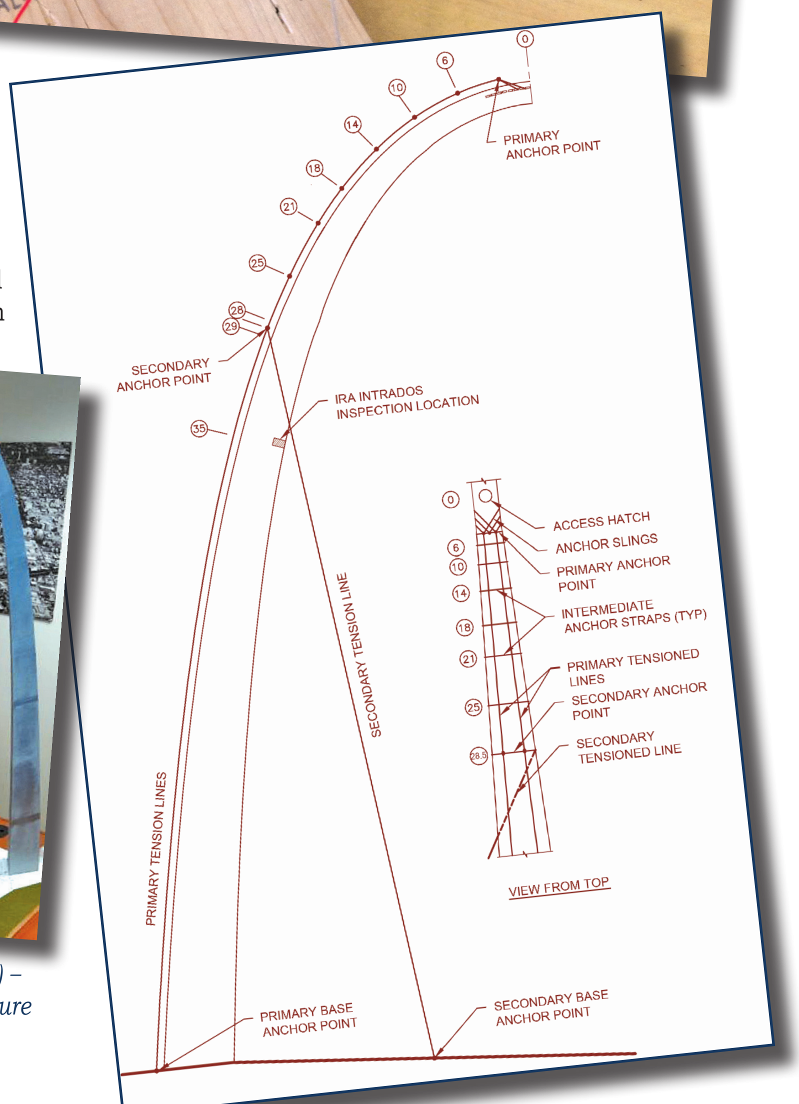
Gaining access to the Arch was not simple from above or below. The legs of the Gateway Arch are equilateral triangles in cross section, with a width of approximately 54 feet at the base tapering to a width of approximately 17 feet at the apex (*Figure 1*). The orientation of the triangular cross section is such that the extrados (upper or outer curve of an arch) creates a horizontal surface at the apex that slopes downward to become nearly vertical at the base of the legs. This means that the intrados (lower or interior curve of an arch) is comprised of the other two sides of the triangular cross section. Access to the intrados was the most challenging, and of course is where many of the areas of visual concern were located.

The WJE Difficult Access Team custom-designed an industrial rope access (IRA) system specifically for this project. Like many things large and complicated, the rope access system design started small and simple in the form of a rough model built in a home workshop. An engineer's scale was used to simulate the triangular shape of the structure, then string and wires were used to simulate the rigging that needed to be installed (*Figure 2*).

As the design progressed, a three-dimensional scale model was printed to replicate the Gateway Arch and to assure the system would provide access to the areas of interest during the site investigation (*Figures 3A* and *3B*).

Once it was determined the rigging was possible, custom fabrication of the system components was completed and transported to the site. From the small hatch at the apex of the Gateway Arch, the custom-designed and fabricated system was installed along the north leg (*Figure 4*).

The IRA system used the temporary construction of a bridle



Figures 3A (above) and 3B (right) – 3-D printed scale model of structure showing the custom IRA system.

Figure 6 – Investigating Engineers on the Extrados of the Gateway Arch.

Figure 4 – Rigging at interior of hatch at apex.

Figure 5 – Custom IRA system at the top of the Gateway Arch.

system that was tensioned from the top of the Gateway Arch down the extrados of the north leg to the base of the structure (*Figure 5*). Two-rope systems were used along the bridle system in order to reach areas of work. No intrusive or permanent connections were made to the exterior stainless steel skin or interior structural components. Metal components of the rope access system were separated from direct contact with the stainless steel skin at all times to avoid contamination of, and/or potential damage to, the stainless steel. Additionally, investigative staff used work boots, knee pads, and other equipment that would not leave any marks on the stainless steel skin as they traversed from the hatch to the ground. Use of the IRA system was contingent on weather and wind speed. The investigation was halted multiple times due to unfavorable conditions, extending the total time on site from five to 11 days.

Overall, the exterior stainless steel of the Gateway Arch was found to be in serviceable condition, without significant structural distress or deterioration. A series of cleaning trials—mild detergents, solvents, weak acids, and surface refinishing techniques—were conducted at the base of the north leg to mitigate the appearance of visual anomalies. The trials were successful in reducing some surface corrosion and provided a wide range of passivation and refinishing options for the stainless steel. WJE recommended isolated cleaning treatments for some of the visual anomalies at the base of the structure. On the remainder of the structure, WJE noted that treatment of the visual anomalies is not necessary, as they are not contributing to the long-term deterioration of the stainless steel, and access to most of the exterior surface area is difficult.

Accessing the exterior of this structure was truly a monumental task (*Figure 6*). While the goals of the investigation were well defined, the means and methods of achieving them (i.e., accessing areas of interest) were not. The knowledge, experience, and professionalism of all the staff involved allowed the work to be completed safely, in conspicuous view of the public and governing safety bodies, and in a cost-effective manner.

Remo R. Capolino

Remo R. Capolino, a principal with Wiss, Janney, Elstner & Associates, grew up in a family-owned specialty roofing contracting business, and graduated from the University of Connecticut with a BS in civil engineering. After more than 15 years in contracting and leadership roles with the Association of General Contractors (AGC), Northeast Roofing Contractors Association (NERCA), and the National Roofing Contractors Association (NRCA), he turned to consulting. He is a member of the RCI Interface *Peer Review Board.*

Christine Freisinger

Christine Freisinger is a senior associate at WJE's Chicago office, where she has worked as a structural engineer since 2004. She is a graduate of the Illinois Institute of Technology and of the University of Minnesota. Freisinger is a board member of the Structural Engineers Association of Illinois (SEAOI) and a member of the Task Committee on the Evaluation and Repair of Existing Buildings of the American Institute of Steel Construction (AISC).