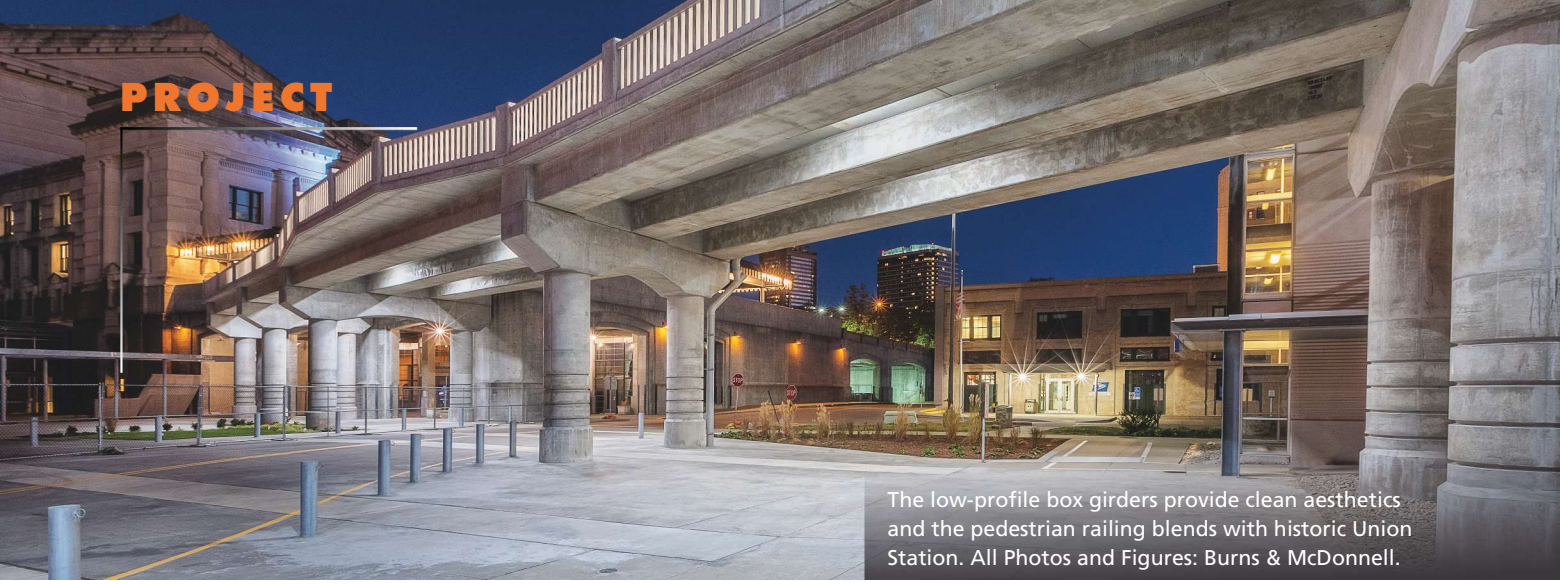


The low-profile box girders provide clean aesthetics and the pedestrian railing blends with historic Union Station. All Photos and Figures: Burns & McDonnell.

THE CARRIAGE PAVILION BRIDGE AT UNION STATION

by Julie Sarson, Burns & McDonnell

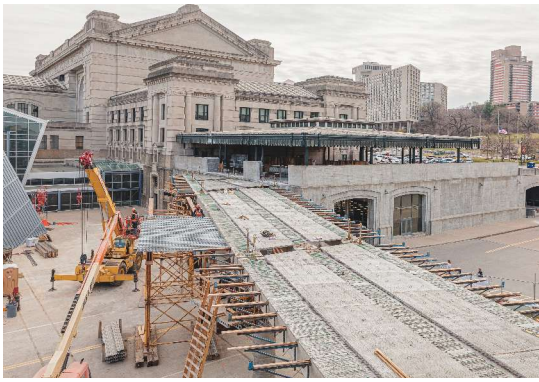
Built in 1914, Union Station Kansas City is a major attraction for culture, education, and entertainment. The facility is a historic landmark and civic asset that was extensively renovated and reopened to the public in 1999. Union Station is currently home to a science center, a planetarium, theaters, restaurants, and a busy Amtrak station. In addition, Union Station regularly hosts traveling exhibitions and community events.

Because parking and pedestrian access to this bustling facility needed improvement, Union Station Kansas City Inc. wanted a new bridge to carry vehicles and pedestrians from the front of this grand building to the third level of the existing West Yards parking structure. The bridge was constructed in 2016 as a part of the $7.8 million western expansion project. An integrated and dynamic design-build project-delivery method allowed the client to provide input about the design as construction progressed. The expansion project also included a modernization of the streetscape in the "front yard" of this majestic building, an updated eastern plaza to incorporate the terminal for Kansas City's new streetcar system, and improved bus access to the facility for school groups. With these renovations, Union Station has truly returned to its roots as a transportation hub for the region.

One of the most exciting features of the expansion project is a sprawling festival plaza for community-based events, located immediately north of the new bridge. The first outdoor extension of Science City, the science center in Union Station, is adjacent to the festival plaza and features interactive exhibits based on the concepts of simple machines. The new bridge includes a pedestrian overlook that extends toward the festival plaza and outdoor exhibit space. This overlook, designated as Kansas City's newest "selfie spot," also has stunning views of the downtown skyline to the north and the majestic National World War I Museum and Memorial to the south.

The Design Process

During the design process, Union Station's corporate, operations, and maintenance personnel provided critical input to determine the specific needs of the facility and its many events. Previously, the West Yards parking structure was only accessible by driving a circuitous route around the back of the building, nearly a half mile from the main entrance. Visitors to the facility found this parking situation



Box girders and deck form panels in place before deck reinforcement is installed.

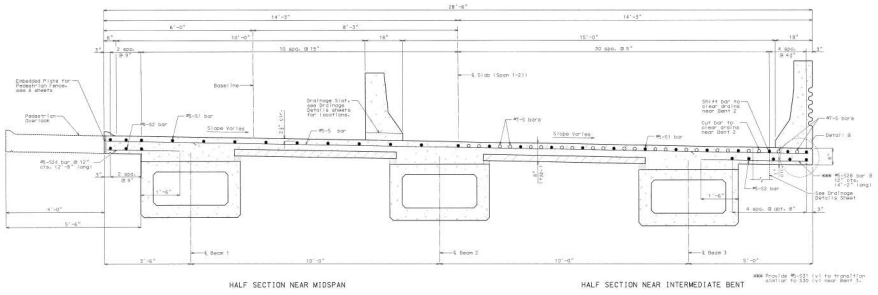
profile

THE CARRIAGE PAVILION BRIDGE AT UNION STATION / KANSAS CITY, MISSOURI

BRIDGE DESIGN ENGINEER AND DESIGN BUILDER: Burns & McDonnell, Kansas City, Mo.

PRIME CONTRACTOR: L.G. Barcus & Sons, Kansas City, Kans.

PRECASTER: Coreslab Structures (Kansas), Kansas City, Kans. (box girders and deck form panels), and Coreslab Structures (Missouri), Marshall, Mo. (railing)—PCI-certified producers



Cross section of bridge.

to be frustrating, particularly when attending large events with a specific start time. In addition, once parked in the four-level structure, pedestrians had to travel down to ground level, cross the north lot and a local street, enter the back of the building, and take an escalator up before finally reaching the building's Grand Hall. Union Station's management wanted to improve access from the parking structure to the building and make the pedestrian approach part of the overall visitor experience.

Located at the west end of the Union Station building, the Carriage Pavilion and its roof structure were included in the 1999 renovation. This area was once used by horse-drawn carriages to drop off passengers at the Grand Hall. In more recent years, the Carriage Pavilion had been used by delivery trucks serving the post office within the building. As part of the expansion project, this area has once again become a passenger drop-off site, and it also allows vehicles to access the bridge and parking structure directly from the front of the building. The traffic crunch for major events has been alleviated with the additional entrance on the third level of the parking structure.

Specific pedestrian needs have also been addressed with the new bridge structure. The barrier-separated pedestrian path is 10 ft wide to allow ample room for families with strollers visiting the attractions. Visitors can now park and walk into the Grand Hall at the same level, which has greatly improved the pedestrian experience. In addition, a 4-ft-wide overlook juts out from the path at the center of the bridge, to provide a location to stop and take in the 360-degree view of Kansas City.

The span arrangement for the bridge was controlled by horizontal clearance to the local access road and was also set to frame the existing arches at the base of the Carriage Pavilion, resulting in spans of approximately 33, 33, 75, and 57 ft. Prestressed concrete box girders were selected for the superstructure system. These were preferred over steel girders or concrete I-girders because of their clean, low profile and because a "heavy" structure was desired to complement the aesthetic of the massive Union Station building.

Also, because this bridge is located in an urban environment, Union Station's management required a "pigeon-proof" structure with no ledges, crevices, or other nesting spots that would attract birds. Traditional cast-in-place concrete diaphragms at the pier caps to fully enclose the ends of the precast concrete box girders were the cost-effective and clean-lined solution.

Fabrication and Installation of Precast Concrete Components

The 27-in.-deep, 48-in.-wide box girders were fabricated at a local precast plant. Eleven girders ranging in length from 31 ft 0 in. to 74 ft 1 in. were required for the project. The bridge design engineers worked closely with the precaster to simplify and economize the box girder design, such as duplicating strand

Erection of a box girder in a tight space.

UNION STATION KANSAS CITY INC., OWNER

BRIDGE DESCRIPTION: Pedestrian and vehicular bridge with unusual geometry constructed using spread prestressed concrete box girders with precast deck panels and railings. The length of the four-span bridge is approximately 207 ft, the distance between the historic building and parking garage.

STRUCTURAL COMPONENTS: Prestressed concrete box girders with 3-in.-thick precast, prestressed concrete deck panel forms, 15 precast concrete rail panels (193 linear ft total), 11 prestressed box beams (556 linear ft total), 43 prestressed panels (2300 ft^2 total), and precast concrete decorative pedestrian railing

BRIDGE CONSTRUCTION COST: $1.2 million

Complex geometry at the Carriage Pavilion end of the bridge required a high level of detail for fabricating box girders and deck form panels.

patterns to allow multiple girders to be cast in one bed. Prestressing strands were extended and bent up at the ends of the boxes to provide connections to the cast-in-place diaphragms. The boxes were cast with square ends, and the cast-in-place diaphragms were meticulously detailed to avoid conflicts at the ends of the box girders.

The box girders were shipped only 10 miles from the fabrication plant to the Union Station project site where they were erected on the bents. The girders were seated on plain neoprene bearing pads. The biggest lift was about 31 tons, which was easily handled by the equipment on the small site.

Precast concrete deck form panels were selected to be used in the superstructure system to speed construction. Again, close coordination with the precast concrete producer ensured that the panels fit perfectly with the flared and skewed box girder framing near the Carriage Pavilion. Panels slightly wider than standard panel widths were allowed because of the reduced vehicular wheel loading. Deck panels are typically designed for HL-93 wheel loads. However, the design loading for the Union Station bridge was a 100-lb/ft^2 pedestrian loading, a 64-lb/ft^2 vehicular loading, or an H-5 maintenance vehicle which has an 8-kip axle loading, and tended to control the design of the slab, precast concrete panels, and shorter box girders. This design loading also allowed for snowplow equipment or other light maintenance vehicles to access the bridge and for pedestrians to occupy the full bridge width, as for a mass exit from a large event at Union Station.

The framing and overall geometric control for the bridge were complicated. Unlike a typical highway or railroad bridge, there was no established stationing or obvious tie to set the horizontal control. The bridge was detailed, fabricated, and constructed using spatial coordinates to locate the nine drilled shafts. This approach was unique but manageable. A construction baseline was established from these coordinates, using a line parallel to the northernmost drilled shafts and the north fascia of the bridge. This baseline was used to set the geometry for the box girders and precast concrete deck form panels. The precaster produced shop drawings and fabricated the girders and deck panels using this baseline, ensuring a perfect fit into the framing system.

A precast concrete pedestrian railing was desired for its smoother and more consistent finish. The rail panels were fabricated in lengths up to 15 ft and were installed at the north slab fascia between cast-in-place concrete pilasters. A precaster fabricated the rail for the panels and, as with the box girders, close coordination of the geometrics was critical. The metal forms for the panels were custom crafted in the precast producer's plant, and the spaces between the balusters were formed with expanded polystyrene. The rail panels were reinforced with epoxy-coated steel and designed for pedestrian loading.

Summary

The bridge structure brings a "heavy" but clean and low-profile aesthetic to the surrounding area, complementing both the majestic historic building and the new north festival plaza and outdoor exhibit space. As endorsed by Union Station's management, "the new Union Station Carriage Pavilion Bridge…is both an engineering marvel and aesthetic masterpiece. A mix of high-function, historic reference, and physical beauty, the bridge immediately solved a long-standing and significant customer experience challenge for the station…moving volumes of pedestrian and vehicular traffic intuitively in and out of our massive historic campus with ease. This cornerstone component of our Western Expansion Project was validated by our guests within the first fifteen minutes of opening, and every day since. In a most literal sense, it's as if the new bridge were always meant to be," said George Guastello II, president and CEO of Union Station Kansas City Inc.

Julie Sarson is the section manager for bridge design at Burns & McDonnell in Kansas City, Mo.

Placement of deck concrete.