2007 Award of Excellence

Parking Structures Category

Auditorium Plaza Garage Repairs and Improvements

Kansas City, Missouri

Submitted by Structural Engineering Associates

Central Street entrance to the Auditorium Plaza Garage

The Auditorium Plaza Garage (APG) is the largest municipal parking structure in downtown Kansas City, MO. Constructed in 1954, this large, three-level garage occupies an entire city block, with a parking capacity of approximately 1000 spaces. The reinforced concrete structure consists of two framed/elevated slab levels, with a lower level that is slab-on-grade. The APG has over 280,000 ft^2 (26,000 m^2) of supported/framed slab area, excluding the roof slab.

Condition Study

A structural condition study of the parking structure was performed in 2001. The outcome of the assessment and testing drove the need to address the continued onslaught of slab, soffit, column, and wall corrosion since the last major repairs in 1984. Additionally, the garage exhibited moderate to severe leaking of the under-street tunnels; a poorly-lit and deteriorated interior pedestrian walkway that connected the garage to the tunnels and buildings beyond; and the need for repairs and waterproofing to the large water feature above the garage. There were also various nonstructural repairs and needs for improvements, including lighting, electrical service, a new garage revenue control system, repairs to slabs drainage, signage, wayfinding, and ADA accessibility issues.

The structural concrete parking level slabs are four-way reinforcing, flat slab construction, with column capitols and drop heads/panels. These slabs are 10.5 in. (267 mm) thick, and have a nominal 2 in. (50 mm) latex-modified topping slab that was added in 1984. There are also three reinforced concrete tunnels that connect the APG with three large hotels and the City's Municipal Auditorium facility. All of these tunnels are under major city streets that receive numerous applications of deicing salts.

During the preparation of the condition study, forensics testing of the structural slabs and soffits was performed and included:

- Chloride ion content at three depths to evaluate the corrosion threshold levels at various locations on framed levels;
- Electrochemical (half-cell) potential testing of the reinforcing steel in selected, high-delamination areas; and
- Concrete core samples to examine whether the larger delamination areas of the slabs were due to corrosion of the embedded steel, or due to debondment between the latex-modified topping/overlay slab and the underlying structural slab.

These test results, coupled with the condition surveys and analysis, led the owner to move forward with the preparation of the construction documents.

The Repairs Begin

The APG repairs and improvements project was bid in May 2005, and was initially budgeted at $4.1 million. Work commenced in June 2005, and the general contractor and the repair contractors soon realized the many challenges of phasing extensive soffit and slab repairs with a mandatory operational parking garage. Each of the three parking levels was broken into smaller, more manageable repair subareas to facilitate vehicular and pedestrian traffic in the garage, while managing the constant, large amounts of dust and poor air quality during the hydrodemolition surface preparation (on both slab and soffit) and dry-process shotcreting work.

The engineer determined that a number of repair procedures were required, including conventional "chip-and-patch" concrete repairs for horizontal and vertical surfaces and the installation of galvanic anodes in the repaired soffit areas. Over 13,500 galvanic anodes, or "hockey pucks," were installed in the three soffit levels to minimize the high corrosion rates and anodic ring effect in the 20,450 ft^2 (1900 m^2) of delaminated soffit repairs. It is estimated that this passive form of cathodic protection will protect the repaired areas for 15 to 20 years.

Slab repairs to the framed levels included both partial and full depth, amounting to approximately 6600 ft^2 (615 m^2) and 14,200 ft^2 (1320 m^2), respectively. One full bay on Level 2 required full-depth replacement, along with temporary shoring and bracing for the affected and contiguous bays to ensure continuity of the moment framing conditions.

Hollow plane epoxy injection was also performed on the many debonded topping slab areas where the latex-modified topping had produced shallow, hollow planes between the structural and topping slabs. The repair contractor could pump a low-viscosity epoxy in a range of 12 to 20 psi (0.8 to 0.14 MPa) into the void without the more invasive and costly partial-depth slab repairs method. This repair procedure was about half the cost of the conventional chip-and-patch slab repair method and saved the owner over $70,000 in repair costs.

Cracked and leaking soffits and walls were a constant problem on the project, and there were a number of epoxy injection and/or crystalline waterproofing repairs used, particularly along the pedestrian walkway, much of which is under the city streets surrounding the garage. Soffit and slab repairs had to be addressed before the replacement ceiling tile, lights, and resilient tiling/flooring could be installed by the other contractors working on the walkway. The garage's south entrance elevated slabs were also badly delaminated and required a good amount of partial- and full-depth slab repairs and bearing wall strengthening.

During the initial stages of design, it was decided to excavate and expose the north and south tunnels under 12th and 13th Streets, respectively, so as to repair and waterproof the leaking tunnels from the positive side. After further analysis and discussion with the owner, however, the engineer was able to provide a value engineering solution consisting of the application of a crystalline waterproofing system from the negative, inside of the tunnels. This repair approach saved the city approximately $275,000 in construction costs and traffic disruption.

Constant leaks at failed expansion joints, soffit, and wall cracks in the tunnels and pedestrian walkway were a major maintenance nuisance and slip hazard, so new expansion joints and negative-side waterproofing, along with the many structural repairs, would be needed to mitigate these adverse conditions. A redundant expansion joint approach was used for the north and south tunnels, employing 20 expansion

Existing soffit corrosion (note the electrical conflicts/challenges)

Delaminated soffit repairs

Shotcreting a soffit

Garage, Level 2, following concrete repairs and painting

Water feature repairs underway

joints and primary and secondary joints at the severely leaking roof joints of both tunnels. The badly corroded structural steel at the north tunnel entrance to the APG (supporting the north wall) was also removed and replaced with new, galvanized steel beam and tube columns. Cementitious repair mortars were used with the crystalline waterproofing to allow the repaired areas to be infiltrated with the insoluble migratory crystalline complexes.

Following completion of all repairs to each of the three levels, all columns, walls, and soffits were painted and new signeage was added.

Above-Ground Improvements: Water Feature and Vendor Area

An existing reflecting pool and cascading water feature bounds the north side of the plaza above, and is completely over the garage below. The pools were drained and the deteriorated waterproofing membrane was milled and scraped off the concrete substrate, while the granite waterfall stones were removed and marked for the new surface-applied waterproofing membrane. Some concrete, plumbing, and lighting repairs were also necessary, and each and every granite stone on the waterfall was cleaned and restored with a cleaning agent, and re-anchored.

A new "Vendor Area" at the corner of 13th and Main Streets (southwest corner of garage), was also constructed by demolishing two planter areas, constructing new slabs-on-grade, repairing stone masonry walls, installing new water service and electrical outlets for street/kiosk vendors, and applying a new traffic-bearing waterproofing system in the two spaces. The City of Kansas City passed a new vendor area permit ordinance, and these spaces, which are directly opposite to the main entrance to the city's convention center, are being used for food service vendors during the various events.

Plaza Improvements

The City's Barney Allis Plaza is located directly above the garage roof structure at ground level, and during the course of the garage repairs and improvements, the engineer and general contractor were directed to design and construct improvements to most of the park/plaza area. These were completed in the midst of the garage project, and had to follow a fast-track delivery schedule to accommodate a major national tennis championship match without adversely impacting the ongoing garage work. The plaza now features a new championship tennis court facility, with space for temporary bleachers providing seating for 2600 event patrons.

Additional plaza improvements included new surface and subsurface drainage systems; a large slope-critical slab-on-grade and special tennis court coatings; new concrete sidewalks and accessible ramps; security fencing; electrical service; and "high-mast" sports event light structures that had to be anchored (following a full structural analysis assessment and design details) to the roof slab of the garage.

The Auditorium Plaza Garage Repairs and Improvements project was substantially completed on January 3, 2007, for a total project cost (garage and plaza repairs and improvements) of $6.7 million, and provides the City of Kansas City with a structurally restored and greatly enhanced municipal asset with safer and more efficient operation, more color, and higher functionality for all patrons

Auditorium Plaza Garage

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City of Kansas City
Kansas City, Missouri

Project Engineer/Designer
Structural Engineering Associates
Kansas City, Missouri

Repair Contractor
Mid-Co Contractors, Inc.
Kansas City, Kansas

Material Suppliers/Manufacturers
BASF Building Systems
Shakopee, Minnesota

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