Repairs Extend Service Life

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The Euclid Autopark, a $650,000 project that is located in the heart of the University of Colorado campus in Boulder, Colorado, has approximately 406 spaces, and the structural system consists of two supported levels of post-tensioned concrete slabs and beams supported by cast-in-place concrete columns and walls. The Regent Autopark has approximately 850 spaces, and the structural system consists of four supported levels of precast, prestressed double tees and beams bearing on precast columns and spandrels. Both autoparks were constructed in 1992.

The autoparks were subjected to years of exposure to road salts and moisture. Corrosion-induced deterioration had started to compromise the structural integrity of the floor systems. Tripping hazards due to the settlement of the sidewalks and equipment pads surrounding both autoparks were also creating a liability issue.

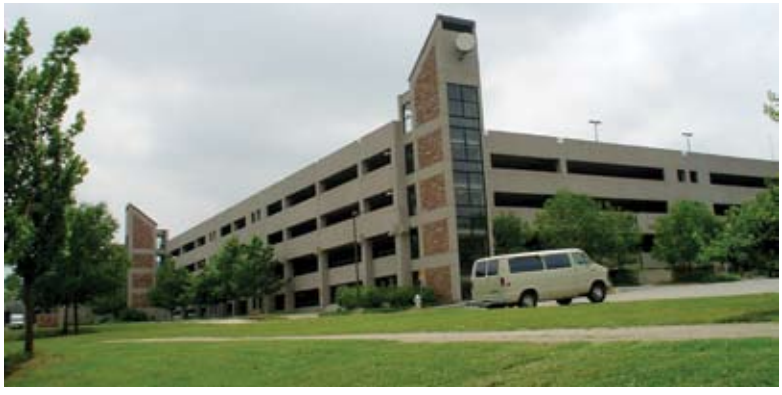
Numerous condition appraisals and studies have been done on the garages over the past few years, with the most recent condition appraisal conducted on both autoparks in 2003. These studies found minor deterioration on the supported levels of both parking structures. The repairs and protection options chosen for the structures needed to extend the service life of the 12-year-old structures for at least another 30 years. It was also very important to the university that portions of the facilities remained open while the restoration was underway.

The typical structural restoration work included replacement of deteriorated concrete topping and slabs, beam and column repairs, masonry repairs, expansion joint replacement, sealant work, and the installation of a slab-protection coating. Because these structures are located at the central location of the university, the logistics of this restoration project were truly challenging. Balancing the construction phasing, noise suppression, dust control, construction traffic, and various trades within the job site footprint was a unique challenge.

The Euclid Autopark is a three-bay, three-level garage. The garage consists of a slab-on-ground level and two supported levels of cast-in-place post-tensioned concrete slabs and beams supported by concrete columns and load-bearing walls. The footprint of the structure is rectangular with a width of 172 ft (52 m) and a length of 286 ft (87 m), for a total of approximately 48,500 ft^2 (4506 m^2) per level.

The Regent Autopark is a four-bay, five-level garage consisting of the ground floor level and four supported levels of precast/prestressed double tees and beams supported by precast concrete columns and spandrels. The footprint of this structure is rectangular with a length of 258 ft (79 m) and a width of 215 ft (65 m), for a total area of approximately 55,500 ft^2 (5156 m^2) per level.

Euclid Autopark



Regent Autopark

Problems That Prompted Repair

Of primary concern to the university was the settlement of the soil surrounding both autoparks, which resulted in broken and misaligned concrete. These misaligned sidewalks had resulted in tripping hazards and were a great liability to the university.

Also, at both autoparks, equipment support pads had tipped in toward the structures, resulting in damaged gas, electrical, and water lines.

Inspection/Evaluation Methods

Numerous studies, tests, and report programs were completed over the life of the parking structures. The latest evaluation included a complete review of all past documentation and testing, plus new in-depth field investigation and materials testing. The evaluation included:

- Supported floor survey—A chain drag was completed on all supported slab surfaces;
- Ceiling survey—A detailed visual review and selective sounding of the underside of the double tees, beams, and post-tensioned slabs was completed;
- Slab drainage survey—An elevation survey of the supported parking levels was completed to evaluate the existing drainage in the structures and to locate ponded areas;
- Waterproofing systems review—The condition of the deck coating, expansion joints, and sealants were reviewed;
- Stairs/elevator—Deterioration areas were noted, and renovation ideas were reviewed for the stair towers and elevators;
- Exterior façade review—A complete visual review of the exterior of the structure was completed; and
- ADA compliance review—The structures were reviewed for compliance with the recommendations of the Americans with Disabilities Act (ADA).

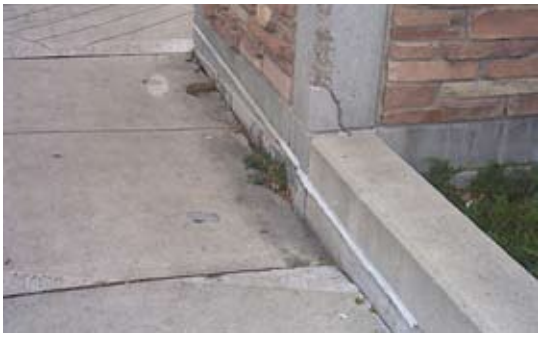
Based on geotechnical engineering analyses, subsurface exploration, and laboratory test results, it was concluded that the distress observed at the sites was due primarily to settlement or consolidation of poorly compacted backfill or fill materials placed during the original construction of the parking facilities. Petrographic analysis of the concrete cores extracted from the Euclid Autopark indicated that the overall quality of the concrete was good and the concrete had good durability due to an air void system that is consistent with current technology for resistance to freezing-and-thawing deterioration.

An analysis of the chloride ion content indicated that the chloride ion concentration at the level of reinforcement was below the threshold needed to support corrosion of the steel reinforcement in the concrete. The analysis, however, also indicated that the chloride ion concentration was approaching this threshold, so waterproofing measures should be undertaken to mitigate the continued intrusion of chloride ions.

Repair System Selection

There were several concrete structural restoration methods used to achieve the requested 30 years of additional service life. Among these were the following:

- Sidewalk and equipment settlement—rigid polyurethane injection grout;
- Deteriorated deck and slab areas—localized conventional partial depth concrete repair;
- Drainage—improved by providing additional floor drains and reworking the low areas by grinding and/or patching;
- Waterproofing—The existing expansion joints and joint sealants were removed and replaced; and
- Deteriorated columns, beams, spandrels and walls—conventional concrete patch repair.



Settling sidewalks

Settling equipment pad

Lightweight equipment was used

Shotblasted surface

Repair Project

The parking facilities are located at the heart of the university campus. Therefore, there were critical site preparation issues to consider for the demolition and repair of the sidewalks. To accommodate the university's continued use of the facilities, the projects were restored in two phases. Temporary signs and barricades were provided for each of the two phases of the construction.

For the concrete replacement areas, light equipment was used in the demolition. Fifteen-pound jackhammers were used to minimize the damage to the surrounding concrete.

To prepare the surface for post-tensioned and topping slab replacement, material was removed down to sound concrete. Concrete surfaces and reinforcing steel were abrasive blasted prior to patching. All exposed reinforcing was epoxy coated. A slurry coat of the repair concrete was scrubbed onto the concrete surfaces prior to the application of the patching material.

Shotblasting was used to clean all areas receiving a silane or epoxy sealer.

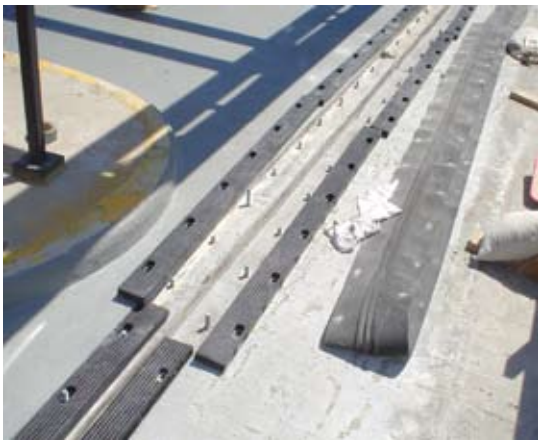
Where there were expansion joint blockouts, the existing delaminated concrete was removed and new blockouts and anchorages were cast onto the floor slab to support the new expansion joint system.

Slab prepared for deck coating

Application Methods Selection

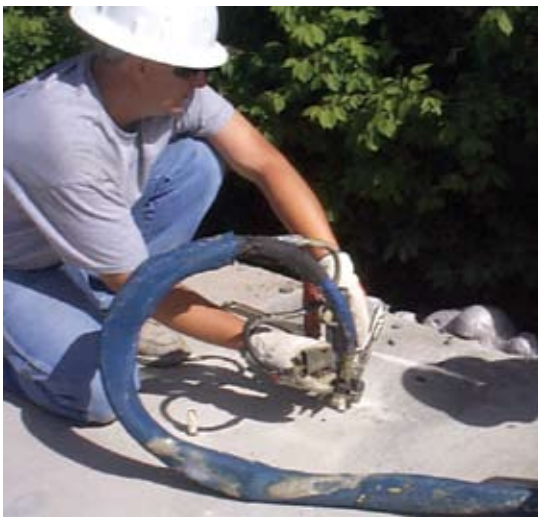
For the ceiling repairs, trowel-applied repair mortars were used for partial depth ceiling repairs less than approximately 5 ft^2 (0.5 m^2). For the beam and column repairs, a combination of formed and poured concrete and trowel-applied mortars was

Expansion joint preparation



Expansion joint installation

Drilling of injection ports



Pressure injection of grout

Exterior face and corner

Interior face of wind wall

Corner ramp at Regent Autopark

Ramps at Euclid Autopark

used on these repairs, depending on the location and size of the repair.

Rigid polyurethane injection grout was pumped below the concrete slabs to lift and stabilize the settlement of the sidewalks and equipment pads.

The restoration was completed in two separate phases, which enabled the autoparks to remain open during the repairs. Phasing drawings were prepared to maintain access to at least half of the parking stalls and to provide access to stair and elevators during the restoration.

Other Renovation

The University of Colorado at Boulder made a significant investment to extend the service life of the autoparks by another 30 years, and they were committed to implementing other renovation options to improve the user comfort at the parking structures. These renovations, briefly described as follows, included improvements to the parking facilities' functionality, aesthetic appeal, and security.

Functionality and Safety:

- Vehicular restraint system—The existing barrier restraint systems were tightened and strands were added for safety and code compliance;
- Patron safety—A concrete wind wall was constructed to shield a stair tower from the westerly winds. Flagstone was incorporated on the exterior face to blend with the existing walls; and
- ADA compliance—ADA ramps were updated when the sidewalks were replaced.

The overall restoration work included: 7800 ft^2 (725 m^2) of deteriorated concrete topping slab replacement and repair, beam and column repair, masonry repair, expansion joint replacement, sealant work, 8000 ft^2 (743 m^2) of deck coating, and over 285,000 ft^2 (26,477 m^2) of surface sealer. Polyurethane foam was injected into over 4000 ft^2 (372 m^2) of sidewalks and concrete pads to stabilize the surrounding soils. An additional 3500 ft^2 (325 m^2) of sidewalks and ADA ramps were replaced over compacted soil.

Euclid/Regent Autoparks

Owner
The University of Colorado
Boulder, Colorado

Project Engineer
Carl Walker, Inc.
Denver, Colorado

Repair Contractor
John Rohrer Contracting Company
Conifer, Colorado

Material Supplier
Denver Grouting—a Division of Hayward Baker
Broomfield, Colorado

Material Supplier
DeNeef Construction Chemicals
Houston, Texas