

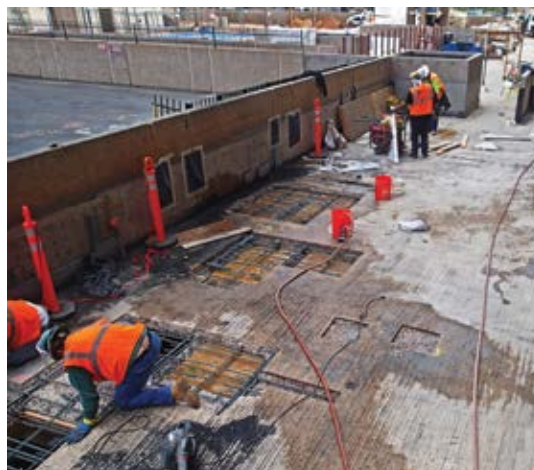
Regency House Condominium Plaza Parking Garage Repairs

Phoenix, AZ

Submitted by Gervasio & Associates, Inc.



The start of concrete repairs to a beam. Note how ties on the right side are all broken from the expansive pressure of corrosion of longitudinal bars



Full- and partial-depth repairs on slab in planter area

Regency on Central (also known as Royal Towers and Regency House) is a 21-story condominium located in Phoenix, AZ. When constructed in 1964, it was the highest residential structure in the Phoenix area. Two levels of underground parking extend beyond the tower's footprint, creating Plaza space at street level (totaling 215,000 ft² [19,975 m²]).

STRUCTURAL CHARACTERISTICS

Below the high-rise tower, the ground-level plaza/parking structure is a cast-in-place concrete pan-joist system, with cast-in-place exposed aggregate concrete planter walls. Below the Plaza are two stories of underground parking, also constructed of a cast-in-place concrete pan-joist system. Within the below-grade parking structure, there is a mechanical room on each level that supports all the building's mechanical equipment.

PROBLEMS THAT PROMPTED REPAIR

Moisture infiltration from planters and plaza areas occurred for years. Metal "drip pans" had been erected in many areas to catch dripping water and prevent damage to cars. Removal of the drip pans revealed widespread corrosion and spalling, resulting in emergency shoring.

Mechanical equipment is housed on two floors of the underground parking garage. Mechanical

systems lacked redundancy, and most systems were beyond their useful service life. The water heaters, boilers, water pumps, and water softener were supported by a severely deteriorated cast-in-place floor slab, which also required emergency shoring.

TEST FINDINGS

Carbonation testing showed the effects of 50 years of automobile exhaust in a poorly ventilated garage. Carbonation levels extended over 1 in. (25.4 mm) in depth, higher than normally expected.

Chloride testing in the mechanical room floor slab revealed near-surface chloride levels 30 times higher than allowable limits. Furthermore, chloride levels were very high throughout the entire floor slab thickness, indicating use of calcium chloride in the original concrete mixture.

REPAIR METHODS

The repairs at Regency used a wide range of materials and methods, including:

1. Ready mix cast-in-place concrete: including corrosion inhibitors, silica fume, and shrinkage-reducing admixtures to improve durability;
2. Dry-process shotcrete: for small isolated joist and slab repairs;
3. Form and pump with preplaced aggregate: for joist repairs;
4. Form and place: for numerous locations;

5. Hand patching: isolated areas;
6. Epoxy injection: for non-moving crack repair;
7. Chemical grout injection: moving crack repair;
8. Helical pier tieback anchors: for basement wall shoring where the mechanical room floor slab was removed and replaced;
9. Carbon fiber: strengthening the basement wall between the helical pier tiebacks;
10. Soil stabilization: with intrusion pressure grouting addressing voids beneath the basement floor slab-on-ground;
11. High-density foam: Two types used, reducing topping weight and providing slope for drainage;
12. New steel stairs: instead of extensive concrete repairs to existing; and
13. Lightweight soil mixture in planters: avoiding additional structural support.

PROTECTION

Good-quality concrete repairs require various protection methods to provide the longest life possible. Protection methods included:

1. Galvanic anodes: both “hockey puck” and “drilled-in” anodes were used in all repairs;
2. Reinforcing bar coatings: epoxy reinforcing bar coatings applied to existing reinforcing bar, and new epoxy-coated reinforcing bar;
3. Corrosion inhibitors: admixtures included in all ready mixed concrete, and proprietary bagged materials were only selected, which included corrosion inhibitors;
4. Anti-carbonation coating: anti-carbonation coatings were applied to the bottom surface of the slab;
5. Cold- and hot-applied liquid waterproofing: used below Plaza areas and in all planters. This system included electronic leak detection technology, which was used during construction, but can also verify the presence/absence/location of future leaks;
6. Epoxy flood coat: used to “heal and seal” floor slab cracks, and as primer beneath all urethane deck coatings;

7. Urethane deck coating: used at vehicular traffic areas, mechanical rooms, cooling tower, and below artificial grass in the dog park;
8. Waterproof ceramic tile systems: used at Plaza areas;
9. Water repellants: for concrete masonry units and concrete; and
10. Epoxy coatings: on exposed architectural steel.

CONSTRUCTION LOGISTICS/CONSTRAINTS

Maintaining a fully operational parking garage significantly affected the difficulty of performing the repairs. With only one combination entrance/exit, and only one main drive throughout the garage, no more than half of the drive lane could be obstructed and no more than 40 of the 280 parking spaces could be displaced at any given time. Often-times, shoring and forming of structural elements of the Plaza required reshoring at the second basement level, resulting in two levels of lost parking.

Mechanical room floor slab replacement resulted in complex issues:

- Mechanical equipment had to be temporarily relocated/re-supported and kept operating for entire building;
- Bracing the basement wall for earth pressure, therefore requiring helical pier tieback/shoring;
- Carbon-fiber reinforcement for the wall; and
- Shoring/formwork below in a mechanical room with extensive piping, electrical conduits, and equipment obstructions.

UNFORESEEN CONDITIONS

Every concrete repair project is plagued with its share of unforeseen conditions due to limited structure access/visibility. Despite these unforeseen repairs, the overall repair was \$500,000 under budget.

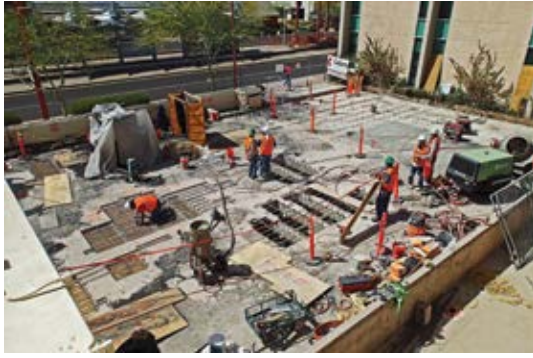
Thru-deck repairs: The largest unanticipated concrete repair was in the front street level parking area, which had concrete topping over a waterproof membrane over a structural pan deck floor joist system. In some areas, the bottom side of the structural slab showed significant signs of moisture



Complete removal and replacement of a portion of floor slab in front of building



Removal of concrete topping in front parking lot



Looking down at front parking lot repairs



Back patio plaza area after renovation

intrusion. Those areas were identified for complete removal and replacement. However, after the topping/waterproofing was removed, significant additional deterioration was discovered at top reinforcing bars of slabs and beams. Because portions of the slab had to remain available for on-site parking, the topping for the full parking area could not be completely removed. The full magnitude of this problem remained unknown until final repairs were exposed.

Subsurface sink holes: A shocking discovery occurred in the garage when saw-cutting the floor slab-on-ground at the lowest basement level for plumbing trenches. After saw-cutting a 2 ft (0.6 m) wide strip, the newly cut slab section dropped 4 to 6 in. (102 to 152 mm) in elevation. Removal of the concrete revealed large voids beneath the slab-on-ground in numerous areas. The voids were caused from inadequate backfill compaction around column/wall footings. The concrete floor slab was poured on top of the soil, but due to poor compaction, the soil simply settled away from underneath. Repairs by soil stabilization were achieved through intrusion pressure grouting with a cementitious slurry material.

Primary electrical duct bank: In the cooling tower area, a section of concrete with severe cracking was raised above the floor level for unknown reasons. During construction, further investigation revealed it encased the electrical conduits/wire from the underground transformer vault to the electrical service entrance section (SES).

These conduits house the electrical wires that supply power to the entire building and were completely rusted through, a condition unacceptable to the power company. Turning off the power to the SES and relocating/replacing the conduits was not viable at this time. In addition to being very disruptive to building occupants (extended shutdown), the 50-year-old SES switch gear was outdated, and may not even turn back on when re-energized. Therefore, the condition was temporarily epoxy injected, and a urethane deck coating applied over it. Ownership is currently working to replace the transformers, SES, and conduits.

Incorrect topping slab thickness: Concrete topping in the front parking area was indicated on the original construction drawings to be 2 in. (51 mm) maximum thickness. Circa 1980s, a new waterproof membrane was installed, requiring topping replacement. To provide storm-water drainage, this new topping was sloped by increasing depth. During design, coring revealed actual topping thicknesses two to six times the original design thickness, significantly overloading the structure.

The solution was to use high-density foam in lieu of concrete between the waterproofing and topping, which reduced structural loading, provided proper slope for drainage by tapering the foam, and eliminated costs of reinforcing the structure.

UNIQUE ASPECTS

The Regency House Condominium Plaza parking garage repair is an extraordinary project that entailed implementing numerous and innovative repair methods and materials, which successfully mitigated severe structural deterioration, and effectively managed unforeseen conditions and complex construction logistics while increasing the lifecycle of the Plaza.

Regency House Condominium

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