Parking Structures Category

55 East Monroe Street Parking Garage Rehabilitation

Chicago, IL

Submitted by Klein & Hoffman, Inc.

The project encompassed a nine-story unheated parking structure at the base of a 52-story high-rise building in downtown Chicago, IL, constructed in 1970 to 1971. The parking structure needed to be repaired due to severe deterioration and also in anticipation of future residential tenants, as the top 15 floors were concurrently being developed into condominiums. The parking decks were flat plates constructed with lightweight concrete.

There are nine continuously sloped levels of parking, identified as P-1 through P-9, with the lowest deck starting three stories above the ground level. Two helical ramps provide access from the ground level to Level P-1. Retail space occupies the levels below the P1 deck, and there is a 41-story office tower above parking Level P-9.

Problems Needing Repair

Parking Levels P-1 and P-2 were repaired approximately 5 years earlier. After conducting a series of nondestructive tests, along with visual inspections and some limited observation openings, the levels were judged to be in acceptable condition and were excluded from this repair program.

Parking Levels P-3 to P-9 were badly deteriorated, especially on the top surfaces. Extensive repairs had been performed to these decks, many of which had failed. It was estimated that the extent of deterioration on the top side ranged from 30 to 70% of the surface areas. Although there was some delamination and cracking on the bottom surfaces of the decks, it was far less extensive than on the top surfaces.

The parking garage before rehabilitation

The suspected cause for many of the existing repair failures was due to the halo effect, or anodic ring effect, around the perimeter of the patches. The ICRI definition of anodic ring effect is a "corrosion process in which the steel reinforcement in concrete surrounding a repair area begins to corrode preferentially to reinforcement in the newly repaired area." Other factors contributing to the deterioration were insufficient bar coverage at various locations, extremely high chloride levels, and buried electrical conduits.

Project Challenges

Owner Issues

- The retail space beneath the parking decks was to remain open and the tower above the garage was to remain in use throughout the duration of the repairs;
- There was a major hotel across the street that was highly concerned about noise, especially at night; and
- As a result of the significant income generated, the owner wanted the garage to remain open and have a maximum amount of spaces available while the repair work progressed.

Contractor Issues

- An elevated mass transit system runs over the street directly west of the garage structure;
- The hours when certain aspects of the work could be performed were an issue; and
- The scheduling of work was complicated because:
  - The repairs had to be done quickly while the garage remained open;
  - Delivery of concrete to the work site was difficult due to major streets west, north, and south of the garage;
  - Removal of existing concrete and removal of debris from the work site was a challenge;
  - Shoring schemes would have to be carefully developed to facilitate temporary load conditions and vehicular movement within the garage; and
  - Traffic patterns within the garage during all phases of the construction had to be carefully developed maximizing the number of available parking spaces for each phase.

Engineering Issues

- No heat in the garage;
- Concerns regarding thermal movements considering that the length of the floor plate is over 350 ft (107 m) without an expansion joint;
- Changes in the building codes since the garage was built;
- Finding a design mixture closely resembling the original substrate concrete;
- Assessing temporary conditions during the duration of the work for structural adequacy; and
- Difficulty in determining the actual scope of work for bidding, considering that only a limited evaluation for the prepurchase survey was performed.

Project Approach

Many problems needed to be solved before the engineer could complete the construction documents including:

- The properties of the design mixture had to match the original substrate;
- The repairs had to be done in compliance with the current ACI 318, which, in many cases, conflicted with the original design; and
- The sequencing of the work by the contractor could impact the design.

With the addition of a contractor on the design team, an efficient design was developed from both a construction and engineering perspective. A bonded overlay was selected, as opposed to providing repairs only where required, because the long-term costs were considerably less.

Inspection/Evaluation Methods and Test Results

To solve some of the obvious construction issues and to test trial design mixtures, a mock-up was installed at Level P-9. In particular, the team was concerned about maintaining the quality of the lightweight concrete considering the concrete would have to be moved up three stories of helical ramps, along nine levels of 350 ft (107 m) length of parking ramps and up to a vertical distance of more than 112 ft (34 m) for some pours.

Two different bonding techniques were used:

- A conventional sand-slurry bonding agent; and
- A proprietary epoxy-based bonding agent.

Extensive testing of the mock-up was performed including:

- Tensile bond tests of the overlay to the substrate; and
- Cores were removed from both the mock-up and at other locations in the garage so that the design mixture could be formulated to match the existing substrate concrete as closely as possible.

The testing indicated that the quality of the lightweight overlay concrete was not affected by the distance of the pour from the truck. Better bond strength was achieved using the proprietary bonding agent. The initial design mixture, however, was rejected because the aggregates did not match the substrate closely enough.

Rapid transit and major streets surrounding the site. The retail space and parking levels occupied the lowest levels of the 52-story structure

Sequencing of full slab removal of column with 46 stories above it. The slab removal was done in four quadrants. Note shear collar at top of columns added to reestablished shear

Structural Analysis and Design

The original design was adequate except were there were significant code changes from the 1963 ACI 318 code used for the original design. The primary complex issues to solve were:

- Punching shear changes: The current code requires that unbalanced moments must be considered when checking for punching shear. Based on this requirement, the slab was significantly overstressed at many of the exterior columns. To solve this problem, the slab was tapered at the exterior walls to increase the thickness of the total slab.
- Detailing changes since 1963: ACI currently offers no guidance of how to handle detailing changes. Our approach was to comply with the code when possible and to assume that all other detailing issues would be grandfathered as acceptable.

Repair System Selection/ Repair Strategy

- Use of lightweight bonded overlay with a design mixture closely matching substrate concrete;
- Hydrodemolition would be used for concrete removal which provided an excellent profile for bonding an overlay;
- Most of the existing reinforcing could be reused if undamaged, having minimal corrosion, and if adequately cleaned;
- Passive cathodic protection was used to mitigate the halo effect where reinforcement extended into substrate concrete with the use of embedded galvanic anodes;
- Three gallons (11.3 L) of calcium nitrite was added to the design mixture to provide further protection against corrosion;
- The water-cement ratio of the concrete mixture was limited to approximately 0.40 to minimize cracking;
- The air content of the design mixture was limited to 6% at the point of discharge;
- A bull floated or broom finish was specified;
- A high-quality vehicular traffic bearing membrane was specified to be installed over all of the parking decks; and
- The traffic bearing membrane could only be installed when the manufacturer agreed that the moisture was low enough to satisfy their installation requirements. To avoid this issue, the contractor delayed the application of the membrane until all of the work was completed. To protect the completed work during the winter, a silane sealer was applied prior to the time when the city would use salt on the roads.

Tapering of slab to resolve punching shear issue

Anodes have been placed to mitigate the halo effect. Note that the additional top reinforcement has been placed around the column to meet current code requirements

The parking garage after rehabilitation

Ongoing Exchange of Information

Project meetings were held on a regular basis that always included the owner and the parking service representatives, as well as the contractor and engineer. The owner and the parking service representatives were informed at all times of the traffic patterns for each phase, the number of spaces available, and location of available spaces. Any issues that came up were discussed with the owner and contractor immediately.

The project was in large part successful because the owner, parking service representatives, contractor, and engineers worked together as a true team. What made this project unique and challenging was having to keep the garage open, with a maximum number of available spaces, while completing the repairs.

55 East Monroe Street Parking Garage

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GlenStar Properties, LLC
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Project Engineer/Designer
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Repair Contractor
Golf Construction
Hammond, Indiana

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