DOWNTOWN PARKING REVITALIZED

FIRST & JASPER PARKING DECK FLOOR SLAB REPLACEMENT

BY DARYL PREFONTAINE

The First & Jasper office tower and underground parking structure was constructed in 1974 on a busy corner of Edmonton, AB, Canada. The project originally included a 20-story office tower; movie theater; concourse shopping level; and an underground, reinforced concrete parking deck. The underground parking structure consists of a slab-on-ground and one suspended parking level, plus a suspended entrance/exit ramp structure providing access to the ground-floor level. The suspended parking level consists of 7 and 9 in. (180 and 230 mm) thick reinforced concrete slabs, supported on 16 in. deep x 48 in. wide (405 x 1220 mm) slab-bands, supported on interior columns and perimeter foundation walls.

Knowledge of the early history of the parking structure was lost due to changes in building ownership; however, it was apparent through inspection that concrete repairs and application of a traffic deck coating had been completed in the past, likely in the first 15 to 20 years of service. Another concrete repair and coating program was undertaken in 1998.

A series of structural evaluations of the reinforced concrete parking deck performed from 1997 to 2007 revealed ongoing and increasingly larger areas of concrete deterioration to the supported floor slab surfaces and soffits, and increasing wear, damage, and debonding of the thin waterproof traffic deck coating. In addition to the increasing amounts of corrosion-related concrete delamination at the slab surfaces, a series of chain-drag tests detected an increasing extent of "unsound" concrete that did not appear to be due to "typical" corrosion-induced concrete deterioration. The high magnitude of concrete deterioration warranted significant repairs to the parking structure.

EVALUATING THE STRUCTURE

In 2012, a retrofit of the entire office tower was planned to accommodate new tenant occupancy, and the opportunity to restore the underground parking deck arose as part of the program.

Subsequent to the initial evaluations, concrete core samples were obtained in locations where chain-drag testing detected unsound areas that did not appear to have the same characteristics as "typical" corrosion-induced concrete delaminations. These core samples revealed a horizontal plane separating two distinct layers of concrete—a top layer of relatively dense but partially honeycombed repair concrete overlying a lower-density original concrete slab. The interface between the concrete layers appeared sandy and dusty at many core locations, indicating possible poor substrate cleaning and preparation prior to placement of the previous repair concrete. In addition, the original concrete slab immediately below the interface was generally found to be very fractured and microcracked, possibly due to demolition and surface preparation techniques used during the earlier repair programs.

The concrete core testing also revealed that the original (1974) concrete was of significantly lower compressive strength than typical construction of that era, with compressive strength results ranging from 2500 to 2900 psi (17 to 20 MPa). Although not indicated on the original structural drawings, parking structures of that era were typically designed with a concrete strength of 3500 psi (24 MPa). Exposed steel reinforcement was found to be severely corroded at surface delaminations; however, reinforcement within core samples generally had little evidence of significant corrosion in the "unsound" but "non-delaminated" test areas.

Chloride ion testing revealed that significant levels of chloride contamination had accumulated in locations of slab surface and soffit deterioration, up to 22 times the threshold value required to initiate corrosion of the embedded steel reinforcing. Chloride testing included background testing in non-contaminated areas to assess if chloride-based admixtures had been added during the original construction. Sampling at various depths also aided in developing a chloride profile through the deck thickness.

Permeability testing of the existing traffic deck coating was performed by damming and flooding localized areas, then visually monitoring at the slab soffit for evidence of efflorescence and water seepage over 2 to 4 weeks. Material sampling and chain-drag testing of the existing coating was also performed. The testing indicated significant levels of pin-holing, cracking, debonding, and water leakage through the coating system and it was deter-

mined that the existing coating had exceeded its useful service life in most areas of the parking deck.

In consideration of the high magnitude of ongoing corrosion-related concrete deterioration, the low compressive strength of the original floor slab concrete, the high levels of chloride ion contamination, and the debonded interface at previous repair areas, it was determined that a significant reduction in the load-carrying capacity of the supported floor slab had occurred in localized areas. Structural repairs were considered necessary and recommended within the near-term to reinstate and maintain a safe load-carrying capacity for the underground parking deck structure. Based on the results of a life-cycle cost assessment comparing the forecasted future structural and maintenance repair requirements in comparison with a removal and replacement program, a long-term strategy was proposed that included full-depth removal and replacement of the majority of the existing reinforced concrete parking slab and slab-bands at the suspended parking level, in addition to re-waterproofing and drainage system replacement.

THE PROJECT'S CONCRETE REPAIR AND PROTECTION METHODOLOGY

Given that the existing underground parking deck and the office tower's columns, core walls, and perimeter basement walls were of reinforced concrete construction, concrete was selected as the most suitable structural framing material for the First & Jasper Parking Deck floor slab replacement project (Fig. 1). Alternative materials and framing systems were considered, but would have significantly reduced available headroom within the suspended and slab-on-ground parking levels and would have introduced unnecessary complexity, cost, and time to the repair program.

- Concrete materials were considered to provide the best opportunity to enhance the durability of the parking structure, and provide added value for the owner by minimizing future structural repair and maintenance requirements.
- Protective components were specified to better protect the new and existing embedded reinforcing steel against future corrosion. These included a corrosion-inhibiting admixture, supplementary cementitious materials, improved water drainage slopes, and increased concrete cover wherever possible alongside perimeter slab and column edge transitions.
- Traffic deck coatings were specified to protect and waterproof the new concrete parking deck surfaces prior to any vehicle traffic, thus limiting the exposure of the reinforced concrete structure to the corrosive effects of deicing compounds.
- The original design aesthetics, framing schemes, and layout of the parking levels were generally maintained with the restoration program; however, the reconstruction included replacement of the lighting and mechanical systems with new, higher-efficiency components and updated interior paint schemes and signage to improve the building aesthetics and functionality for the new building tenants.
- By reducing the size of a storage room, a small number of additional parking stalls were added. Handicapped parking stalls were also incorporated by elevator entrances to improve building functionality for disabled users of the facility.

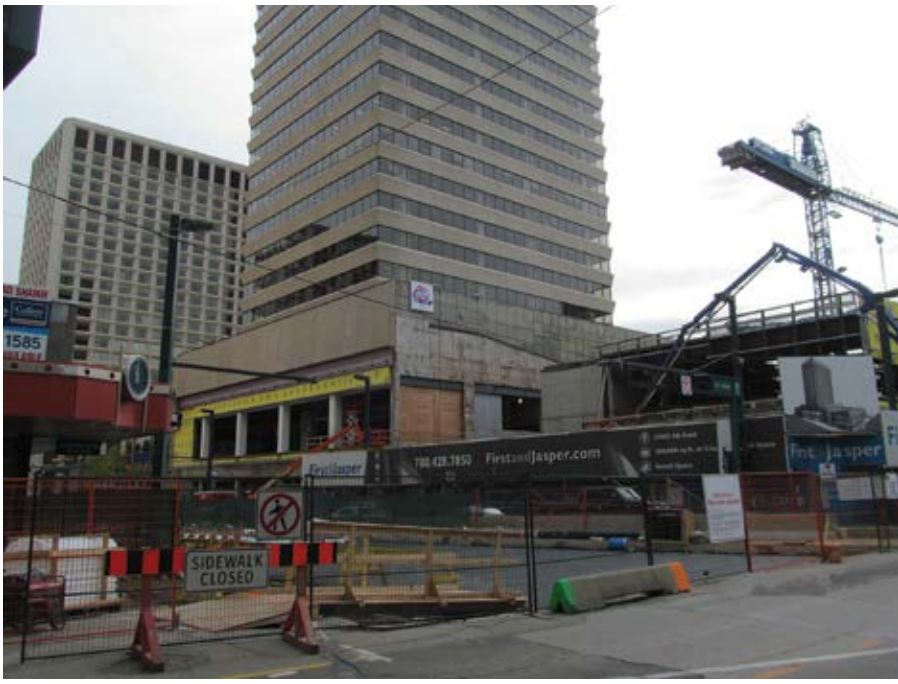

Fig. 1: Overall view of project site during construction

The reconstructed parking deck floor slab was designed and constructed in accordance with the requirements of CSA S413-07, "Parking Structures," and the latest update to the Alberta Building Code. This was intended to provide the owner with an essentially brand-new suspended parking deck structure that incorporated current state-of-the-art construction and durability enhancements.

As a result, the completed floor slab reconstruction provided significantly enhanced structural durability and added value for the owner, and is intended to minimize future structural repair and maintenance requirements. The use of new, high-quality, durable concrete mixtures; protective waterproof coating systems applied to new, non-chloride-contaminated parking deck surfaces; and improved surface drainage slopes all serve to provide the owner with an essentially new and significantly improved parking level in an existing facility. The completed parking deck restoration minimizes future structural maintenance and repair requirements and thus limits disruptions to the new building tenants in future years.

Fig. 2: Steel bracing members installed prior to concrete removal at core walls, columns, and perimeter walls. Plywood sheathing was applied to protect steel members from damage during the construction demolition process

Fig. 3: Typical column bracing along demolition phasing boundary. Demolition debris was stockpiled on slab-on-ground during some phases of work

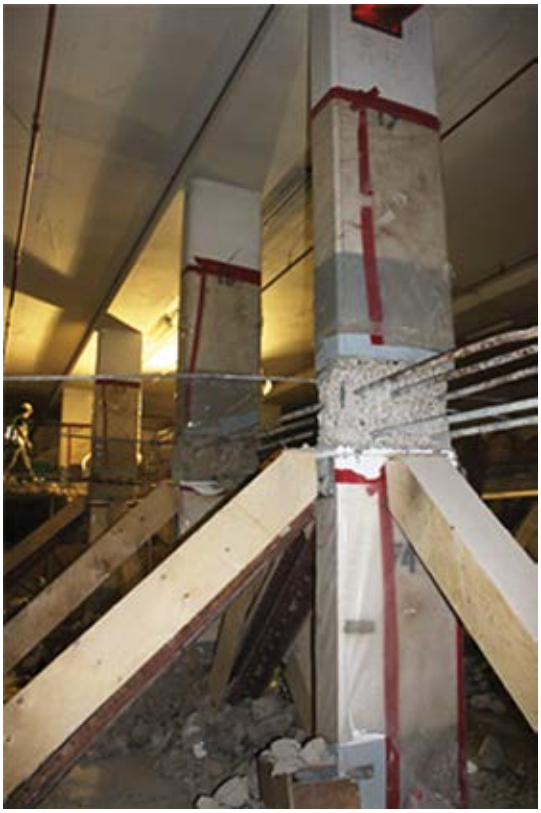

Fig. 4: Interior concrete columns braced to maintain load-carrying capacity

PROJECT COMPLEXITY AND REPAIR PROCESS EXECUTION

The significant complexity and challenges of the First & Jasper Parking Deck floor slab replacement project included maintaining the load-carrying capacity of the office tower's columns, core, and perimeter basement walls during the demolition and reconstruction work (Fig. 2). Removal of the underground supported parking level had the potential to reduce lateral support for the vertical structural members, thus creating a risk of localized or widespread structural failure or collapse. Lateral bracing assemblies were designed and incorporated into the repair methodology and the concrete demolition work and reconstruction of the parking deck floor slab was carefully sequenced and phased to ensure that structural failure or weakening of the office tower would not occur during the work (Fig. 3 through 5).

The structural risks were managed by carefully phasing and sequencing the demolition and reconstruction work to maximize the ability of the remaining portions of the existing concrete structure to provide continued lateral support for the office tower's vertical structural elements, which extended through the underground parking levels (Fig. 6 and 7). In addition, the strength of the new concrete elements were tested and monitored to ensure they had achieved sufficient strength and capacity to provide support for these critical concrete elements

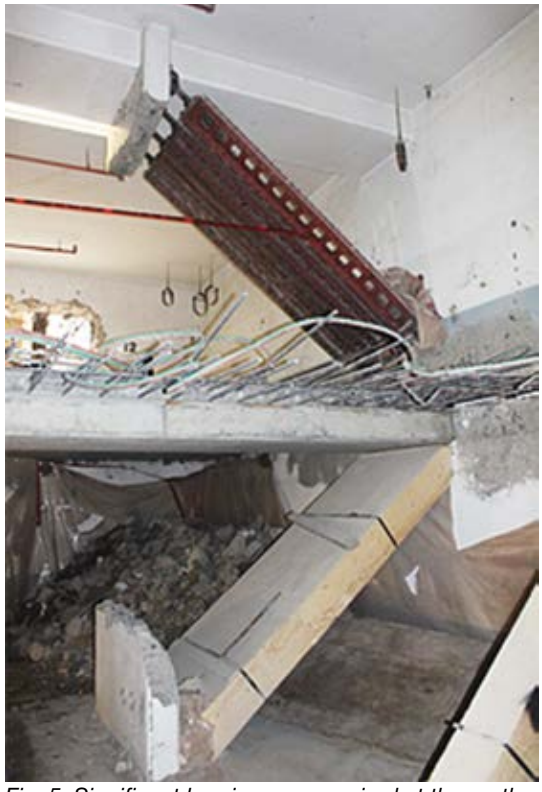

Fig. 5: Significant bracing was required at the north interior wall to ensure the stability of an adjacent LRT Pedway tunnel cantilevered from the building structure

Fig. 6: Slab demolition in progress

Fig. 7: Slab removal and replacement operations were carefully sequenced over several phases to maintain lateral support for the building walls and columns, while minimizing bracing and shoring requirements

prior to the removal of structural bracing. Sawcutting, slab demolition, and reconstruction phasing schemes were jointly developed via a strong and continued cooperative effort between the general contractor, the demolition and bracing subcontractors, and the structural engineering consultant.

During the project, a small number of unforeseen conditions and obstacles arose, which were quickly resolved by the project team without affecting the project schedule and cost:

- The long pumping run lengths required to provide ready mixed concrete to the underground parking level along with the corrosion-inhibiting admixture combined to cause some premature concrete setting during initial concrete placement phases. During a collaborative process, it was determined that the originally specified concrete mixture design could be modified to improve set times and finishing workability while still achieving the project's strength and durability requirements. Modifications included changes to cement, fly ash, and corrosion inhibitor content, and the addition of other admixture components.
- Reinforcing steel was missing in some locations, although anticipated based on the original construction documents. During the course of the repairs, it was possible to supplement and provide additional reinforcing bars and dowels at necessary locations.
- The contractor's access into the underground project site proved to be a challenge during demolition debris removal, forming, and concrete pouring operations. However, the general contractor was able to successfully coordinate access for all trades and complete the project in the confined working conditions.

Adjacent buildings and structures were carefully inspected and evaluated prior to the start of the demolition work, and again at the completion of the repairs. No weakening or damage was found to have occurred to the First & Jasper office tower structure or to the adjacent buildings, roadways, underground subway, and pedway tunnels.

As one of the critical keys to the project's success, the owner, structural engineering consultant, general contractor, and major subcontractors worked as a collaborative team, meeting regularly to identify and resolve upcoming phasing and site challenges. This collaborative approach enabled the project to be successfully accomplished while meeting the project's aggressive scheduling requirements and budgetary restraints. The parking deck floor slab removal and replacement project was completed on time and was delivered under budget by the project team.

SUSTAINABILITY IN MIND

Sustainable goals for the project were established early in the evaluation and preliminary design process. They were based on the premise that reconstruction of this existing, significantly deteriorated parking facility presented a more sustainable, long-term, and cost-effective alternative to an escalating series of localized structural repairs and maintenance over the remaining service life of the facility.

In addition to extending the useful service life of the underground parking facility's aging concrete infrastructure, the First & Jasper Parking Deck floor slab replacement program included several structural concrete initiatives for environmental sustainability, including:

- The incorporation of significant levels of fly ash (25% replacement of cement content) into the ready mixed concrete materials.
- Existing reinforcing steel was maintained, cleaned, and reincorporated into the new concrete parking level structure at perimeter slab edges, core walls, and where extending through interior column sections (Fig. 8).
- Additional new reinforcing was provided to supplement existing corroded bars, and as necessary to meet current code requirements for flexural, shear, progressive collapse, and integrity reinforcement (Fig. 9).

- The selection of a highly durable protective coating and sealant materials (Fig. 10).

In addition to the structural considerations, other environmental sustainability initiatives included the following:

- Original lighting fixtures were removed and replaced with higher-efficiency fixtures. Lighting levels were improved for vehicle and pedestrian traffic users of the facility while reducing overall power demands for this portion of the office tower.
- Mechanical upgrades included installing higher-capacity, corrosion-resistant floor drains and reusing portions of the original mechanical ductwork and sprinkler piping where possible.

In addition to reduced environmental impact, the cost savings represented by concrete restoration and renewal are significant when compared with the construction cost of a new parking structure. Coupled with proactive structural monitoring and maintenance, a concrete restoration program of this nature is a cost-effective and efficient way to sustain existing built infrastructure.

Fig. 8: Existing slab and slab-band reinforcing steel were maintained, abrasive-blast cleaned, and reincorporated into the new work at the perimeter walls, core walls, and interior columns

Fig. 9: Forming and placement of new reinforced parking deck floor slab prior to concrete placement

Fig. 10: Highly durable protective coating and sealant materials were used on the new parking deck floor slab surface

First & Jasper Parking Deck Floor Slab Replacement

OWNER (DURING PROJECT)
GE Canada Real Estate Equity Holding Company
Toronto, ON, Canada

OWNER (AT PRESENT)
GWL Realty Advisors Inc.
Edmonton, AB, Canada

STRUCTURAL ENGINEER
Read Jones Christoffersen Ltd.
Edmonton, AB, Canada

GENERAL CONTRACTOR
Ledcor Construction Ltd.
Edmonton, AB, Canada

CONCRETE SUPPLIER
Lafarge Concrete–Edmonton
Edmonton, AB, Canada

CONCRETE DEMOLITION
Quantum Murray LP
Calgary, AB, Canada

***Daryl Prefontaine**, BSc, MEng, LEED AP, P.Eng, is a Principal at Read Jones Christoffersen Ltd., in the Edmonton office's Building Science and Restoration group. He specializes in the evaluation and repair of concrete structures, and has over 25 years of experience in the design of new buildings and the restoration and protection of existing structures. Prefontaine received his BSc in civil engineering in 1985 and his master of engineering (structural) degree in 1995 from the University of Alberta, Edmonton, AB, Canada. He is a member of ICRI and the American Concrete Institute (ACI) and currently serves on ICRI Committee 150, ICRI Notes on ACI 562 Code Requirements.*