AWARD OF EXCELLENCE

PARKING STRUCTURES CATEGORY

Post-Tensioned Garage Repairs

TORONTO, ONTARIO, CANADA

SUBMITTED BY EDISON ENGINEERS, INC.

Underground parking garage structure at 275 Bamburgh Circle in Markham, Ontario.

Just north of the provincial capital of Toronto is the growing city of Markham, Ontario. Among many condominiums built in the mid-1980s is 275 Bamburgh Circle. The 18-story building's underground, two-level, parking garage structure was in need of repair to restore its structural integrity, protect the structure, and improve aesthetics. The 86,000 ft^2 (8,000 m^2) garage consists of a slab-on-grade and an intermediate suspended slab which is ⅓ conventionally reinforced and ⅔ post-tensioned (PT). Built in 1986, the suspended slab was constructed using a first-generation extruded PT system. This PT system is characterized by extruded plastic sheathing along the cable length and bare strand at the anchors. The garage had poor protection from moisture and salt, with caulked expansion joints and a penetrating sealer on the intermediate slab. After almost 30 years, it was time for the PT system to be assessed.

CONDITION ASSESSMENT

PT shop drawings were located in archived files from the original structural designer. Using these drawings, cables could be easily identified and located and made the investigation process more efficient (Fig. 1). During the garage assessment, a visual review was performed to identify locations where PT cable deterioration is more likely, such as leaking expansion joints. Forty-four (44) cables were assessed using penetration testing with a screwdriver and hammer. The test involves trying to wedge a flat-head screwdriver between the wires in a PT cable (Fig. 2). If penetration is achieved, the cable is likely not tensioned enough. The PT cables were categorized as totally loose, appears under-stressed, or appears adequately stressed. Three PT strands were found to be totally loose and in need of repair.

RESTORATION PROGRAM

As expected, the cables that were found to be totally loose were heavily corroded at anchors at leaking expansion joints. In addition, cables that had not initially been identified as loose at another expansion joint were severely corroded and individual wires in the strand had ruptured. Due to the heavy corrosion of the wires, the wires had bonded with each other and the failure was not identified by the penetration test carried out several feet away from the anchor.

During the repair project, concrete removals for conventional delaminated concrete repairs exposed additional cables, allowing for further PT testing within these open excavations. These new test openings revealed 11 additional loose cables in need of repair. After investigation, it was evident that many of the loose cables had not been damaged from corrosion.

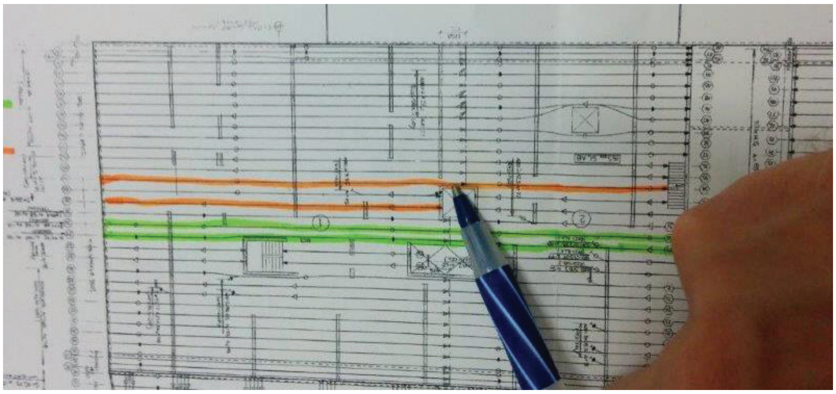

Fig. 1: Marked up PT shop drawing

Damaged Cables

Previous contractors' work had apparently drilled, cored, jackhammered and cut concrete without knowing that the slab was post-tensioned. At one location, the rupture location was traced back to a slab penetration for an electrical conduit (Fig. 3).

Another cable rupture was traced back to a locker room in the garage. This area was only exposed to foot traffic and was generally dry. The drilling of the anchors for the cage lockers was found to be the cause of the rupture.

Fig. 2: Penetration testing on PT cable

Finally, there were previous concrete repair areas that were found to be the source of PT cable deterioration (Fig. 4). The cables that intersected these repairs were severely corroded, the sheathing was damaged, and no waterproofing protection was applied to the surface. This condition allowed water and chlorides to reach the cables, causing aggressive corrosion.

Repairs

As is typical for PT repairs, each cable repair had to be customized to suit site conditions and the cause of failure. In addition to innovative repair methods, state-of-the-art repair materials were used to maximize durability while minimizing repair costs and disruptions.

Fig. 3: Electrical conduit (red arrow) and PT cables from top of slab

For cables that had been damaged by drilling but were otherwise in good condition, a splice repair was completed (Fig. 5), and the remainder of the cable including the anchors were salvaged. This repair saved time and was more economical than cable replacement.

Within some concrete repairs, there was minor corrosion of anchors and cable tails. In this case, sacrificial galvanic anodes were installed to reduce corrosion rates and extend the life of the PT system (Fig. 6). Within some previous concrete repairs, cables were found to be locally corroded due to poor cable protection. It is likely that the sheath was damaged during old concrete removals, and not properly sealed before placing concrete. At these locations, splice repairs were completed to salvage the remainder of the cable.

Fig. 4: Localized corrosion in previous concrete repair

One area included corroded anchors and cables along a construction joint in the slab. In order to safely repair the hollow sounding (delaminated) concrete at the intermediate anchors, fifteen (15) existing cables were de-tensioned and re-tensioned following the repairs. Temporary shoring would have been needed along the entire length of the affected cables. In order to avoid this costly repair, a zinc sheet was installed on the soffit of the slab (Fig. 7) to sacrificially corrode instead of the anchors and cables. Holes were drilled through the slab to reach the bottom of the anchors, and the zinc sheet was electrically

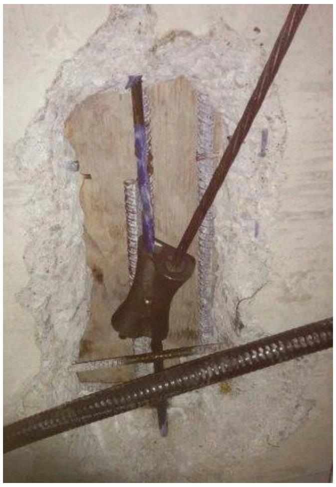

Fig. 5: "Dogbone" splice coupler

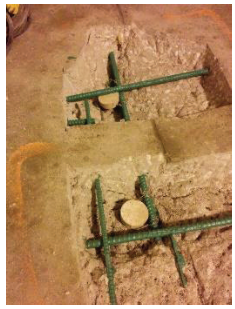

Fig. 6: Galvanic anodes in concrete repair area

Fig. 7: Sacrificial zinc sheet at slab soffit

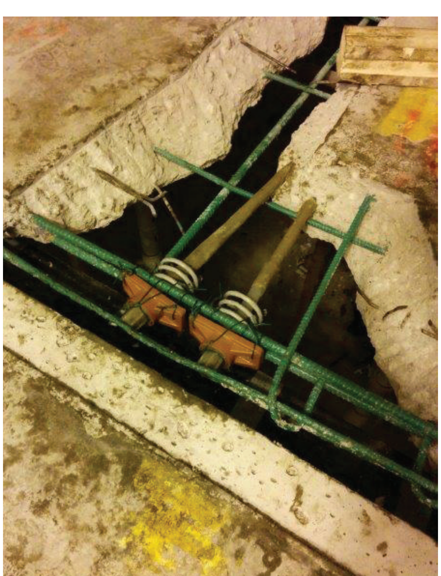

Fig. 8: New encapsulated PT anchors at expansion joint

connected to the intermediate anchors. The zinc sheet was approximately 20 ft (6 m) long. This repair provided a safe, cost-effective and timely solution for the Owner. The cables connected to the zinc sheet have test openings that can be re-tested in the future to check their tension. Eventually, the zinc sheet will need to be replaced but in the meantime, it will help protect the PT anchors and cables from corrosion.

Waterproofing Protection

Where new anchors were required, fully encapsulated and watertight anchors were installed (Fig. 8). Caulked expansion joint seals, that had failed many years ago, were replaced with new preformed neoprene glands.

Lastly, an elastomeric traffic deck coating system was installed to protect the concrete slab and the embedded PT system. A thinner light duty coating was used for the parking stalls which see less traffic, and a thicker coating was used for all drive lanes and turning locations.

CONCLUSION

Overall, the project finished under budget and on schedule. The cooperation between the owner, contractor and engineers allowed tailored solutions to be implemented successfully. A PT monitoring program has been implemented to test the cables periodically and will allow the condominium corporation to appropriately plan for repairs and have more confidence about the integrity of the PT system. ■

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