

# Post-Tensioned Concrete Structure Evaluation

By Michael Tabassi



*Severely deteriorated concrete soffit*

**P**ost-tensioned concrete structures often reveal very little about their lifetime condition until failure of the post-tensioning becomes evident. A thorough evaluation of the existing condition is essential to the safety and stability of the structure and provides an important tool regarding the repair or replacement of the concrete structure.

The idea behind post-tensioning is to balance or counteract a certain portion of the load imposed on the structure. It involves applying large tension stress to post-tensioning steel and anchoring the steel in a stretched condition at the ends of the concrete slabs or beams, thus imposing compressive forces in the concrete.

The post-tensioning (PT) system can either be bonded or unbonded. The bonded system will be secured to concrete, whereas the unbonded system, which is enclosed in grease, can move freely within the concrete. Modern PT steel may be constructed of wire, strand, or threaded rod. A system that is no longer used is the button head system, which consists of ¼-inch diameter wires made of 240 ksi steel, greased and wrapped in kraft paper. The most popular strand system today is ½ inch in diameter and consists of 7 individual wires twisted together with the strength of 270 ksi, greased and wrapped in plastic sheathing. Threaded rods can have a different diameter and are fabricated from 160 ksi ultimate tensile strength steel.

## Damage to Post-Tensioning Systems

For discussion purposes, we will concentrate on unbonded concrete monostrand and multistrand PT

positioning structure. The damage to PT cables can occur as a result of the following reasons:

- Core drilling for new pipes or equipment;
- Power drilling for installation of pipe hangers or other equipment that may need to be supported from the slab;
- Overloading the post-tension cables beyond their ultimate strength;
- The effect of salt brought to the garage by the cars on the unprotected portions of the strands at the anchor ends or intermediate anchors; or
- Corrosion of the PT steel, the anchors, or the wedges at grout plugs.

In addition, water can penetrate into the porous concrete and enter the protective post-tensioning sheathing through the exposed ends. This water can emulsify the protective grease and produce embrittlement of the strands. Corrosion and embrittlement of the PT strand can cause the strand to reach its ultimate strength and eventually break. When breakage occurs, it can be explosive, resulting in collapse of the released strand upon itself, and, in some cases, exploding out of the structure at the ends or at locations where shallow concrete covers exist.

## Evaluation

Although other techniques of evaluation are available, most engineering evaluations of PT parking structures will include some or all of the following techniques during an investigation:

- Removal of random grout plugs to test the anchors;
- Inspection pits at tendon low points and examination of the strands for corrosion, pitting, grease emulsification, and presence of water;
- Inspection of tension in the cable using screwdrivers, crowbars, and lift-off; and
- Extraction of cables for corrosion and metallurgical examination as well as examination for wire breakage.

The investigation may reveal three things: a minor concrete spalling without any PT damage, moderate spalling and a small number of cables in need of repair or replacement, or moderate spalling and many cables in need of repair or replacement. The best strategy in regard to the first two scenarios involves repair, as this is usually the most cost-effective option. However, the final case should be evaluated based not only on cost, but on the long-term usage of the structure as well. Thus, it is



*Severely corroded and/or broken PT cables at intermediate stressing location*

important to consider repair costs and estimate the long-term maintenance costs in comparison to the cost of total removal and replacement of the slab.

## Case Study

As a case study for the third scenario, consulting engineers were retained to evaluate the condition of the PT elevated slab and PT mat foundation slab at the Gadsby Holiday Inn in Alexandria, Virginia. After careful survey and inspection of this garage, the engineers determined that the elevated slab required removal and replacement of almost all of the PT cables due to corrosion and breakage. Approximately 10% of the cables within the mat foundation required repairs. The cost analysis revealed that replacement of the PT elevated slab with a conventional reinforced slab offered a more cost-effective alternative than repair of the concrete spalls and PT breakage. However, for the mat foundation, it was more cost-effective to simply repair the slab and cables.

The Gadsby Holiday Inn is located in the heart of Old Town in Alexandria, Virginia. It is a popular hotel that caters to corporations and government agencies for conferences as well as to its many guests. Typically, most removal methods produce large amounts of noise during the process, which could not be tolerated during normal hotel operation. Along with the contractor, the design team decided to use a mobile hydraulic demolition machine to remove the existing concrete PT slab. After detensioning the post tensioning, the slab was extracted without cutting the existing reinforcing bars along the columns and walls. The 37,000-ft<sup>2</sup>



*Photo shows replace concrete slab with striping and freshly painted walls and columns*

slab was removed in 3 weeks. The total cost of removal and replacement of the slab in addition to installing new lights, sprinkler system, and painting of the garage was \$1,127,000.

The circumstances found at the Holiday Inn in Alexandria, VA are quite common and are typical in buildings of this age in most major U.S. cities. The conditions have been ongoing for years and no longer represent minor repair issues. A professional engineer with adequate experience in PT structures must routinely examine structures with these types of systems. ICRI's task group on Evaluation of Unbonded Post-Tensioned Structures is currently developing a "Guideline for the Evaluation of Unbonded Post-Tensioned Concrete Structures," which will greatly assist in the evaluation and detection of PT problems and issues. Additionally, if repairs are required, they should be performed by experienced contractors before the structure reaches an unsafe condition or repair is no longer a viable solution due to the excessive cost.

## Gadsby Holiday Inn

### Engineer

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### Contractor

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