

# Post-Tensioned Balcony Slab Evaluation and Repair

By James A. Wilson

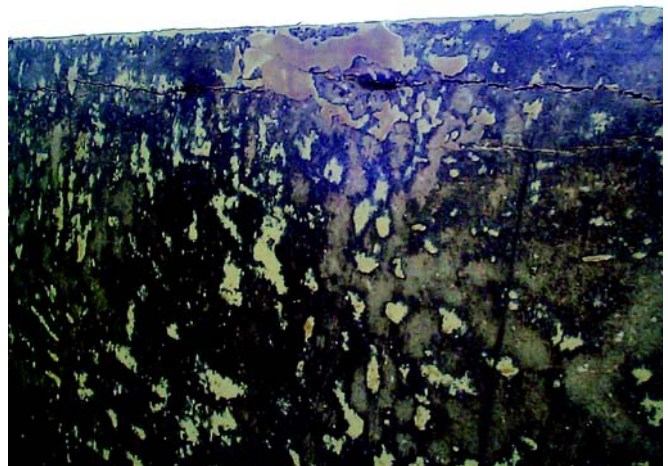
**M**any high-rise residential structures are constructed using post-tensioned slab reinforcement. Post-tensioning offers several advantages over other types of structural systems, which is why it is often used in multifamily residential construction. Some of the advantages of post-tensioned construction are that it allows the builder/developer to build more floors of living space within the limits of a given building elevation, add longer cantilever balcony slab spans, and increase the interior column spacing (which translates into larger room sizes), all of which improve the marketability of the building.

The typical post-tensioned two-way slab system uses 1/2 in. (1.3 cm) diameter seven-wire steel

strands that are anchored at each end but remain permanently free to move within the slab, as they are unbonded and encased within a plastic sheathing. This assembly of strand and anchors is referred to as a tendon and these tendons are the primary means of reinforcing the slab. Each 1/2 in. (1.3 cm) tendon is usually stressed to a load equal to 33,000 lb (15,000 kg) of force. In most residential buildings, the tendons are placed in two directions. In one direction, the tendons are evenly spaced approximately every 16 to 24 in. (41 to 61 cm) on center and are referred to as the uniform tendons. Running perpendicular to the uniform tendons are the band tendons. These tendons are usually spaced approximately 6 to 12 in. (15 to 30 cm) apart in very tight



*Anchor with spalled concrete exposing corroded bursting bars*



*Balcony slab edge with severe cracks, evidence of corroded bursting bars*



*Anchors with spalled concrete exposing corroded bursting bars*



*Balcony slab edge showing previous repairs that have failed and are spalling*



groups and are concentrated over the lines of columns within the structure.

Advancements in the post-tension manufacturing industry have led to improved corrosion-resistant tendons, but there remain problems associated with post-tensioned durability. One of the most pervasive yet misunderstood problems is related to corrosion damage associated with the conventional mild steel reinforcement used at the slab edge to support the anchors at the tendon ends. The typical end anchor is within 3 to 6 in. (8 to 15 cm) of the slab edge and is supported by two pieces of steel reinforcing bars (not post-tensioned) that generally run perpendicular to the anchors and parallel to the slab edge. These reinforcing bars are commonly referred to as bursting bars because they restrain the very high tensile bursting forces concentrated in the concrete behind the anchors. It is these bursting bars that are a major source of durability problems associated with post-tensioned slabs.

## Is This a Post-Tension Problem?

One of the most common forms of balcony problems in our area (coastal South Florida) is corrosion-related cracking and spalling of balcony slab edges. This problem is exacerbated by the building's proximity to the ocean and the resulting increased levels of chlorides found in exposed concrete elements. These higher levels of chlorides lead to a significant increase in corrosion potential within the exposed concrete slabs. Absorption of chlorides over time causes much of the cracking and spalling problems that are often seen in these structures.

Structural engineers and property managers may be well informed about corrosion-related concrete repair issues but sometimes do not recognize the significance of these issues in the context of a post-tensioned structure. This can lead to a dilemma when the need arises to repair the slab edges due to corrosion of the steel bursting bars, particularly if the exposed portions of the post-tension anchors and strand



*Anchor with spalled concrete exposing corroded bursting bars*



*Top edge of slab showing improper repair demolition (Note corroded reinforcing steel and cracks in concrete behind anchor)*



*Anchor that is still under tension and has burst out of concrete during repair demolition*



*Improper slab edge repair that has failed (Note new mortar on top, old substrate below, and bursting bars sandwiched between)*



do not appear to be equally corroded. The obvious question is: Do you have a post-tension problem?

## Repair of the Slab Edge

In many cases, the answer to that question is yes. However, this is one of the most misunderstood and overlooked issues related to the inspection and repair of balcony slabs. What many often fail to recognize is how important the relationship is between the need to repair corrosion-damaged bursting bars at the slab edges and the



*Improper slab edge repair that has failed  
(Note bursting bars and anchor are sandwiched  
between new mortar and old concrete)*

often-difficult issue of accounting for the impact on the post-tensioning.

One mistake that is often made out of ignorance or budgetary constraints is the removal and replacement of concrete from the slab edge up to, but not around and behind, the bursting bars and post-tension anchors. This leads to an incomplete and improper repair of the damaged area.

If the bursting bars are not properly excavated during the repair, then the existing reinforcing bar and post-tension anchors will be sandwiched between the old concrete and the new repair mortar. This sandwiching of the reinforcing bar between two vastly dissimilar concrete materials creates an accelerated corrosion condition. Rather than fixing the slab edge, a new problem has been created that is at least equal to or arguably of greater magnitude than the original condition.

In the American Concrete Institute (ACI) Committee Report 546R-96, "Concrete Repair Guide," it is stated in Section 2.4 that "The most inexpensive (on a short-term basis) and common approach to repair of deterioration resulting from reinforcement corrosion is to replace concrete only where spalls or delaminations have occurred. Generally, this approach leaves chloride-contaminated concrete surrounding the repaired area which is highly conductive to corrosion. The repairs may actually aggravate corrosion in the area adjacent to them."

It is further stated in Section 3.2 of another ACI Committee Report, 222R-96, "Corrosion of



*Correct repair of post-tensioned slab edge/beam*



*View of same area before repair*

Metals in Concrete,” that when “some of the steel is in contact with chloride-contaminated concrete while other steel is in chloride free concrete...this creates a macroscopic corrosion cell that can possess a large driving voltage and a large cathode to small anode ratio which accelerates the rate of corrosion.”

Most engineers in the concrete repair industry subscribe to the concrete preparation guidelines outlined by ICRI. ICRI conventions on excavation around embedded reinforcement call for a minimum clearance of 3/4 in. (2 cm) (or 1/4 in. [0.6 cm] greater than the largest aggregate) behind the reinforcing bar. If this recommendation is followed, then the concrete around and behind the bursting bars and post-tensioned anchors must be removed. Due to the enormous loads residing on the anchors, however, the concrete cannot be safely removed while the anchors are still under tension.

What this means is that in order to properly excavate the corroded reinforcing bar at the slab edge, the post-tensioning forces must be temporarily relocated from the existing anchors at the slab edge to an anchor inserted elsewhere on the effected tendon. The slab edge can now be properly repaired and the post-tensioning restored to its original configuration.

## How to Lower the Repair Costs

It is important to understand that the inclusion of post-tension work has a significant impact on the overall cost of the repair project. In many cases, the value of the post-tension-related work is at least equal to or greater than the cost of the concrete slab repair items. Knowing the full extent of work required on a given project empowers the owners and allows them to negotiate the lowest and best cost for the repairs. If the post-tension work is not fully accounted for prior to the solicitation of bids and it is later determined to be a larger part of the overall balcony repair project, then the owner may have lost his or her leverage to negotiate with the contractor and may pay a higher cost for the work.

## From Inspection to a Successful Building Repair

Experience has proven that successful post-tensioned structural repair projects have several things in common. Most of these projects started with an owner and a structural engineer that recognized and acknowledged the significance of corrosion-related damage on the post-tensioned structure. This knowledge allows the structural engineer to investigate the structural damage and to account for its impact on the post-tension reinforcement. By documenting the full extent of all known scopes of repair work, the owner can adequately budget for the upcoming repair project.



*“Text book” repair of slab edge (Note the temporary lock off and slab edge with excavation per ICRI guidelines)*



*Close-up of balcony slab edge with spalled concrete exposing corroded bursting bars*

More importantly, the owner can competitively negotiate with the prospective contractors for their lowest prices.

Cutting corners on the concrete repairs by not following industry demolition and repair standards, or hoping and wishing that the concrete damage would not have much impact on the post-tensioned reinforcement, is a recipe for disaster. At best, the owner may still have the structure properly repaired, but at a much higher cost. At worst, the structure may be improperly repaired by covering up the problem, only to require extensive re-repair of the same areas in just a few short years.

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