Evaluation and Repair Strategies for Post-Tensioned Slabs

By David Rodler

The evaluation of a post-tensioned slab suffering corrosion-related concrete deterioration presents several difficulties for the restoration consultant or contractor. The first question the owner wants answered is "How much is this going to cost?" The answer to this question, unfortunately, can never be known with much certainty until the project has been completed. The final cost will be affected significantly by the methodology used during the repair to uncover corrosion-related problems with the post-tensioned cables, and the judgment used in deciding whether the level of corrosion observed on a cable or anchor warrants replacement. There are, however, choices for the owner to make during the initial evaluation that can have an effect on the accuracy of the estimate. The level of exploratory demolition and testing prior to preparation of the repair estimate will affect the accuracy of the estimate, and the owner should be informed of the different methods available. The following is a summary of the tools available for the initial evaluation of the post-tensioned slab and a review of the different approaches that may be taken during the repair with regard to repair or replacement of post-tensioned cables.

Initial Evaluation

The first step in the evaluation of a post-tensioned slab should be to **determine the post-tensioned hardware used.** A paper-wrapped monostrand or button-head system has far less corrosion protection than an extruded sheathing system. A cigarette-wrapped system is more likely to suffer water penetration into the sheathing than an extruded system. Plastic sheathings will tend to collect water at low points in the cable profile, causing corrosion at the low points, and paper-wrapped systems will be more likely to have corrosion at the top of the slab. Knowledge of the post-tensioned hardware and details of hardware at construction joints will help in the investigative stage to focus on the potential problem areas within the slab.

Next, a **complete sounding of the slab** with a chain drag and mason's hammer is needed. Delaminated areas should be located and quantified on a plan view drawing of the slab, and visible post-tensioned cables that are broken should also be noted on the plan. At this point in the investigation, there is a working knowledge of the post-tensioned hardware and the extent and location of corrosion related concrete delaminations. Broken post-tensioned cables, which are visible, have been located and quantified. The number of broken or corroded post-tensioned cables, which were not visible on the surface of the slab, is still unknown.

The options available to determine the extent of corrosion or failure of post-tensioned cables within the slab include:

- Exploratory demolition;
- X-rays;
- Lift-off stress tests at anchors;
- Ferroscan tests; and
- Load testing.

The extent to which any of the above methods is used should be discussed with the owner. It may not be practical to test a significant portion of the cables due to cost or access limitations. Exploratory demolition in delaminated areas of the slab may, however, be revealing even on a limited basis. Figure 1 shows an exploratory demolition area that uncovered several broken and severely corroded cables in an area with only one visible broken cable prior to the demolition. A previous repair can also be seen in Figure 1. Previous repairs should be suspect if no documentation is available, as broken cables may have been abandoned within the repairs.

Figure 2 shows a construction joint soffit in a slab reinforced with paper-wrapped button-head post-tensioned wires. It is clear from the photograph that water penetration through the construction joint has caused significant corrosion to the anchorage hardware and cables. Construction joints are a good place to perform exploratory demolition for the purpose of estimating the extent of cable repairs that will be needed.

The degree of certainty with which the estimate of post-tension cable repair costs is given and the size of the recommended contingency for the project should be tied to the level of testing

performed in formulating the estimate. The owner, or anyone reading the condition survey report, should understand what is known, and what is only an educated guess with respect to the potential cost of the post-tensioned cable repairs.

Repair Guidelines During Construction

The actual repair methods for broken post-tensioned cables are well established. The more subjective question is when to de-stress a cable and replace it due to corrosion but prior to failure. It is often not practical to be too rigid in requiring replacement of cables with minor corrosion, as the cost of the project can spiral out of control. As a starting point, the following methods should be considered:

- Do not leave broken cables in the slab, even if the live load capacity of the slab exceeds code required levels, as this will most likely not be documented properly, and there is always the possibility that broken cables will go undetected. A consistent position that all broken cables found will be repaired is easier to explain upon review of the project by others;
- Cables with one wire broken due to corrosion that have not yet failed should be de-stressed and repaired;
- Cables with significant corrosion pitting that have not yet failed should be de-stressed and repaired;
- Anchor wedges with significant corrosion scale should be replaced; and
- New cable splice repairs should be stressed to a load higher than the service load to help determine whether there are other weak spots on the cable due to corrosion. The load can then be reduced to the service load if no failure occurs. Frictional losses for a splice repair will not be of the same level as losses for a new cable. There are different approaches to the level of overstress during repair, but the final lock-off stress is typically the service load for splice repairs, and a stress compensation for losses is used for cable replacements.

Notice the word "significant" in two of the five guidelines. This is an indication that regardless of good methodology, judgment will enter into the decisions made during construction. Again, it is most important that judgments be consistent and well documented.

All delaminated areas in the slab should be demolished, allowing for direct examination of the cables within these areas. Areas outside of concrete delaminations should be investigated by exploratory demolition during construction if there is evidence of the potential for cable failures. The factors to consider for determining the location and extent of demolition outside of concrete delaminations include the post-tensioned cable hardware, the details for anchorages at construction joints, and the results of any exploratory demolition or non-destructive testing performed during the investigation of the slab.

Fig. 1

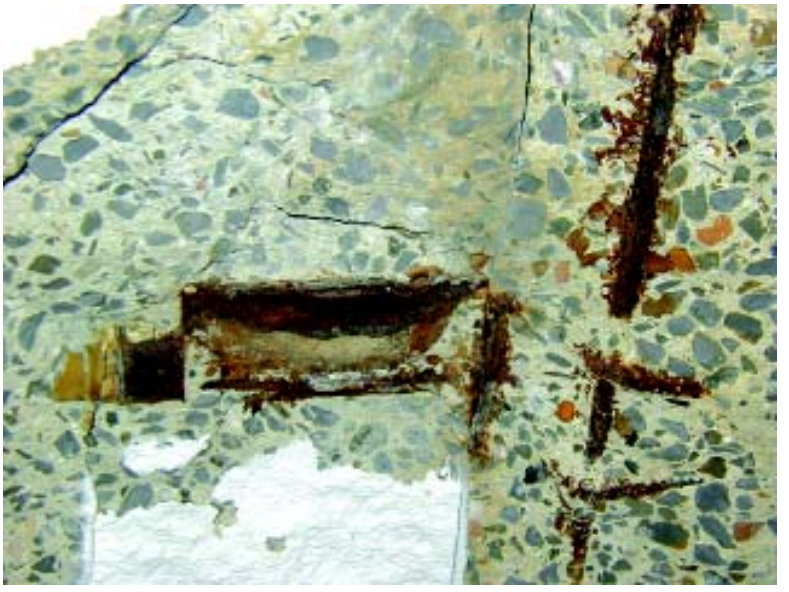

Fig. 2

ICRI member David Rodler, PE, is a Principal with Smislova, Kehnemui & Associates in Rockville, Maryland. Over the past 11 years, he has performed or supervised the investigation and repair inspection of over 100 parking garages in the Washington, DC, metropolitan area. He received a BSE from Tulane University in 1986, and a MSE from the University of Texas-Austin in 1987.