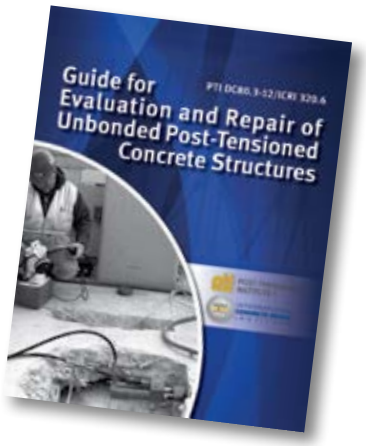
INTRODUCTION TO THE ICRI/PTI JOINT DOCUMENT PTI DC80.3-12/ICRI 320.6,

GUIDE FOR EVALUATION AND REPAIR OF UNBONDED POST-TENSIONED CONCRETE STRUCTURES



BY GABRIEL A. JIMENEZ

The use of unbonded post-tensioned (PT) reinforcement in concrete structures has been popular for many decades. The use of PT reinforcement in concrete structures greatly reduces the amount of cracking and possible leakage into the structure while providing economical long-term possibilities. The construction boom of PT structures in the United States began in the 1960s and coincides with the heavy use of deicing products. Many of these early PT structures have been encountered in a deteriorated condition, with varying degrees of damage to the post-tensioning systems themselves.

The restoration team (consultants and contractors) needs an effective strategy for evaluating the condition of the structure (the post-tensioning system in particular), identifying appropriate repair concepts for the PT system, and making the most appropriate selection of repair methods to meet the owners' short- and long-term needs. Without an appropriate methodology, inappropriate decisions based on incorrect assumptions regarding the repair strategy and durability of the PT system can be made.

To assist owners, design professionals, contractors, suppliers, and other interested parties with the procedures, tests, equipment, and other aspects of the evaluation and repair process, ICRI and the Post-Tensioning Institute (PTI) joined forces to develop a comprehensive guideline. This article provides a summary of the key sections encountered in this new guideline.

DESCRIPTION OF THE GUIDELINE

This new Guideline, PTI DC80.3-12/ICRI 320.6, "Guide for Evaluation and Repair of Unbonded Post-Tensioned Concrete Structures," is comprised of five sections:

1. Introduction and Scope;
2. Notation and Definitions;
3. Evaluation;
4. Repair; and
5. References.

SECTION 1, INTRODUCTION AND SCOPE

The first section provides a brief discussion regarding the scope and limitations of the structural systems contained in this guideline, and emphasizes the importance of having an experienced team for the evaluation and repair of PT structures. The guideline recommends that all firms and on-site supervisory personnel have a minimum of 5 years of experience working with PT systems, including certification in PTI training programs, such as the PTI Level 1 Unbonded PT – Field Installation program.

SECTION 2, NOTATION AND DEFINITIONS

This section includes basic definitions devoted to clarify the location of the PT anchoring system and the protective PT coating.

SECTION 3, EVALUATION

Outlines of detailed protocols for the evaluation of PT systems are contained in Section 3. It begins by discussing the characteristics of PT concrete systems and the corrosion performance of paper-wrapped systems (Fig. 1), heat-sealed systems (Fig. 2), and button-headed wire tendons.

The initial phase in the restoration and maintenance of a PT structure begins with a comprehensive condition assessment of the facility. The condition assessment requires an in-depth review of existing conditions by performing visual observations of each structural component, identifying materials used in the structure, and conducting nondestructive testing. Recommendations for the evaluation process are discussed in the guideline and include:

Document Review

The first step in preparing for the condition assessment is to collect and review plans, specifica-

Fig. 1: Paper-wrapped tendon with corrosion deposits

Fig. 3: Schematic view of concrete spalls in a PT slab

Fig. 2: Exposed strand with severe corrosion and wire section loss for a push-through system

Fig. 4: Corrosion potential testing of mild reinforcement in the vicinity of PT tendons

tions, and miscellaneous information regarding the PT structure. The history of maintenance performed on the structure is also useful.

Visual Examination

During this portion of the assessment, deterioration in members is identified and recorded in the field survey sheets using a task item notation. The noted deterioration needs to be documented by means of photographs and should include:

- Documenting the size, location, and depth of spalling and scaling on floor surfaces (Fig. 3), beams, columns, and ceilings;
- Recording cracks, crack patterns, types, widths, and lengths;
- Documenting the location and condition of the expansion and construction joint systems;
- Determining the location and condition of drains;
- Locations of exploratory openings; and
- Locations for material testing, including the locations for nondestructive evaluations.

The author suggests that the evaluation data for the top of a floor slab be entered on a different sheet than the underside of a slab and that a task item legend with a different color coding be used, particularly when extensive deterioration is encountered.

Testing

In conjunction with the walk-through examination, it is necessary to perform materials and nondestructive testing to supplement the results of the visual observations. The testing assists in verifying the extent of deterioration and evaluating the condition of the existing structure. The selection of the types, location, and amount of testing should be consistent with the size of the structure so that the results are statistically meaningful. The tests recommended in this guideline are:

Instrumental Testing

- Acoustic testing/hammer sounding
- Impact-echo
- Impulse response
- Cover meter
- Ground-penetrating radar
- X-ray

Fig. 5: Overview of screwdriver penetration test

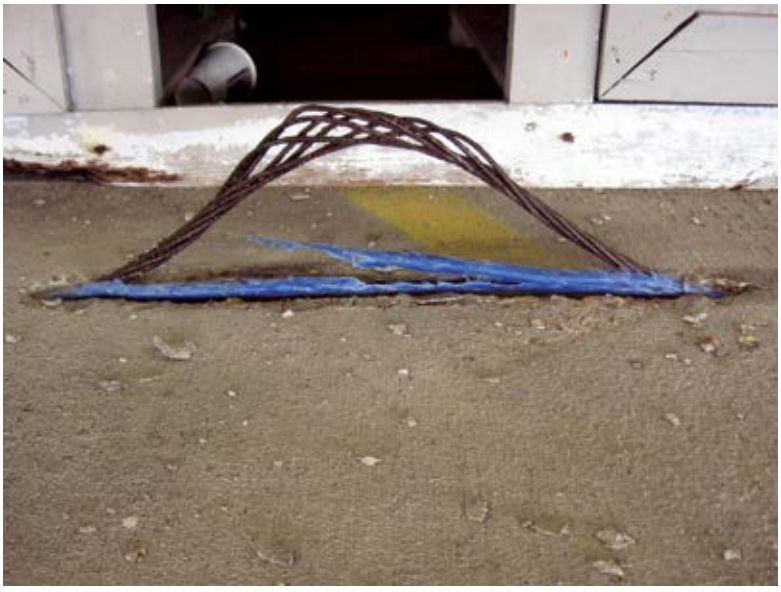


Fig. 6: Post-tensioning tendon failure due to corrosion at high point

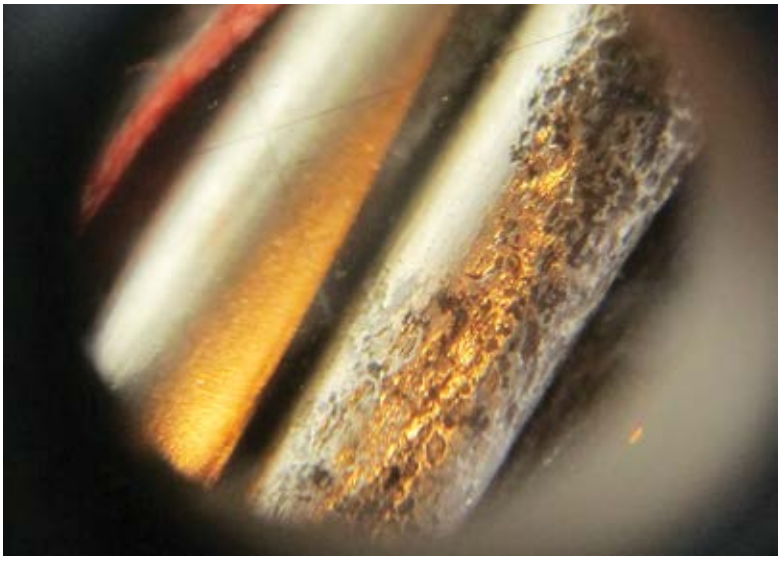


Fig. 7: Close-up view of PT strand using a borescope

- Rebound hammer
- Corrosion potential testing (Fig. 4)
- Acoustic monitoring

Exploratory Investigation

- Screwdriver penetration test (Fig. 5)
- In-place strand tension test
- High-point/low-point inspections (Fig. 6)
- Anchor inspection
- Lift-off testing
- Strand extraction
- Grease inspection and testing
- Borescope (Fig. 7)
- Core sampling
- Load test

Material Testing

- Compressive strength
- Petrographic examination
- Chloride content
- Carbonation
- Metallurgical and physical examination of the prestressing steel strand

SECTION 4, REPAIR

This section begins by highlighting various important characteristics that a repair team must have when dealing with the restoration of PT structures and also provides important design considerations regarding the original design loads and strength evaluation. In addition, this guideline presents various contract methodologies that can be used between the owner and contractor and basic considerations for the preparation of repair documents, including general notes, plans, submittals, pre-bid meeting, construction meetings, products, execution, and safety plans.

The restoration of PT structures requires the use of several repair methods to address deterioration of structural members while providing effective protection to extend the service life of the repaired structure. Once the condition assessment is performed, the findings are used to select the appropriate repair methods and materials discussed in this guideline.

To provide appropriate shoring and bracing during the repair sequencing, experienced personnel need to gain an in-depth understanding of the structural system. One major concern is the effects of tendon detensioning that can be experienced along the entire length of the PT tendon. Design professionals who specialize in the PT field typically follow repair strategies that include:

1. No tendon repair;
2. Selective abandonment;
3. Repair;
4. Tendon supplement/replacement;
5. Selective or full structure replacement; and
6. Stabilization/strengthening.

The guide also examines procedures to be followed for the most common types of PT repairs: partial and complete tendon replacement. To perform these repairs, the guideline discusses tendon detensioning, saw cutting or flame cutting of tendons, detensioning at anchor points, and the splicing of various types of tendons. The guideline also looks at tensioning, stressing procedures and equipment, design and repair forces, and other considerations for tendon-related repairs.

Partial Tendon Replacement

Partial tendon replacement is recommended in slab tendons where the corrosion or deterioration is localized. Common locations for this type of repair are the high points of tendons and at construction joints. The affected section of the tendon is replaced by a new section that is attached to the existing tendon by couplers, as shown in Fig. 8. In the case of a button-headed system, the repair follows a similar procedure using threaded rods, wire splices, and a combination of button-headed hardware with monostrand replacement tendons, as shown in Fig. 9.

Complete Tendon Replacement

Where multiple failures of the same and adjacent tendons occur, complete tendon replacement should be considered. With this approach, the existing deteriorated tendon is removed or abandoned and a new tendon is installed. For monostrand systems, strand replacement eliminates tendon components where hidden corrosion could result in future failures.

After completing repairs, special attention should be given to waterproofing details to isolate the PT system from the environment. Critical areas that need to be addressed are discussed in the guideline and include joints and cracks, the bond line between new repair materials and the substrate, expansion joints, and the concrete surface.

The end of Section 4 is devoted to strengthening of structures using external post-tensioning. The guide provides conceptual schemes on how to strengthen a deficient structure using external PT for both one-way and two-way systems. External post-tensioning works well when the structure in question has design or construction deficiencies, loss of strength due to deterioration, change of building use, or change in code requirements.

MAKING INFORMED DECISIONS

The initial selection of appropriate repair concepts and the final selection of the optimum repair scheme can only be made after an appropriate evaluation process of the PT structure. The new ICRI/PTI guideline provides useful information to the repair team to address the evaluation and repair of PT structures.

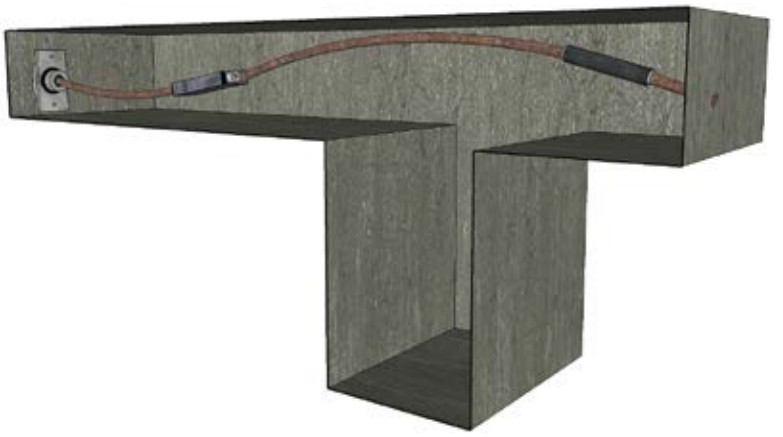


Fig. 8: Schematic view of partial tendon replacement for unbonded monostrand system

Fig. 9: Monostrand to wire system splice

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