Report on Corrosion and Repair of Unbonded Single-Strand Tendons

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Reported by Joint ACI-ASCE Committee 423

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This report gives general information regarding evaluating corrosion damage in structures reinforced with unbonded single-strand post-tensioning tendons. Historical development of those parts of the building code dealing with durability and corrosion protection is explained. Evolution of the types and components of unbonded tendons is described. Specific aspects of corrosion in unbonded single-strand tendons are described, and common problems in structures reinforced with these tendons are discussed. Methods are presented for repairing, replacing, and supplementing tendons.

Keywords: allowable stresses; anchorage; carbonation; concrete construction; corrosion; corrosion protection; cover; durability; embrittlement; external post-tensioning; post-tensioned concrete; prestressed concrete; sheathing; single-strand tendons; unbonded post-tensioning.

CONTENTS

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CHAPTER 1—INTRODUCTION

1.1—General

This report provides general information on the evaluation of known or suspected corrosion problems in unbonded single-strand tendons, historical information on the types and components of unbonded tendons and on the durability and corrosion protection provisions in the building code, and describes typical repair methods in use today. Expertise in design, construction, evaluation, and repair of structures using single-strand unbonded tendons is strongly recommended for a team undertaking evaluation and repair of corrosion problems.

Historically, there have been corrosion problems with other types of pre- and post-tensioning systems (Nehil 1991); however, certain aspects of corrosion of unbonded single-strand tendons are unique. The causes and effects of corrosion of unbonded single-strand tendons are, in several respects, different from those of bonded conventional reinforcing or other post-tensioning (PT) systems, so the methods for evaluating and repairing corrosion of single-strand tendons are also different. For example, because the tendons are largely isolated from the surrounding concrete, they may not be affected by deleterious materials such as chlorides and moisture in the concrete. The surrounding concrete does not stop corrosion alone because, if water gains access to the inside of the sheathing, PT coating is rendered ineffective. Measures taken to repair and protect the surrounding concrete may not repair or reduce deterioration of the prestressing steel where corrosion has been initiated. The tendons usually require separate evaluation and repair.

1.2—Background

Unbonded PT systems were introduced to North America in the 1950s. At that time, there were no accepted standards for design or material specifications for prestressing steels. Guidance came in the form of tentative recommendations from Joint ACI-ASCE Committee 323 (1958), Bureau of Public Roads (1954), or Structural Engineers Association of Northern California (SEA/NC) (1959). Unbonded tendons in the early systems used bundles of wires or strands, sometimes inaccurately called cables, of various diameters, and were assumed to be protected by PT coating and paper sheathing that were sometimes applied by hand (Nehil 1991; Schupack 1991a).

The use of unbonded tendons became more common during the late 1950s and early 1960s, as progress was made in establishing design and materials standards. Acceptance of the concept was regional at first and was largely the result of sales efforts and design tutoring by tendon suppliers. The use of post-tensioning increased rapidly during the late 1960s and 1970s as advantages of the system were demonstrated. For many types of structures, these advantages included shorter construction time, reduced structural depth, increased stiffness, and savings in overall cost. In addition to their use in enclosed buildings, unbonded PT systems were used in parking structures and slabs-on-ground, and bonded post-tensioning was used on water tanks, bridges, dams, and soil tie-back systems. Unbonded multi-wire and multi-strand tendons have been used extensively in nuclear power structures.

Incidents of corrosion of unbonded single-strand tendons began to surface during the 1970s. It was believed that corrosion protection would be provided by the PT coating during shipping, handling, and installation, and by the concrete thereafter. The early PT coatings, however, often did not provide the corrosion-inhibiting characteristics that are presently required in ACI 423.7 or PTI M10.2. In the early 1980s, the Post-Tensioning Institute (PTI) recognized the structural implications of corrosion and began implementing measures to increase the durability of unbonded PT systems (Post-Tensioning Institute 1985). Relying on the experience and practice of the nuclear industry's use of corrosion-inhibiting hydrophobic grease, similar performance standards for grease were adopted. In 2000, PTI published the second edition of its "Specification for Unbonded Single Strand Tendons (PTI M10.2-00)." In ACI 318-89, measures were incorporated that related the required protection of the tendons and the quality of the concrete to the environmental conditions that could promote corrosion of the post-tensioning.

In 2007, ACI published ACI 423.7, which provides detailed specifications for PT coating. With the adoption of this specification, the term "grease" was replaced with the more generic term "PT coating" to address other mate-