

Latest Developments in QC for Bond of Prestressing Steel to Concrete

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Summary

For prestressed concrete structures to perform, bond of prestressing steel strands to the surrounding concrete (a.k.a. strand bond) is essential. Poor bond results in excessive transfer and development lengths, thereby reducing the end region shear and flexural strengths of prestressed concrete members. Shear failures of flexural members discovered in the 1990s were later determined to be initiated by a failure of strand bond. Two such projects are described herein.

The National Cooperative Highway Research Program (NCHRP) funded two recent studies associated with strand bond that resulted in the development of standardized tests for strand bond. Recent research funded by Precast/Prestressed Concrete Institute (PCI) has focused on development of simple quality control tests that can be run in the precast concrete plant. These tests help assure that the prestressing strands used in our structures have reliable, predictable strand bond resulting in satisfactory performance of the prestressed concrete structures.

Keywords: prestressing steel, prestressing strand, strand bond, wiredrawing lubricants, transfer length, development length

1. Introduction

The transfer of prestressing force from prestressing strand to the surrounding concrete over a predictable length is essential for the reliable performance of prestressed concrete. It also is essential that lubricants be used in the wiredrawing process to manufacture prestressing strand so that the process is cost-effective and does not damage the wire. However, residual films of lubricant and other contaminants remaining on the wire surface after manufacture are known to be highly effective in preventing the cementitious bond between the steel and the concrete. Residual films on wire can be difficult to remove since some residual films, including those resulting from calcium stearate based lubricants, are water insoluble.

The residual film that persists on strand wire surface is influenced by many factors, including the condition of the raw rod stock, the pre-treatment and lubrication materials and procedures, and the production system, particularly the die condition and line speed. Therefore, to produce strand that reliably bonds with concrete in prestressed elements, the manufacturing process must be carefully controlled, and the appropriate surface treatments must be selected throughout the wiredrawing and stranding processes. A set of testing procedures to be used as part of routine quality control (QC) program is needed to assess factors that are known to affect strand bond properties.

2. The Nature of Bond between Prestressing Steel and Concrete

In prestressed concrete members, strands are initially tensioned, concrete is cast around them, and when the concrete reaches sufficient strength, the strands are released. The tensioned strands impart their force into the surrounding concrete through strand bond over a certain distance called the transfer length.