Florida Department of Transportation Research

Shear Behavior of Webs Post-Tensioned with Tendons Containing Flexible Fillers

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Current Situation

Many highway bridges are supported by prestressed concrete girders that come in a variety of shapes. Commonly, girders are created by two upper and lower "flanges" connected by a thinner vertical "web" in an I-beam or in a box shape. These shapes are much lighter than a solid rectangular girder of the same length, can allow for longer bridge span lengths, and can provide significant construction savings. Post-tensioning ducts with prestressed steel tendons are located in voids in the web. However, post-tensioning can induce stresses in the web which can lead to cracking. The opening in the web can also result in a reduction in web strength if the duct diameter is large. Over several decades, studies to examine this have resulted in design standards that call for an increased ratio of web thickness to tendon duct diameter. Experiments have validated these standards, but only for ducts backfilled with grout, which tends to restore the strength reduction caused by the duct. Flexible fillers such as wax have become more common in recent years because of the additional protection for steel tendons, especially in Florida's salty and humid environments, but flexible fillers do not provide a restoration of strength.

The I-beam is widely used in bridge and overpass construction because it allows for longer spans at lower weight.

Research Objectives

University of Florida researchers tested the shear strength of two types of full-scale-concrete I-beams with voided webs to determine if there were any design challenges that need to be addressed.

Project Activities

The research was divided into two phases. The first used six modified pre-tensioned AASHTO Type III I-beams with various cross sections but no post-tensioning. The second used seven post-tensioned Florida I-beams (FIB-54) and various ratios of web width to duct diameter.

Five AASHTO I-beams were shear-tested in positive bending; the sixth was tested in negative bending. These tests were primarily intended to investigate the sensitivity of variables such as presence and number of post-tensioning ducts, transverse reinforcement, influence of top flange, web width, and duct diameter-to-web-width ratio. Four specimens showed a web crushing failure at the duct location and specimens with excessive duct sizes showed reduced shear strength. Specimens containing ducts typically experienced localized diagonal cracking at the duct location followed by formation of diagonal web cracks through the full depth of the web.

Two FIB-54 beams were shear-tested in negative bending and five in positive bending. Each was tested twice; one on a one-duct end and one on a two-duct end. Duct-diameter-to-web-width ratio was varied among several of the specimens. As in phase 1, localized cracking typically occurred near the duct at lower loads and, as load increased, full-depth web cracks formed. Positive bending tests containing two ducts experienced localized cracking near the top duct location but not at the bottom duct. This occurred due to the bottom duct's proximity to the thick FIB bottom flange. Negative bending specimens experienced localized duct cracking simultaneously for both duct locations.

Project Benefits

This project further validated standard design approaches and provided new insights into girder design that will help ensure that girders perform as expected throughout their intended service life.

For more information, please see www.fdot.gov/research/.