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Louisiana Transportation Research Center

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Fatigue and Shear Behavior of HPC Bulb Tee Girders

Introduction

The Louisiana Department of Transportation and Development has been introducing high performance concrete into its bridge construction program. At the same time, the Louisiana Transportation Research Center has been sponsoring research work addressing design and construction issues related to the utilization of high performance concrete. The research team included Tulane University; the CTL Group; Henry G. Russell, Inc.; LTRC, and Gulf Coast Prestress, Inc. The cooperation of LADOTD and FHWA is acknowledged.

Five 96-ft. (29.3m) long, 72-in. (1.83m) deep, precast, pretensioned bulb tee girders were tested in an effort to evaluate their behavior under flexural fatigue. Three of the girders were also tested to measure their static shear strength. The cracked-bulb tee girders performed satisfactory under 5 million cycles of flexural fatigue loading at a maximum tensile stress of 610 psi (4.21 MPa). At a concrete tensile stress of 750 psi (5.17 MPa) or larger, fatigue fractures of the prestressing strand were observed. Measured shear strengths of six bulb tee girder ends exceeded the shear strengths calculated according to the AASHTO standard specifications and the AASHTO LRFD specifications.

Objectives

The objectives of the research were (1) to provide assurance that full size, deep prestressed concrete girders made with HPC would perform satisfactorily under flexural fatigue, static shear, and static flexural loading conditions; (2) to determine if a higher allowable concrete tensile stress can be used in the flexural design of high strength prestressed concrete girders; and (3) to investigate the use of welded wire deformed reinforcement as an alternate to deformed bars for shear reinforcement.

Research Approach

In an effort to address the guidelines of Louisiana DOTD, the test specimens were designed and fabricated to be representative of actual bridge and girder designs used by DOTD. One of the bridge designs was based on the *AASHTO Standard Specifications for Highway Bridges*, 16th Edition. The second design was based on the

LTRC Report 395

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AASHTO LRFD Design Specifications, 2nd Edition. Five test specimens were fabricated and designated BT6, BT7, BT8, BT11, and BT12. Two other specimens, BT9 and BT10, were also fabricated but were rejected because of insufficient strength. The girders were tested, and data was collected and subsequently analyzed. The design, fabrication, testing, analysis, and conclusions are reported in the project Final Report.

Conclusions and Recommendations

Precracked girders performed well under 5 million cycles of flexural fatigue loading at a maximum tensile stress of 610 psi (4.21 MPa). At 750 psi (5.17 MPa) or higher, fatigue fractures of the prestressing strand were observed. Uncracked girders performed well under 5 million cycles of flexural fatigue loading at a maximum concrete tensile stress of 600 psi (4.14 MPa) in one girder and 750 psi (5.17 MPa) in a second girder. Measured shear strengths of six bulb tee girder ends exceeded the shear strengths calculated according to the AASHTO standard specifications and the AASHTO LRFD specifications.

The maximum level of concrete tensile stress used in flexural design of high strength prestressed concrete girders should be limited to 6 $\sqrt{f'_c}$ =650 psi when cracking of the girders is anticipated and to 7.5 $\sqrt{f'_c}$ =750 psi when cracking is not anticipated. Seventy two-inch (1.83m) deep prestressed concrete bulb tee girders made with 10,000 psi (69 MPa) compressive strength concrete can be expected to perform satisfactorily under static shear loading conditions when designed by either the AASHTO standard specifications or the sectional design model of the AASHTO LRFD specifications. Therefore, both design approaches may be used by the Louisiana DOTD. Welded wire deformed reinforcement with a yield strength of 75 ksi (517 MPa) may be used as an alternate to deformed bars for shear reinforcement in prestressed concrete beams. Additional research to determine the effect of the loading rate on fatigue performance is recommended .

Implementation Status

As a result of this research, HPC bulb tee girders are presently being incorporated into two spans of the Rigolets Pass Bridge. Two other projects are scheduled to utilize high performance concrete girders in their design and construction. The Union Pacific Railroad Overpass on Highway U.S. 165 in Jefferson Davis Parish (SP No. 014-02-0018) will use AASHTO Type IV girders with a maximum span of 115 ft. (35 m). The LA 27 Overpass in Calcasieu Parish (SP No. 450-91-0087) will use AASHTO Type IV girders with a maximum span of 112 ft. (34 m).