Second International Interactive Symposium on Ultra-High Performance Concrete
Extended Abstract (no paper submission)

Caltrans Implementation of UHPC Connections for ABC Projects

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ABC
Production, Supply and QA/QC

November 5, 2018

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In recent years the California Department of Transportation (Caltrans) has turned to ultra-high performance concrete (UHPC) to meet the goals of constructability, seismic performance and durability of precast bridge element connections in accelerated bridge construction projects (ABC). Design details for the Laurel Street Overcrossing (OC) ABC Pilot Project, located in the seismically active California Bay Area, provide a resilient fixed connection between precast column and precast cap with a circular pattern of #14 reinforcing bars threaded through 4" corrugated UHPC filled ducts. The recently awarded Echo Summit Sidehill Viaduct Replacement project calls for the use of UHPC in adjacent box beam keyways to provide a quick and durable connection solution to be rapidly constructed during a 14-day full closure of heavily traveled Hwy 50 near Lake Tahoe. Caltrans' first time use of UHPC for the connection of precast bridge elements included special attention given to material testing, constructability considerations, QA/QC practices, and project specification development. In addition, validation of UHPC performance prior to field construction has been an important aspect of UHPC implementation in California.

The Laurel Street OC column-to-cap connection detail developed for this project is based on UNR's research "Next Generation of Bridge Columns for ABC in High Seismic Zones" (ref 1). The research project investigated eight connection types with varying outcomes. Upon review by the Caltrans Earthquake Committee the UHPC filled duct connection was selected as the preferred alternative due to performance, simplicity and reliability. The full-scale implementation of this connection consisted of a circular pattern of 20 No. 14 reinforcing bars extending from each column threaded through a precast drop cap via multiple 4-inch internal diameter corrugated galvanized metal ducts. The Laurel Street OC pilot project represents the first use of UHPC to connect precast bridge elements in California. In order to reduce risk and assure quality the Department required 2 types of full-scale UHPC mockups: The Pullout Mockup and the Fit Up

and UHPC Placement Mockup. The purpose of the Pullout Mockup was to verify the performance of the reinforcing bar when bonded to the UHPC under tensile loading conditions. A full-scale mockup of precast concrete blocks with a single 4- inch internal diameter galvanized corrugated metal duct was fabricated to represent the in-field condition. A single No. 14 reinforcing bar was placed in the center of the UHPC filled duct. Caltrans Materials Engineering and Testing Services (METS) tested the specimen in a two-million-pound reaction frame. Testing confirmed that the failure mode of the connection was tensile failure in the reinforcing bar. The reinforcing bar achieved ultimate strength, fractured at a peak load of 216 kips and remained bonded to the UHPC throughout the testing.

The contract required a full-scale mockup of the cap to column connection to demonstrate that the UHPC placement method filled spaces with UHPC and the steel fibers were uniformly distributed. To inspect the UHPC, the mock up was saw cut in several locations and visual inspection confirmed that the acceptance criteria had been met.

UHPC keyways were chosen for the adjacent box beam superstructure of the Echo Summit Sidehill Viaduct for constructability and long-term performance of the superstructure. UHPC filled keyways generate savings in construction time and precast element weight by eliminating the need for transverse post tensioning, intermediate diaphragms, and a cast in place (CIP) bridge deck. The use of rapid strength UHPC (12 ksi in 12 hours) presented two areas of investigation to be performed by the owner prior to advertisement of the contract. The first was validation of estimating the concrete strength by the maturity method and the second was to determine the UHPC curing requirements prior to placement of a polyester concrete overlay. In early 2018 Caltrans obtained samples of the Lafarge Ductal mix design number JS1212 to conduct strength-maturity testing and bond beam testing.

California specifications typically require a 28 day wait between concrete placement and polyester concrete overlay. Caltrans wanted to determine if this cure time could be reduced for UHPC applications. Bond beam testing (California Test 551) was used by METS to determine the overlay placement wait time required to attain sufficient bond strength between the Ductal JS1212 and the polyester concrete. Findings of the tests suggest that the UHPC is of sufficient strength for placement of the polyester overlay at 12 hours of age (12,000 psi) if heat cured at a temperature of approximately 100 degrees Fahrenheit for the first 12 hours.

The maturity method to estimate the strength of UHPC without dependence of concrete compressive strength testing provided a method that aligned with an ABC schedule. Strength-maturity testing on JS1212 was performed in accordance with ASTM C1074 on both heat cured and room temperature specimens to develop strength maturity relationship and support the development of project specifications.

References

1. Tazarv, Mostafa, Saiidi, M. Saiid, (2014) *Next Generation of Bridge Columns for Accelerated Bridge Construction in High Seismic Zones*, Report No. CA 14-2176, CCEER 14-06, Center for Civil Engineering Earthquake Research, University of Nevada Reno, Department of Civil and Environmental Engineering, Reno NV