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OKLAHOMA Transportation **RESEARCH**

PROJECT TITLE
EVALUATION OF ULTRA-HIGH-PERFORMANCE CONCRETE FOR USE IN BRIDGE CONNECTIONS AND REPAIR

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EVALUATION OF ULTRA-HIGH-PERFORMANCE CONCRETE FOR USE IN BRIDGE CONNECTIONS AND REPAIR

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OVERVIEW Deterioration of bridges is often related to poor performance of longitudinal connections between precast members or transverse deck joints. Ultra-high performance concrete (UHPC) is a relatively new class of cementitious composite that has mechanical and durability properties far exceeding those of conventional concrete. Although relatively expensive, the use of UHPC is most economical when use of a small quantity can have a large impact on the overall performance of a structure. Therefore, UHPC has great potential for use in bridge connections and rehabilitation in Oklahoma. This two-phased study examined available materials (proprietary and non-proprietary) and potential applications of UHPC for connections and repairs with the goal of creating specifications for composition and use of UHPC in Oklahoma.

RESULTS In Phase 1 of this study, three promising mix designs using local materials were developed through a systematic investigation of mix constituents and methods for obtaining optimal particle packing density. After comparing the material properties of the developed mixes, 'J3 mix' was considered for further structural testing. Two specific applications of UHPC were considered in Phase 1, namely deck slab joints and girder continuity connections.

Initial investigation of deck slab joint details was conducted by evaluating bond strength between UHPC and base concrete for different surface preparation methods using small-scale flexural specimens. Laboratory-scale full-depth joints were cast between 4 ft x 4 ft slab specimens using a proprietary UHPC and the OU developed J3 mix (Figure 1(a)). The composite slabs were then tested in flexure. Results of the tests indicated that the UHPC joint improved the capacity of the slabs and that the J3 material performed similarly to the proprietary UHPC.


(a)


(b)

Figure 1 Tests for (a) deck slab joint and (b) girder continuity connection using UHPC

Additionally, laboratory-scale girder continuity connections were designed based on standard practice and were tested to failure. Two different connection details were used, one representing new construction and one representing a retrofit of an existing structure. A series of three specimens was casted for each detail using two 18 ft long, approximately half-scale AASHTO Type II prestressed concrete beams and the proprietary UHPC. Both joint details produced an effective continuity connection between the precast girders with the retrofit connection providing slightly better performance.

Recommendations for use of UHPC drafted after the first year of the project and were used to conduct a field test involving retrofit of an existing expansion joint. Only a portion of the joint was constructed using UHPC. The interfaces between the UHPC materials and the bridge deck concrete were monitored for almost three years for cracking or separation due to differential shrinkage or applied loading (Figure 2). Overall, the replaced section of joint performed very well. In addition, two demonstration joints were cast at Fears Lab; one with proprietary UHPC and another with OU developed J3 mix. These joint specimens were then placed outside for continued monitoring for over 2 years. The specimens were found to exhibit similar performance to the joint in the field.

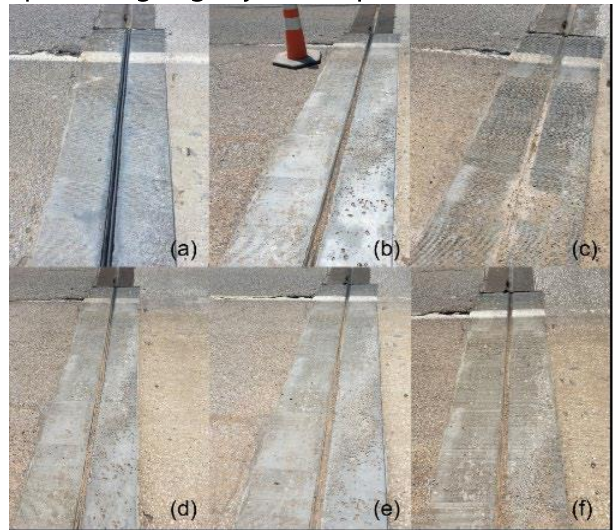

Figure 2 UHPC joint on the SH-3E bridge: (a) immediately after joint seal placement, (b) 7 months, (c) 14 months, (d) 21 months, (e) 29 months, and (f) 33 months after casting

Phase 2 involved testing of a partial depth slab joint detail using the same methods as for the full-depth joint detail, examination of reinforcement bond, and durability testing of proprietary and non-proprietary UHPC material. The half-depth joint detail produced similar ultimate strengths to the full-depth joint detail, but a lower cracking load. UHPC bond to concrete substrate was examined for different surface preparations and base concrete saturation levels using direct pull-off tests. Results indicated that flowability and surface preparation were the most important considerations for UHPC to concrete bond. UHPC durability testing indicated excellent performance for both proprietary and non-proprietary UHPC relative to freeze-thaw and chloride ion penetration. Corrosion testing produced mixed results with the non-proprietary J3 UHPC mix design exhibiting the best performance relative to the Halo Effect. The results of both phases of the project were combined with information available in the literature to produce recommendations for draft standard specifications for UHPC materials, mixing, placing, and quality control for use in bridge connections in Oklahoma.

(a) (b) (c)

Figure 3 J3 mix specimen after (a) freeze-thaw, (b) chloride ion penetration and (c) corrosion testing

POTENTIAL BENEFITS This study examined multiple aspects of UHPC for use for bridge element connections and overall bridge repair. A UHPC mix design (J3) made with material constituents available in the state of Oklahoma and with potential for use in multiple bridge applications was developed. Also, recommendations and specifications were developed for use of UHPC in Oklahoma. Testing showed that the joints and connections prepared with UHPC effectively increased the capacity of the bridge element and have the potential to improve the performance of this type of construction.