Bonding of Overlays to Ultra High Performance Concrete

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Abstract

In Delaware, polyester polymer concrete (PPC), latex modified concrete (LMC), and modified concrete type D overlays are commonly applied over UHPC components as a riding surface. The overlay-UHPC bond characteristics are unknown and the current literature does not address this knowledge gap. The project evaluated the effects of UHPC surface preparation method (specifically, grinding and sandblasting, hydrodemolition, and surface retarder) on the bond strength of overlays on UHPC. The research found that PPC had the highest pull-off bond strength averaging at 730 psi (5.17 MPa) at 28 days, followed by LMC with an average of 450 psi (3.10 MPa) and, finally, MCD which did not exceed the minimum recommended value of 250 psi (1.72 MPa), prescribed by Delaware Department of Transportation. The pull-off bond strength did not vary significantly between the three surface preparation methods. It was concluded that surface profile gauge is the most appropriate method to quantitatively evaluate UHPC surface roughness, but it is not the most practical to implement.

Keywords: overlays; bond; polymer concrete; surface preparation; bridges.

1. Introduction

Transportation agencies utilize UHPC in link slabs, connections in precast concrete bridges, Overlays are materials used to provide a smooth riding surface and protect the bridge decks by preventing infiltrations of deicing salts and other aggressive chemicals. In Delaware, the three types of overlays used by the Delaware Department of Transportation (DelDOT) are polyester polymer concrete (PPC), latex modified concrete (LMC), and modified concrete class D (MCD). These overlays differ in constituents, bonding agents used, permeability, curing time, and shrinkage. Therefore, it is expected that each of the overlay materials would have distinct bond performance when applied to a UHPC substrate.

Few studies evaluated the performance of overlays on UHPC. Haber et al. (2017) compared LMC and UHPC as overlays on normal concrete and UHPC substrates. For each overlay, the concrete surfaces were prepared via scarification and hydrodemolition (HD), then bond pull-off tests were conducted to evaluate overlay-UHPC bond strength. Comparatively, the bond strength of UHPC overlay was higher on HD substrates. Overall, authors concluded that hydrodemolition is more

desirable than scarification. In addition, it was observed that the measured bond strengths on UHPC were higher than those on the normal concrete substrate.

To determine optimal surface preparation methods and overlays, this study tested bond pull-off strength of PPC, LMC, and MCD on UHPC substrates prepared with grinding and sandblasting (GSB), hydrodemolition (HD), and surface retarder (SR). Pull-off test results were compared against the relevant recommendations by AASHTO and ACI.

2. Materials and Methods

PPC, LMC and MCD complying with the DelDOT requirements were supplied by state-approved manufacturers and/or licensed contractors. Standard fresh property and mechanical tests were conducted to ensure that overlay materials met minimum DelDOT requirements. A proprietary UHPC material, typically utilized in bridge connections and link-slabs, was used as the substrate material. Overlays were placed on UHPC substrate following manufacturer's recommendations and DelDOT construction specifications. For MCD, the effect of substrate hygric state (air-dry or 'D' and saturated surface dry or 'S') was varied.

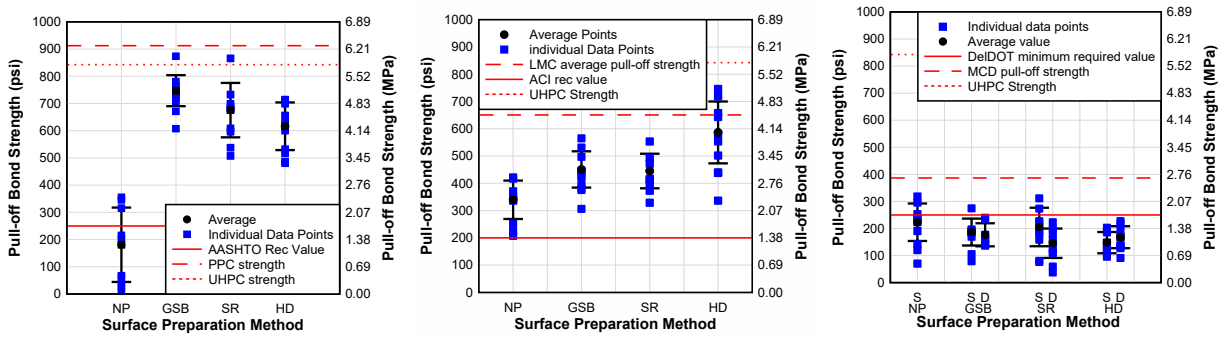
Grinding was conducted using a hand-held concrete diamond grinder, and was followed by sandblasting. HD (with a water pressure of 34 ksi or 234 MPa) was conducted by a licensed contractor. The process exposed UHPC fibers. Finally, SR involved applying a surface retarder on plywood sheets and placing them atop freshly placed UHPC, followed by pressure washing (at 3,200 psi or 22 MPa) the retarted surface within 6 to 12 hours of UHPC placement. The process exposed UHPC fibers.

Bond pull-off tests were conducted per ASTM C1583, using Proceq DY-216 bond pull-off tester. Two-inch (50-mm) cores drilled to 0.5 in. (12.5 mm) depth into UHPC using a Hilti DD120 core drill. Aluminum pucks were then bonded to the core surface using a structural epoxy adhesive. Load was applied at a constant loading rate of 5 psi/s (25 kPa/s). Bond peak load and failure mode were recorded for each tests. Additional details about materials and methods can be found elsewhere (Larfi et al. 2022).

3. Results and Discussion

Pull-off bond strength results are shown in Figure 1. PPC exhibited high bond strengths for all surface preparation methods, but low values were noted for UHPC substrate with no surface preparation (NP). There was no statistically significant difference between GSB, SR, and HD, and all three surface preparation methods led to bond strength values significantly exceeding the minimum recommendation by AASHTO T-4. Overall, LMC exhibited lower bond strengths than PPC; however, LMC had significantly better bond to NP substrate. In LMC group, HD led to highest bond strength. All bond strengths in the LMC group exceeded the minimum recommendation by ACI 548.4M. Finally, MCD had significantly lower bond strengths than PPC and LMC. In addition, substrate hygric state did not have a significant effect on the average bond

strength. DelDOT requires a minimum bond strength of 250 psi (1.7 MPa) for MCD overlays, which was not exceeded my majority of the conducted tests.



(a) (b) (c)

Figure 1. Pull-off bond strengths for: (a) PPC; (b) LMC; and (c) MCD overlays.

3. Conclusions

UHPC is increasingly used in link slabs and bridge decks connections, but the literature addressing the bond performance of overlays with a UHPC substrate is limited to investigating LMC and UHPC as overlay materials. In addition, the studies that evaluated overlay-UHPC bond considered only scarification and hydrodemolition as surface preparation methods. To address this knowledge gap, this project studied the bond performance of PPC, MCD, and LMC to UHPC by means of bond pull-off test method. The study considered GSB, SR, and HD as surface preparation methods, while NP served as control. The study revealed superior bond performance of polymer and polymer-modified overlays (PPC and LMC, respectively) over the cementitious overlay (MCD).

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