# RESEARCH**NOTE**

## ASSESSING CHLORIDE INGRESS THROUGH CONSTRUCTION JOINTS IN UHPC OVERLAYS

Office of Infrastructure R&D


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### PROJECT DETAILS

This study was conducted by FHWA's Office of Infrastructure Research and Development under contract DTFH6117D00017.



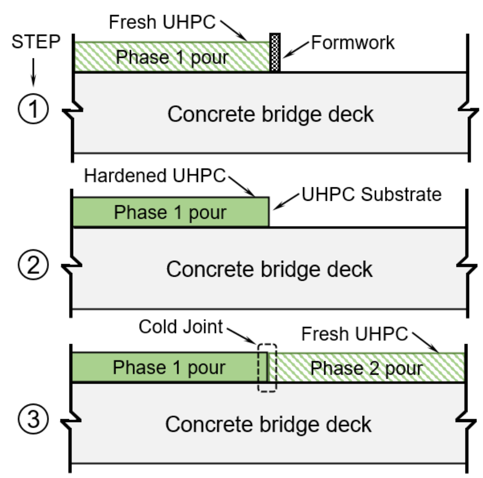
### SUMMARY

Ultra-high performance concrete (UHPC) overlays are beginning to be recognized as a viable solution for bridge deck preservation. To accommodate construction sequencing during installation, vertical cold joints between UHPC pours are often unavoidable. Furthermore, the formwork and detailing used at these cold-joint locations are not yet standardized. Ingress of water and chlorides through these cold joints can affect the durability of the overlay. This study aimed to assess chloride ingress through construction joints in UHPC overlays. Four different formwork details were investigated, replicating techniques that might be employed in the field. A sodium chloride (NaCl) solution was ponded over specimens for 1 year. Measured chloride profiles indicated that in all cases there was no detectable chloride penetration beyond a depth of 0.2 inches.


### WHY THIS RESEARCH WAS PURSUED

UHPC overlays are gaining traction within the United States as a strategy for the preservation and rehabilitation of concrete bridge decks. It is often not feasible to install an overlay across the entire width of a bridge deck surface at once because it would require closing the bridge to traffic. As such, construction usually occurs in phases to keep some travel lanes open to traffic. This operation results in construction joints or "cold joints" between the overlay installation phases; this process is illustrated in figure 1. A vertical cold joint is formed when fresh UHPC, the phase 2 pour, makes contact with a previously poured and hardened UHPC, the phase 1 pour. Cold joints can act as a pathway for moisture and chloride ingress and can lead to deterioration of the rehabilitated bridge deck. Ingress through the cold joint depends on a variety of factors. One factor is the texture of the hardened UHPC substrate (step 2), which is created when fresh UHPC (step 1) comes in contact with the formwork surface. Another factor is how the UHPC substrate is prepared prior to placing fresh UHPC during the phase 2 pour (step 3).

**Figure 1. Schematic. UHPC overlay construction.**




*Source: FHWA.*

### WHAT IS BEING DONE?

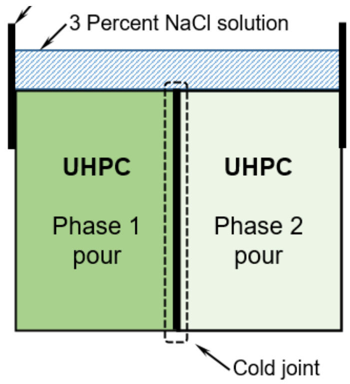
This research investigated chloride penetration into cold joints that are created by phased construction of UHPC overlays. To simulate chloride ingress through a cold joint in a UHPC overlay, the research team used a commercially available UHPC to prepare cylindrical specimens that measured 4 inches in diameter by 4 inches in height. Specimens had a vertical cold joint and were ponded with a 3-percent NaCl solution in accordance with a modified version of ASTM International (ASTM) C1556; see figure 2.[1] The formwork type and UHPC substrate preparation were the main variables. Four different UHPC substrate surface condition cases were created. The surface condition cases were as follows:

- Wooden formwork with no additional preparation.
- Wooden formwork with an inform retarder applied to expose fibers on the substrate surface.

- Wooden formwork with a bonding agent applied to the hardened UHPC substrate surface prior to casting fresh UHPC.
- Sandblasted steel formwork.

The phase 1 sides of the specimens were cast vertically against the formwork and allowed to cure for 24 h. Thereafter, the researchers removed the formwork and prepared the interfaces prior to the phase 2 UHPC pour. Completed specimens were allowed to cure for an additional 28 days before the NaCl solution ponding began. The perimeter of each specimen was sealed with epoxy to promote unidirectional chloride transport through the cold joint. Chloride ponding was conducted in a cyclic fashion: each 2 weeks of ponding was followed by 2 weeks of drying at ambient laboratory conditions to promote accelerated, continuous chloride ingress.

**Figure 2. Schematic. Test specimen.**




*Source: FHWA.*

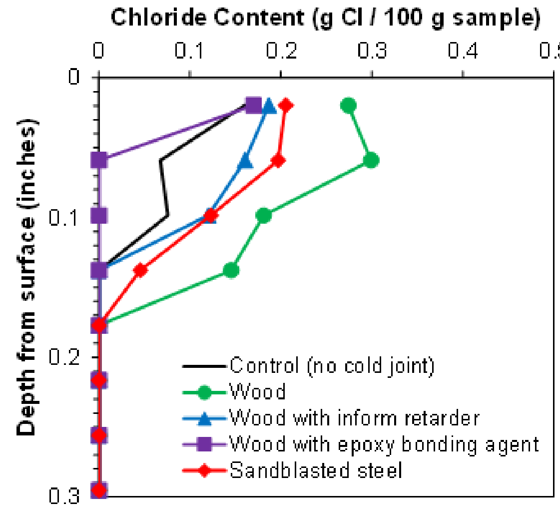
## PRELIMINARY FINDINGS

After 1 year of cyclic chloride ponding, chloride penetration profiles were evaluated according to ASTM C1152, which determines the acid-soluble total chloride content consisting of both free and bound chlorides.[2] Results of this analysis are shown in figure 3. Here, the total chloride content, shown in grams of Cl per 100 g of sample, is displayed as a function of the depth below the UHPC surface. The chloride profile for a UHPC control sample without a cold joint is also shown. None of the specimens displayed detectable chloride penetration beyond a depth of 0.2 inches after 1 year of cyclic ponding. For reference, conventional bridge deck concrete may exhibit 0.8 inches of detectable chloride penetration after 1 year of cyclic ponding. Of the specimens with cold joints, the use of an epoxy bonding agent at the interface resulted in the least chloride penetration, whereas the interface created using wooden formwork with no other preparation led to the highest chloride penetration.

## NEXT STEPS

These results are promising. However, the data collected so far describe only the short-term chloride penetration. The research team is planning to collect chloride penetration data after 3 years (December 2022) and 5 years (December 2024) of ponding. These data should allow the research team to develop recommendations related to best practices for detailing and constructing cold joints. Note that the work presented here did not consider the effect of mechanical loads on these cold joints. The research team is additionally conducting experiments to evaluate the mechanical performance of these joints.

**Figure 3. Graph. Chloride penetration through the cold joint after 1 year of cyclic ponding.**




*Source: FHWA.*

## REFERENCES

1. ASTM. 2016. *Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion.* ASTM C1556. West Conshohocken, PA: ASTM International.
2. ASTM. 2004. *Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete.* ASTM C1152. West Conshohocken, PA: ASTM International.

## NOTICE



## QUALITY ASSURANCE STATEMENT



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