



# Long-Term Performance of Overlays: Thin Epoxy Overlay versus Traditional Rigid Overlay

tech transfer summary

February 2020

## RESEARCH PROJECT TITLE

Long-Term Performance of Overlays:  
Thin Epoxy Overlay versus Traditional  
Rigid Overlay

## SPONSORS

Iowa Department of Transportation  
(InTrans Project 17-627)

## PRINCIPAL INVESTIGATOR

Katelyn Freese, Associate Director  
Bridge Engineering Center  
Iowa State University  
kfreese@iastate.edu / 515-294-3620  
([orcid.org/0000-0003-0546-3760](https://orcid.org/0000-0003-0546-3760))

## MORE INFORMATION

[intrans.iastate.edu](http://intrans.iastate.edu)

**Bridge Engineering Center**  
Iowa State University  
2711 S. Loop Drive, Suite 4700  
Ames, IA 50010-8664  
515-294-8103  
[www.bec.iastate.edu](http://www.bec.iastate.edu)

The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

The sponsors of this research are not responsible for the accuracy of the information presented herein. The conclusions expressed in this publication are not necessarily those of the sponsors.

As thin epoxy overlays become an increasingly popular solution for mitigating bridge deck deterioration, understanding the bond strength and long-term performance of these overlays versus traditional rigid overlays is critical.

## Problem Statement

A study on the long-term performance of thin epoxy and low-slump dense concrete (LSDC) overlays is needed to better understand the applications and ideal scenarios for the use of each overlay type.

## Objectives

- Evaluate the bond strengths of thin epoxy overlays and LSDC overlays and investigate the change in bond strength over time through on-site testing
- Understand the long-term performance of thin epoxy overlays and LSDC overlays via accelerated laboratory testing
- Identify factors that affect the initial and long-term performance of thin epoxy and LSDC overlays



*Thin epoxy overlay being applied to a bridge deck*

## Background

Iowa owns the fifth largest number of bridges of all states in the US. Meanwhile, Iowa's bridges have earned an average letter grade of D+ from the American Society of Civil Engineers, indicating that many bridges in the state require rapid and effective rehabilitation.

Bridge deterioration often originates via cracking in the top surface of the deck, which is regularly exposed to the combined influences of water/chloride ingress, dynamic traffic loading, and freeze-thaw conditions. This cracking can soon compromise the entire bridge's integrity.

Concrete overlays have shown the ability to prolong the life of bridge decks and have been widely adopted. However, polymer overlays have gained popularity for bridges that have not shown extensive deck deterioration.

## Research Description

Six bridges in Iowa—three to be overlaid with LSDC and three to be overlaid with epoxy—were chosen to study the mechanical and durability properties of thin epoxy and LSDC overlays.



*Locations of the six bridges investigated in this study*

## Field Testing

The substrate condition for each bridge deck, including the extent of visible damage and chloride profile, was inspected before overlay application. Additionally, three cores from each bridge were collected to study the bridge decks' porosity and durability to cyclic freezing and thawing in the laboratory.

The top surface of each bridge deck was removed through either milling or hydro-demolition, and the overlays were placed during the spring and summer of 2018. The tensile capacity of the bond between the overlay and substrate was evaluated via in situ pull-off tests following ASTM C1583 immediately after overlay placement and after approximately one year of service.

## Laboratory Testing

For the 18 substrate cores obtained before overlay placement, porosity was measured according to ASTM C642 and durability to freeze-thaw damage was measured according to ASTM C666, Method A. The durability factor was measured at the 300th freeze-thaw cycle, while the mass loss was measured until the 510th cycle was reached.

Additional laboratory tests were carried out on prepared overlay samples to study the overlay types' chloride permeability and the effect of cyclic freezing and thawing on bond strength.

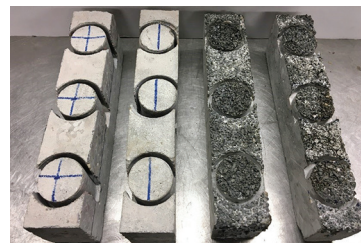
For laboratory testing, eight 1 ft by 1 ft substrate slabs were cast, four to be overlaid with epoxy and four to be overlaid with LSDC. A constant slab thickness of 3.5 in. was achieved by casting the substrate slabs at different thicknesses to offset the different thicknesses of the epoxy and LSDC overlays. The overlays were applied to the substrate slabs in the field using the same materials as those used for the bridge deck overlays.

The overlays' chloride permeability was evaluated according to AASHTO T 259, i.e., the salt ponding test. Two of the concrete-overlaid slabs and two of the epoxy-overlaid slabs were ponded for 90 days, after which chloride permeability was evaluated in accordance with AASHTO T 260. Samples were extracted from depths of 1/8 in., 3/8 in., 5/8 in., and 7/8 in.

To determine the effect of freeze-thaw cycles on bond performance, the four remaining slabs were cut into 12 beams 3 in. wide, resulting in 6 beams for each overlay type. The beams were subjected to cyclic freeze-thaw conditions and tested using the direct pull-off strength test (ASTM C1583) at 0, 100, and 300 freezing-thawing cycles.



*LSDC-overlaid (left) and epoxy-overlaid (right) slabs for laboratory testing*



*LSDC-overlaid (left) and epoxy-overlaid (right) beams for examining the effect of cyclic freezing and thawing on bond strength*

## Key Findings

### Field Tests

- The percentage of air voids in the substrate has the greatest impact on the substrate's durability properties. As the percentage of air voids decreased, the results of the chloride resistance, freeze-thaw durability, and pull-off tests improved linearly.
- The remaining mass after 510 freeze-thaw cycles has a strong linear relationship with chloride permeability, confirming that bridges with better freeze-thaw durability usually have better chloride resistance.
- No relationship was found between a bridge's age and its substrate quality or overlay bond strength. In fact, the oldest bridge in the study exhibited the best laboratory and field performance.

### Laboratory Tests

- The chloride content in the epoxy-overlaid slabs was found to be less than 1/8 of the chloride content in the LSDC-overlaid slabs at a depth of 1/8 in., indicating that epoxy overlays can resist chloride ingress much better than LSDC overlays.
- Freeze-thaw exposure more strongly influences the bond strength of epoxy overlays than that of concrete overlays. In the laboratory pull-off tests, the initial bond strengths of both the epoxy and LSDC overlays were good, while after 300 freeze-thaw cycles the average bond strength of the LSDC overlays was found to be almost twice of that of the epoxy overlays.

## Implementation Readiness and Benefits

Both the thin epoxy and LSDC overlays were found to perform adequately in the field and laboratory tests. While the thin epoxy overlays were found to resist chloride ingress much better than the LSDC overlays, freeze-thaw exposure more strongly decreases the bond strength of the thin epoxy overlays.

Understanding the performance of the two overlay types and the factors that affect their performance can help bridge owners identify the appropriate applications for the different overlay types and the ideal scenarios in which they should be used.