



# Increase Service Life at Bridge Ends through Improved Abutment and Approach Slab Details and Water Management Practices

tech transfer summary

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## RESEARCH PROJECT TITLE

Increase Service Life at Bridge Ends through Improved Abutment and Approach Slab Details and Water Management Practices; Limitations for Semi-Integral Abutment Bridges

## SPONSORS

Iowa Highway Research Board  
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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.

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The proper design and use of integral or semi-integral abutments prevents surface water and deicing chemicals from seeping in and corroding structural elements.

## Background and Problem Statement

With integral or semi-integral abutments in “jointless” bridge design, girders at the bridge ends are encased in a reinforced concrete backwall to prevent surface water and deicing chemicals from seeping in and corroding structural elements. These abutments connect the deck and girders to the substructure so that the abutment moves with the rest of the bridge under traffic loads and cyclical expansion and contraction.

However, this movement can introduce new issues regarding drainage, soil settlement and erosion, void formation beneath the approach slabs and abutments, joint spalling, and transverse cracking in the approach slab. Joints may also open over time, allowing for the infiltration of water and debris. These issues may culminate in a “bump” at the end of the bridge.



*Integral abutment bridge and approach slab*



*Transverse cracking in approach slab (left) and differential settlement at joint (right)*

The use of integral and semi-integral abutments is currently limited to bridges with short or moderate span lengths and those with no or small skewness to eliminate the need to accommodate excessive bridge movements and avoid subjecting the bridges to excessive secondary forces.

## Goal and Objectives

This research aimed to help the Iowa Department of Transportation (DOT) and other Midwestern transportation agencies improve the long-term performance of many key aspects of jointless bridge design.

Objectives included collecting information relevant to increasing bridge end service life and developing recommendations on the design of integral and semi-integral abutment bridges.

## Research Description

The research included a comprehensive literature review, visual inspections and field instrumentation and monitoring of Iowa bridges, and finite element (FE) modeling and simulations.

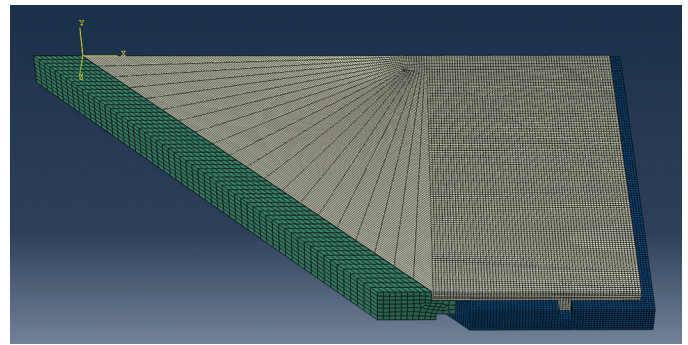
Nine Iowa bridges featuring four different bridge designs with semi-integral abutments or tied approach slabs were visually inspected to assess their condition states, especially at their ends. Bridges were chosen based on factors, such as length, width, skew, abutment type, and use of a tied approach.

Four Iowa bridges (Jasper County 118, Story County 118, Polk County 120, and Butler County 118) were instrumented and monitored to further understand the behavior of integral and semi-integral abutment bridges in service. Strain gauges, earth pressure cells, crackmeters, and displacement meters were used to obtain various performance measurements over time.

To understand the response of integral and semi-integral abutment bridges to thermal movement, skew, settlement, and other contributing factors, several FE models were created. Parameters, such as approach slab friction, soil stiffness, tie bar type, and bridge skew, were investigated.



*Earth pressure sensor on abutment backwall (left) and crackmeter on approach slab surface (right)*



*Jasper County 118 FE model*

## Key Findings and Recommendations

### Visual Inspections

- The ¼ in. tied approach joints in all nine bridges measured between ⅜ in. and 1½ in. at the time of inspection. Decreased joint widths at the opposite ends of the approach slabs indicate that the approach slabs are shifting away from the tied connections.
- Joints between the wingwalls and approach slab curbs showed potential problems, including a 6 in. deep void at the approach to the deck joint and wingwall, joint opening and separation of the approach slab from the wingwall, concrete cracking at the beginning of the approach slab curb, and poor drainage resulting in debris buildup at the beginning of the curb.
- Abutment drainage in the inspected bridges was largely free of debris and able to drain water from behind the abutments should it infiltrate the deck joints. However, the drain exits for one bridge were fairly close to the abutment and were blocked by soil.

### Field Instrumentation and Monitoring

- For Jasper County 118, the displacement data show movements of similar magnitudes for both abutments. Displacement transducers installed perpendicular to the bridge centerline measured transverse displacements equal to 81% and 120% of the longitudinal displacements for this semi-integral abutment bridge with a 45 degree skew.
- For Story County 118, an integral abutment bridge with a 15 degree skew, the data show that the tied approach slab joints experience cyclic opening and closing due to bridge expansion and contraction, though the behavior is not simply linear. Long-term monitoring may reveal additional joint expansion.
- For Polk County 120, the movement between the approach slab and the abutment was very low, indicating a good connection. A strong linear relationship with temperature indicates that the joint opens and closes with expansion and contraction of the bridge.

- For Butler County 118, the movement between the approach slab and the abutment was between -1.2 to 1.0 in. at the east side and between -0.3 to 0.8 in. at the west side. The working room gap between the abutment diaphragm and the backwall was found to push the backwall toward the middle part of the approach slab, creating a detrimental pivot point.

### **Numerical Simulations**

- In the tied joint of the Jasper County 118 approach slab, the lateral and longitudinal forces were similar in magnitude, and only a fraction of the maximum displacement moved the slab in either direction. Tied joint design should therefore account for large lateral forces. Using buttresses to limit transverse expansion could eliminate transverse slab displacement. Moreover, while stress concentrations were observed at this connection point, the stress levels were still reasonably low.
- The Story County 118 approach slab experienced notable tensile stresses when a 6 ft long void was assumed under the slab. Tensile cracking at the connection joint occurred when the void was extended to 11 ft, and transverse cracking in the bottom of the slab began when the void reached 16 ft. Based on void lengths observed in Iowa, however, the approach slab would likely be able to span the voiding conditions typically seen in the field.

- Skew drastically changes the distribution of tie bar stresses across tied approach joints. Force is shifted toward the acute approach slab corner while stresses decrease in the obtuse approach slab corner, resulting in greater stress ranges at higher skew angles. For the extreme 55-degree skew angle of Shelby County 118, a similar variation in tie bar stress was observed across the tied approach joint during bridge expansion and contraction.

### **Implementation Readiness and Benefits**

The use of integral or semi-integral abutments in bridge design has the potential to reduce maintenance and increase service life by preventing surface water and deicing chemicals from seeping in and corroding structural elements. Service life can further be improved by addressing potential issues introduced by the use of these abutment types, including soil settlement, joint opening, and transverse cracking.

The literature review, field studies, and FE simulations undertaken for this research resulted in recommendations for improving the performance of integral and semi-integral abutment bridges.