# Rapid Replacement of Bridge Deck Expansion Joints – Phase II

tech transfer summary

**This project investigated bridge deck expansion joint maintenance and replacement strategies and developed many novel ideas from others for improvement.**

CONSTRUCTION MANAGEMENT AND TECHNOLOGY

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Rapid Replacement of Bridge Deck Expansion Joints – Phase II

**SPONSORS**
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## Background

Bridge deck expansion joints are the components of a bridge that allow for movement of the bridge deck due to thermal expansion, dynamic loading, and several other factors. More recently, expansion joints have had a secondary function of preventing the passage of water. This water often contains de-icing salts and other corrosive chemicals that are harmful to the substructure of the bridge.

Expansion joints are often one of the first components of a bridge deck to fail and repairing or replacing expansion joints is essential to extending the life of the bridge. Failure can be due to increased traffic loading, component fatigue, low-quality work, or several other factors.

Joint failure can lead to increased damage to bridge substructures including rust formation on metal bearings as well as increased spalling on precast beam ends, concrete abutments, and concrete piers. To prevent further bridge damage, joints are often repaired or replaced.

## Problem Statement

Joint replacements are particularly problematic construction projects, often requiring traffic closures to allow completion of the work. Traffic closures are undesirable and often require staged jobs and difficult working conditions.

Completing work during low-traffic periods, nights, and weekends can help alleviate traffic concerns. However, it is challenging to complete a repair in a very short period or at night while still maintaining the necessary joint quality. Improved methods to rapidly repair and replace bridge deck expansion joints are desirable.

*Sliding plate joint anchorage observed during removal in the first phase of the research project*

## Objectives

The objectives of this research were two-fold: examine both current means and methods as well as develop new methods of replacing expansion joints.

## Scope

This research provides the Iowa Department of Transportation (DOT) with detailed information about the types of failure experienced by expansion joints, measures taken by the Iowa DOT to repair and prevent these types of failures, current construction methods undertaken by contractors in Iowa, and hypothesized ways to improve methods of expansion joint repair and maintenance.

Through a cooperative effort with participation from the Iowa DOT Office of Bridges and Structures, Office of Construction and Materials, District bridge maintenance crews, and contractors, the researchers on this project not only investigated and documented bridge deck expansion joint maintenance and replacement strategies, but also gathered, developed, and documented a number of ideas (from the group as well as from other state DOTs) for improvement.

## Research Description

In the Phase I study, the research team focused on documenting the current means and methods of bridge expansion joint deterioration, maintenance, and replacement and on identifying improvements through all of the input gathered.

Research team members visited with Iowa Department of Transportation (DOT) bridge maintenance crew leaders to document methods of maintaining and repairing bridge deck expansion joints. They observed active joint replacement projects in Iowa to document the means of replacing expansion joints that were beyond repair, as well as to identify bottlenecks in the construction process that could be modified to decrease the length of expansion joint replacement projects.

After maintenance and replacement strategies were identified, a workshop was held at the Iowa State University (ISU) Institute for Transportation (InTrans) to develop ideas to better maintain and replace expansion joints. Maintenance strategies were included in the discussion as a way to extend the useful life of a joint to decrease the number of joints replaced in a year and reduce traffic disruptions.

The results of this second phase of the research provide details about the types of failure experienced with expansion joints in Iowa, measures taken to repair and prevent these types of failures, current construction methods undertaken by contractors in Iowa, and hypothesized ways to improve methods of expansion joint repair and maintenance.

In this phase of the project, the researchers completed a review of published literature. Topics included types of joints used or tested in other states, common and reported modes of failures in other states, integral abutments and the differences in their use between states, other methods of eliminating deck joints from existing bridges, and surveys of the average life span of particular types of expansion joints.

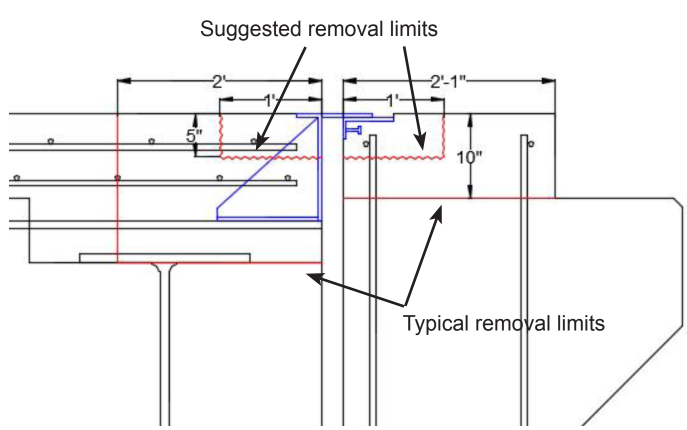
A second workshop was held with the emphasis solely on the replacement of expansion joints. Discussion topics included alternate methods of replacing joints, the possibility of using partial-depth deck removals for replacements, the removal of existing reinforcing steel from the end of the deck, and an alternative construction design that would eliminate the joint at the abutment and move it to a less problematic location.

Further investigations were performed into the prior use and research of the alternative design commonly called a deck extension.

Finally, an overview was completed of several different broad categories of materials that could be used as a high-early-strength pavement to reduce the cure time required for joint replacements, because early investigations found cure times were one of the longest single tasks required in the replacement of expansion joints.

## Key Findings

- Demolition and concrete cure times are the activities that require the most time for existing expansion joint replacement projects. The largest percentage of time would be saved by reducing these steps. However, all concrete units tend to be tied together with embedded reinforcing steel, which largely controls the length of time required for demolition. Requirements to maintain reinforcing steel bar in good condition necessitates the use of smaller handheld demolition equipment as opposed to larger tractor-mounted breakers that damage the embedded reinforcing steel bars.




*Suggested demolition limits for partial-depth joint replacement concept from one workshop breakout group discussion*

- Hydrodemolition has the potential to reduce concrete removal times while maintaining the integrity of reinforcing bars, especially when experienced operators operate the equipment. However, several challenges were observed including the need for a considerable quantity of water and a considerable amount of runoff with suspended small particles, as well as the need for some traditional removal in inaccessible regions. It also required the use of relatively expensive equipment that is unfamiliar for this purpose to most contractors in Iowa.

- Expansion joint repair is accomplished as needed, but preventive maintenance is largely ignored. Cleaning of sealed expansion joints to remove collected debris may only be performed if other repairs are being completed on the same bridge. Additionally, bridge maintenance crews have observed that neoprene glands perform well up to 15 years and 10 years for strip seal and compression seal joints, respectively. The performance of the neoprene seals beyond that age can be unpredictable and often seal replacements occur after failure.

  After failure and before replacement, the joint is left open, allowing possible damage to be inflicted on substructure components by leaking water with dissolved de-icing chemicals. Waterproofing is an important function of expansion joints in Iowa to prevent substructure damage from corrosives such as de-icing chemicals mixed with water.

- Emergency repairs of legacy-type joints, which are often sliding plate joints, by Iowa DOT bridge maintenance crews typically consist of doing whatever is necessary to allow the movement of the bridge deck and the passage of traffic. Restraints on time, manpower, and materials prevent repairs from improving the joint to a better working condition. Joints are left leaking and having rough riding surfaces.

- Angle iron armoring on compression seal joints is susceptible to fatigue failure under traffic loading due to inadequate consolidation of concrete beneath the steel sections. Much like sliding plate joints, attempts to replace broken plate sections have usually proved inadequate with welds quickly fatiguing and failing. In most cases, loose steel sections are removed by maintenance workers and replaced with concrete in a manner that can still provide an acceptable watertight seal if the neoprene gland is still in working condition.

- Full removal of old sliding plate joint anchorages is unnecessary during joint replacements. The old anchorages were typically bolted to the top flange of the steel girder and require a considerable amount of concrete demolition, time, and effort to remove.

- Some of the alternative materials for reducing cure times, such as elastomeric (polymer) concretes had been used previously by state highway agencies with varying results. Materials such as portland cement concrete and magnesium phosphate cement had been tested previously and found to have very high early-strength. However, in achieving that high-early-strength gain, concrete properties may be undesirably altered without the proper precautions.

  Prior research has found that concrete strength requirements can easily be met in as little as 4 hours, but that these mixes often suffer from increased amounts of shrinkage, which can cause premature deterioration in repair projects. Concrete that meets strength requirements in 24 hours is relatively easy to obtain and has few problems with shrinkage.

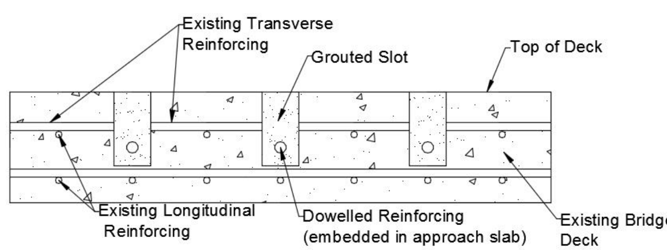
## Implementation Readiness and Benefits

- Contractors on the technical advisory committee and at the workshops think that removal of existing rebar and installation of dowel bars would be faster than maintaining existing rebar. Allowing the removal of the reinforcing that protrudes into the demolition areas would speed up construction. However, this introduces concerns with spalling of the bridge deck if cover concrete is not of sufficient depth.

  When expansion joints are set at a skew, it is important to consider that removal times can be affected by the transverse reinforcement because, when a joint is skewed, both the transverse and the longitudinal reinforcement will remain partially embedded in the deck after concrete removal is finished.

- Concrete can be removed to the depth required for a new strip seal anchorage and the exposed sections of the sliding plate joint anchorage can be removed with a cutting torch given that full removal of old sliding plate joint anchorages is unnecessary during joint replacement. The remainder can be left embedded in the existing concrete. However, it must be ensured that structural requirements for the concrete embedment of the strip seal anchorage are still met.

- An alternative to repairing expansion joints only as needed would be to replace seals on a preventive maintenance cycle of 15 years for strip seal joints and 10 years for compression seal joints, before they fail.




*Slotted dowel concept from one workshop breakout group discussion*

- Several types of joints exist that require very little installation time, including adhesive bonded joints and expandable foam compression joints (e.g., an EMseal joint). These joints could be used to provide temporary waterproofing until a full joint replacement can be completed. However, doing so requires stockpiles of these joint materials so that they are readily available when unexpected emergency repairs are required.

- With joints performing such a critical waterproofing function to prevent substructure damage from corrosives such as de-icing chemicals mixed with water, providing redundancy in waterproofing could prevent damage to the substructure in cases where the joint has undergone damage but is not yet slated for replacement.

## Suggestions for Future Research

Given that a considerable portion of this research focused on the current state of expansion joints and on developing novel ideas to rapidly repair expansion joints, some results are likely to be commissioned as future projects for more detailed evaluation and development. Suggestions follow.

- Look into providing waterproofing redundancy. This could be provided by a flexible waterproof trough located under the expansion joint. As damage occurs, such as damage to neoprene glands where the watertight seal has been broken, the expansion joint will prevent the passage of most debris while the trough will still prevent water and dissolved corrosives from damaging substructure components. This combination might be useful, because a problem with some trough installations is that they become filled with debris and clog. Retaining most debris at the surface of the bridge deck by the original damaged gland will possibly prevent clogging.

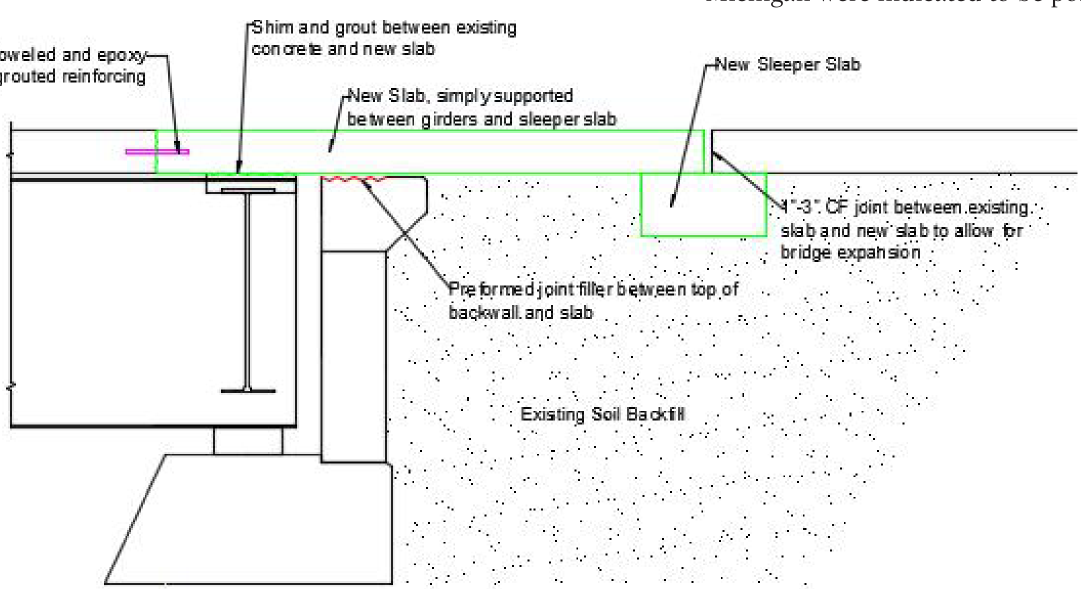
- Develop a suitable high-early-strength concrete mix to be used for repair applications. Alternatively analyze existing commercial products developed for this purpose to achieve a successful mix. Both pre-bagged mixes that could be stockpiled and stored for emergency repairs on short notice as well as large batched mixes ordered from concrete batch plants should be considered. Other types of concretes could be considered including polymer concretes and magnesium phosphate-based concretes, each capable of achieving high early-strengths.

- Redesign strip seal anchorages for a smaller profile. Current anchorages used in Iowa are nearly 6 inches in depth and therefore usually require, at minimum, the removal of the full-depth of the bridge deck to install a new joint. A smaller profile could reduce the amount of concrete required to be removed, particularly if coupled with a bridge overlay, which could reduce the amount of reinforcing that needs exposed.

  We suggest redesigning the anchorage to allow it to be attached to drilled and chemically bonded anchors installed at the end of the bridge deck. These anchors could also serve the dual purpose of providing a bond between the new and existing concrete allowing for the removal of the existing reinforcing by cutting it off at the removal limits for the concrete. A new concept would require a design that is at least as robust and durable as the current design, given that joint damage due to anchorage pullout rarely occurs.

- Design, construct, instrument, and observe a "deck sliding over backwall design" as a pilot project. Discussions during the two workshops completed as part of this project indicated that it would be a superior design from the point of view of the workshop participants to move the expansion joint away from the bridge deck and instead accommodate bridge expansion in the approach slabs.

  It was also thought that such a repair could also be completed in a single weekend; this would not reduce the amount of time required for joint replacements, but would create a more effective joint in the same amount of time. Experiences with a similar type of repair in Michigan were indicated to be positive.




*Tied precast approach slab concept from one workshop breakout group discussion*