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Rapid Replacement of Bridge Deck Expansion Joints Study – Phase I

Charles T. Jahren
Iowa State University, cjahren@iastate.edu

Adma Michael Miller
Iowa State University, adam008@iastate.edu

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Abstract
Bridge deck expansion joints are used to allow for movement of the bridge deck due to thermal expansion, dynamics loading, and other factors. More recently, expansion joints have also been utilized to prevent the passage of winter de-icing chemicals and other corrosives applied to bridge decks from penetrating and damaging substructure components of the bridge. Expansion joints are often one of the first components of a bridge deck to fail and repairing or replacing expansion joints are essential to extending the life of any bridge. In the Phase I study, the research team focused on the current means and methods of repairing and replacing bridge deck expansion joints. Research team members visited with Iowa Department of Transportation (DOT) Bridge Crew Leaders to document methods of maintaining and repairing bridge deck expansion joints. Active joint replacement projects around Iowa were observed 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 had been identified, a workshop was held at the Iowa State Institute for Transportation 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, thus decreasing the number of joints replaced in a year and reducing the traffic disruptions.

Keywords
Bridge decks, Expansion joints, Highway maintenance, Joints (Engineering), Maintenance, Service life

Disciplines
Civil Engineering

Comments
For the 73-page full report of this study, please see: http://lib.dr.iastate.edu/intrans_reports

CONSTRUCTION MANAGEMENT AND TECHNOLOGY

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tech transfer summary

This initial research phase 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.

Background

Bridge deck expansion joints are used to allow for movement of the bridge deck due to thermal expansion, dynamics loading, and other factors. More recently, expansion joints have also been utilized to prevent the passage of winter de-icing chemicals and other corrosives applied to bridge decks from penetrating and damaging substructure components of the bridge.

Expansion joints are often one of the first components of a bridge to fail and repairing or replacing expansion joints are essential to extending the life of any 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.

Joint replacements are particularly problematic construction projects, often requiring traffic closures to allow work completion. 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 of time or at night while still maintaining the necessary joint quality.

Problem Statement

The Iowa Department of Transportation (DOT) doesn't have published guidelines that specifically state the maintenance to complete on expansion joints. Most actions are determined and completed at the discretion of the District engineer and the bridge maintenance crew leader. As such, the actions taken often remain largely unknown to the design engineers who will eventually be designing joint replacements.

One important aspect to the replacement of expansion joints is the collaboration between the designers, constructors, and maintenance personnel working on each joint. Without the input of all involved parties, what may seem like a beneficial idea to one party may adversely affect another party.

Goal and Objectives

The goal of this investigation is to develop a rapid, effective, and economical approach to repairing and replacing bridge deck joints. The objectives of this research are two-fold, to examine both current means and methods as well as develop new methods for replacing bridge deck expansion joints.

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PRINCIPAL INVESTIGATOR
Chuck Jahren, Professor
Civil, Construction, and Environmental Engineering
Iowa State University
515-294-3829
cjahren@iastate.edu

MORE INFORMATION
www.intrans.iastate.edu

CMAT
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103

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Research Methodology

The the first research task was a thorough review of the existing literature.

The second research task involved the development of a visual record to document joint deterioration patterns as well as an explanation of the temporary maintenance activities that are conducted on expansion joints.

- Deterioration patterns were documented primarily through field visits with Iowa DOT District bridge crew leaders. The maintenance efforts taken to correct deterioration patterns were also recorded during these visits.
- Interviews were conducted with Iowa DOT bridge leaders regarding their field experience with joint deterioration and the maintenance efforts they pursue to extend the life of the bridge deck expansion joints in their specific districts. The researchers synthesized and present this information by type of expansion joint in the Phase I report, which discusses identified patterns of deterioration, maintenance methods utilized in extending the life of the expansion joint, and indications that the maintenance crew leaders use to determine when maintenance or replacement may soon be needed.

The third research task consisted of observing current expansion joint replacement projects in an attempt to determine factors that affect the duration of a joint replacement. Detailed observations of current construction methods practiced by contractors on several different expansion joint replacement projects in Iowa were documented.

Finally, a workshop was held to bring together representatives of three Midwest design consultants, three local Iowa contractors, the Iowa DOT Office of Bridges and Structures, the Iowa DOT Bridge Maintenance teams, the Iowa DOT Office of Construction, and the research team. The Phase I report includes detailed results and ideas from this workshop and from the three smaller group discussions, which were held during this workshop to make sure all involved parties were well represented.

Key Findings

The literature review showed that, while there was a considerable amount of literature that addresses expansion joints, and particularly their durability, there was little information regarding their replacement.

Regarding other expansion joint literature, the review found that integral abutment joints are the preferred joint for new bridges (Chang and Lee 2001). For expansion distances greater than those allowed by integral abutment joints, strip seal expansion joints are being used increasingly throughout the US.

In particular, many states are also replacing sliding plate joints and compression seal joints with strip seal joints. However, one research project discovered that a broad range of service lives were estimated by various states for strip seal joints. The service life of a strip seal expansion joint was estimated to be anywhere from 10 to 30 years (Guthrie et al. 2005). This information correlated with a University of Purdue study of expansion joints in Indiana that found strip seal joints were prone to early failure due to incorrect installation of the joint (Chang and Lee 2002).

Four main groups of expansion joints were identified as being widely utilized by the Iowa DOT: sliding plate joints, strip seal and compression seal joints, modular and finger joints, and integral abutment joints. While other joint types have occasionally been utilized by the Iowa DOT, their usage is uncommon, largely untested, and therefore not addressed.

Several factors were noticed during the observations of current expansion joint replacement projects. The Phase I report includes details on two bridge deck expansion joint replacement projects that were observed during this first phase of the project.

Challenges exist with construction in communication and understanding between the design engineers and the workers completing the physical repairs in the field. Design changes can help expedite field work, but existing processes to replace expansion joints must be understood before changes can be made.

Conversely, many jobsite supervisors may also have ideas that can facilitate more rapid completion of repairs but lack the engineering knowledge required to ensure that a design meets required standards for safety and durability.

Implementation Readiness and Benefits

Improved methods to rapidly repair and replace bridge deck expansion joints are desirable. The Phase I report provides details on deterioration of and maintenance efforts for each common group of expansion joints. It also provides information to help engineers become more intimate with the specific means and methods currently used during joint replacement projects.

The results of this 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.

Since a significant portion of this research phase focused on the current state of expansion joints and on developing novel ideas to rapidly repair expansion joints, some results may be contracted as future projects for more detailed evaluation.

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