



ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

ABC-UTC GUIDE FOR:

ACCELERATED REPAIR AND REPLACEMENT OF EXPANSION JOINTS

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Performing Institution:

Iowa State University

PIs:

Dr. Brent M. Phares

Dr. An Chen



IOWA STATE
UNIVERSITY



University of Nevada, Reno

FIU

Civil and Environmental
Engineering

W

WASHINGTON



The UNIVERSITY of OKLAHOMA



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ABSTRACT

This document summarizes the work activities undertaken during this study and presents the results of those activities toward development of this ABC-UTC Guide for Accelerated Repair and Replacement of Expansion Joints. The information will be of interest to highway officials, bridge construction, safety, design, and research engineers, as well as others concerned with the efficient replacement of expansion joints.

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DISCLAIMER

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1. INTRODUCTION

1.1. BACKGROUND

Bridge deck expansion joints are the components of the bridge that help to accommodate movement due to thermal expansion and, to a lesser extent, dynamic loading. Expansion joints may also serve to help prevent de-icing chemicals and other corrosives applied to bridge decks from penetrating and damaging bridge substructure components. Expansion joints are often one of the first components of a bridge deck to fail and may require multiple replacements throughout the life of a bridge. These replacements are seen as critical to extending bridge life and protecting the substructure components.

Currently, the replacement of an expansion joint can take anywhere from a few days to many weeks. These replacements typically involve extensive traffic interference and lane closures. Therefore, there is a need for accelerated replacement options and techniques, especially on bridges with high annual average daily traffic (AADT) and limited time for lane closures.

Accelerated bridge construction (ABC) has gained increasing momentum over recent years and is creating a permanent shift in how bridge construction is performed. ABC techniques focus on ways to reduce lane closures and many times utilize precast components. To date, however, there has been little research into using ABC techniques for expansion joint repair and replacement. The research study resulting in the development of this guide focused on developing these methods for accelerated expansion joint replacement.

Through a literature review, many accelerated methods were evaluated. From this evaluation, it was decided to pursue a combination of hydrodemolition, ultra-high-performance concrete (UHPC), and stainless steel extrusions for the accelerated joint replacement procedure/concept. This combination was explored to extend the life of the replacement joint and further reduce life-cycle costs and the time associated with replacing the joint in the future.

This proposed replacement method involves relatively high initial costs and required evaluation of its economic viability. A life-cycle cost analysis with a sensitivity study compared the proposed replacement to current practices and two alternative methods (i.e., those with lower initial costs). This analysis revealed that for bridges with a life longer than 50 years, the proposed replacement was the most cost-effective option. For bridges with a life of 50 or fewer years, it is more cost effective to consider a joint retrofit near the end of the bridge's life.

This proposed replacement joint system was subjected to bond, static, and fatigue testing. Hydrodemolition was used in the replacement testing process as part of a constructability evaluation. These tests indicated that the joint system utilizing hydrodemolition produces an excellent bond with the existing concrete. The static and fatigue testing revealed the joint system meets department of transportation (DOT) standards and would likely have a long service life.

1.2. SCOPE OF THE GUIDE

This guide is intended to provide details of an expansion joint replacement option that may be paired with ABC methodologies. Additional design, construction, and testing information is available in the final project report.

1.3. INTENDED USERS

This guide is intended for use by highway officials and bridge construction, safety, design, and research engineers.



2. BRIDGE DECK EXPANSION JOINT REPLACEMENT

2.1. COMPONENTS

The proposed replacement comprises multiple components to maximize the utility of the expansion joint replacement. The goals for the proposed replacement are two-fold. First, the replacement methods should require the minimum amount of time possible to install. Second, the replacement methods should have as long a life as possible to minimize the total number of full replacements needed in a given bridge’s life.

Of the types of expansion joints investigated, strip seal joints were among the top rated by the Iowa DOT for bridges of moderate length. Furthermore, strip seal joints are the most commonly used replacement joint when possible.

Strip seal joints consist of two steel extrusions—embedded in the approach slab and bridge deck. A neoprene gland, which is attached to the steel extrusions, is then placed in the gap. The neoprene gland is usually the first part of the joint to fail, after about 15 years. These glands can be removed and replaced with relative ease, and such removal does not compromise the structural integrity of the joint.

The Iowa DOT currently approves strip seal joints manufactured by two companies: Watson & Bowman and D.S. Brown. These products are similar to each other.

After speaking to a representative from D.S. Brown, it was discovered that D.S. Brown has specifications for making a steel railing for a strip seal joint out of stainless steel. These railings are typically constructed with A36 steel, which commonly has a life of about 25 years for the railing. If stainless steel were used instead of A36 for the construction of the strip seal railings, the life of the railing could be extended almost indefinitely. The D.S. Brown A2R-400 strip seal is specified for this proposed replacement.

Sealing Element Cross-Section	Sealing Element	Movement Range MR _L	Movement Range MR _T	Joint Opening
 A2R	A2R – 400	4.0 (102)	±2.0 (51)	0.5 – 4.5 (13) (114)

Figure 1. D.S. Brown A2R-400 strip seal details (D.S. Brown)

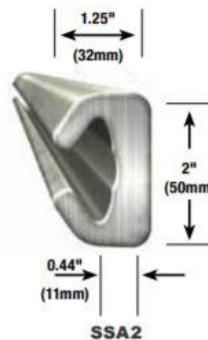


Figure 2. D.S. Brown steel railing for strip seal joint (D.S. Brown)

Of the demolition methods investigated, hydrodemolition was chosen for its quicker demolition time, smaller workforce, and excellent resulting bonding surface. Hydrodemolition is the process



of directing pressurized water to demolish concrete. The hydrodemolition unit is typically programmed and controlled by a walk-behind operator. This process prevents damage to the existing reinforcing steel and has minimal residual cracking in the remaining concrete.



Figure 3. Aquajet Aqua Cutter 710H (Kara Ruble/Bridge Engineering Center)

From the types of concrete investigated for the joint header, UHPC was selected for this proposed replacement. UHPC is a newer material, still being investigated for all its possible applications. UHPC has increased strength and durability compared to conventional concrete to the order of 6 times the strength and 100 times the durability. Because of this, UHPC has an extremely long service life that would last until the end of the bridge's life.



Figure 4. UHPC being placed into an expansion joint (NYSDOT)

In addition to their individual advantages, these components were chosen for the increased advantage of them working together as a system. Stainless steel railings can last until the end of the bridge's life, so it is logical to select a concrete that will last just as long. UHPC was the only concrete evaluated that can last until the end of the bridge's life.

For the UHPC and stainless steel system to last this long, an excellent bond is needed to avoid premature failure. In addition to being the fastest demolition option, hydrodemolition provides the best bonding surface without requiring sandblasting afterwards.



2.2. REPLACEMENT METHOD CONSIDERATIONS

The following items should be considered when choosing the appropriate replacement method for a specific project.

1	Availability of joint components and particularly stainless steel railings from the manufacturer
2	Timeline of the project and curing time for UHPC vs. other fast-setting concretes
3	Projected bridge life for cost analysis
4	Immediate budget of the project vs. relatively high initial costs of the proposed replacement

Figure 5. Summary of replacement method considerations

First, the availability of the joint components should be considered. The availability of stainless steel railings must be confirmed with the manufacturer before the final design stage of the project.

Second, the timeline of the project must be considered. UHPC requires a longer curing time than other fast-setting concretes (but shorter than conventional concrete), but it can still be placed over a weekend.

With this in mind, UHPC and a stainless steel railing would only need one full replacement in the remaining bridge life. One weekend of construction for the replacement in the whole bridge life may be more desirable than multiple days of construction disrupting traffic 3–4 times throughout the bridge’s life. If the project must be opened to traffic within a few hours, a fast-setting alternative, such as elastomeric concrete, may be preferred over UHPC.

Third, the projected bridge life must be considered. The cost analysis detailed in the related research shows that the proposed method is the most cost effective over a bridge life longer than 50 years. If a bridge’s life is less than 50 years, a standard joint replacement or retrofit option may be preferred.

Finally, the immediate budget of the project must be considered. The proposed replacement method in this guide has relatively high initial costs. Over the course of the bridge’s life, it was the most cost-effective option evaluated in the cost analysis. However, the specific budget allocated to a project must be prepared for higher initial costs than a standard replacement.

REFERENCE

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