Improved Bridge Expansion Joints
Our Mission

We provide services to the transportation community through research, technology transfer and education. We create and participate in partnerships to promote safe and effective transportation systems.
Research Report  
KTC-11-17/SPR405-10-1F  
Improved Bridge Expansion Joints

By

Sudhir Palle  
Associate Engineer II, Research

Theodore Hopwood II  
Associate Engineer III, Research

And

Bobby W. Meade  
Transportation Technician

Kentucky Transportation Center  
College of Engineering  
University of Kentucky  
Lexington, Kentucky

In cooperation with  
Kentucky Transportation Cabinet  
Commonwealth of Kentucky

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or the policies of the University of Kentucky, the Kentucky Transportation Center, nor the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

June 2012
1. **Report No.**
   KTC-11-17/SPR405-10-1F

2. **Government Accession No.**

3. **Recipient’s Catalog No.**

4. **Title and Subtitle**
   Improved Bridge Expansion Joints

5. **Report Date**
   July 2011

6. **Performing Organization Code**

7. **Author(s)**
   Sudhir Palle, Theodore Hopwood and Bobby W. Meade

8. **Performing Organization Report No.**
   KTC-11-17/SPR405-10-1F

9. **Performing Organization Name and Address**
   Kentucky Transportation Center
   College of Engineering
   University of Kentucky
   Lexington, KY 40506-0043

10. **Work Unit No. (TRAIS)**

11. **Contractor Grant No.**
    KTC-11-17/SPR405-10-1F

12. **Sponsoring Agency Name and Address**
    Kentucky Transportation Cabinet
    State Office Building
    Frankfort, KY 40622

13. **Type of Report and Period Covered**
    Final

14. **Sponsoring Agency Code**

15. **Supplementary Notes**
    Prepared in cooperation with the Kentucky Transportation Cabinet, Federal Highway Administration, and U.S. Department of Transportation. Study Title: Improved Bridge Expansion Joints

16. **Abstract**
    The Kentucky Transportation Cabinet (KYTC) has both open and closed bridge expansion joints and associated details that are problematic. Several state highway agencies (SHA) have joints that they believe are superior performers to other types and have prepared guidance documents for their use. A literature search indicated that several previous research studies, including national surveys, addressing SHA joint practices have been conducted over the past 10 years. For up-to-date information, a new set of surveys were developed and distributed to all the SHAs by email through the AASHTO Subcommittee on Maintenance - Bridge Technical Working Group chairman in June 2010. There were two sets of surveys: 1) design and construction; and 2) maintenance that were submitted to two separate entities within each SHA.

17. **Key Words**
    Joints, seals, maintenance, construction, bridges, joint replacement

18. **Distribution Statement**
    Unlimited with the approval of the Kentucky Transportation Cabinet

19. **Security Classif. (of this report)**
    Unclassified

20. **Security Classif. (of this page)**
    Unclassified

21. **No. of Pages**
    44

22. **Price**

# TABLE OF CONTENTS

TABLE OF CONTENTS .................................................................................................. III
LIST OF TABLES ........................................................................................................ IV
LIST OF FIGURES ....................................................................................................... V
ACKNOWLEDGEMENTS ............................................................................................ VI
EXECUTIVE SUMMARY .......................................................................................... VII
1. **INTRODUCTION** ............................................................................................. 1
   1.1 **BACKGROUND** ......................................................................................... 1
   1.2 **WORK PLAN** .......................................................................................... 4
2. **WORK ADDRESSING STUDY TASKS** ...................................................... 5
   2.1 **SUMMARY OF LITERATURE SEARCH** .................................................. 5
   2.2 **SURVEY PREPARATION** ......................................................................... 6
3. **SURVEY RESULTS AND DISCUSSION** ................................................... 8
   3.1 **DESIGN AND CONSTRUCTION OF BRIDGE EXPANSION JOINTS SURVEY** .............................................................. 8
      3.1.1 **JOINT SELECTION CRITERIA AND SIZING** ........................................ 8
      3.1.2 **JOINTLESS BRIDGE DESIGN CRITERIA** .............................................. 9
      3.1.3 **ARMORED EDGE AND BLOCKOUT DESIGNS** .................................... 9
      3.1.4 **JOINT INSTALLATION AND WARRANTY** ............................................. 9
      3.1.5 **PERFORMANCE TESTS ON JOINTS** .................................................. 10
   3.2 **JOINT MAINTENANCE SURVEY** ............................................................ 10
      3.2.1 **INSPECTION CRITERIA** ..................................................................... 10
      3.2.2 **JOINT REPLACEMENT CRITERIA** .................................................... 11
      3.2.3 **JOINT REMOVAL** .............................................................................. 11
      3.2.4 **JOINT MAINTENANCE** ..................................................................... 12
4. **NEW JOINT DESIGN** .................................................................................... 13
5. **WORK ON STUDY TASKS** .......................................................................... 16
6. **CONCLUSIONS** .......................................................................................... 17
7. **RECOMMENDATIONS** ................................................................................. 18
8. **REFERENCES** ............................................................................................. 19
9. **TABLES** ...................................................................................................... 20
10. **FIGURES** ................................................................................................... 21
11. **APPENDIX A - Survey of Materials and Practices Related to Bridge Expansion Joint Maintenance** .................................................. 28
12. **APPENDIX B - Survey of Materials and Practices Related to Design and Construction of Bridge Expansion Joints** ..................... 33
LIST OF TABLES

Table 1. Summary of Joints Used in New Design and Construction.......................... 20
Table 2. Summary of Joints Used in Maintenance Activities................................. 20
**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Diverter/Troughs for Open Joints (Top View)</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>Diverter/Troughs for Open Joints (Front View)</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>Diverter/Troughs for Open Joints (Side View)</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>Flex Trough</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>Joint Repair for Type 104 T-Beam Bridges</td>
<td>23</td>
</tr>
<tr>
<td>7</td>
<td>Redundant Poured Joint Seal</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>Rigid Mini-Gutter</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>Sliding Plate for Debris-Laden Decks</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>Strip Seal</td>
<td>26</td>
</tr>
<tr>
<td>11</td>
<td>Trough for Modular Expansion Joint</td>
<td>26</td>
</tr>
<tr>
<td>12</td>
<td>Trough Liner for Finger Dam</td>
<td>27</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

The authors wish to express their gratitude and sincere appreciation to the Kentucky Transportation Cabinet’s Study Advisory Committee (SAC) members – Marvin Wolfe with the Division of Structural Design, Tim Layson with the Division of Construction, and David Steele, Farhad Abad, and Josh Rogers with the Division of Maintenance. They would also like to thank Mr. Peter Weykamp of the New York State Department of Transportation and other members on the AASHTO Subcommittee on Maintenance Bridge Technical Working Group for their assistance in preparing and disseminating a survey on bridge joints to state highway agencies. Additionally, we would like to thank all the officials from the responding state highway agencies who took time from their busy schedules to participate in the survey.
EXECUTIVE SUMMARY

The Kentucky Transportation Cabinet (KYTC) has both open and closed bridge expansion joints and associated details that are problematic, and this is the case with several other state highway agencies (SHA). Several SHAs have joints that they believe are superior performers compared to other types and have prepared guidance documents for their use. The primary objectives of the research study were to; assemble up-to-date industry information about expansion joint/header selection, installation, performance and special inspection/maintenance requirements/practices; prepare guidance on joint selection, enumerating preferred joints for both new construction and maintenance; identify the best performing deck joints/details; and seek to implement enhanced joint materials/designs/installation.

The literature search indicated that several previous research studies, including national surveys, addressing SHA joint practices have been conducted over the past ten years. For more current information, a new set of surveys were developed and distributed to all the SHAs by email through the AASHTO Subcommittee on Maintenance - Bridge Technical Working Group chairman in June 2010. There were two sets of surveys: design and construction, and maintenance that were submitted to two separate entities (e.g. divisions) within the SHAs. The Kentucky Transportation Center (KTC) received survey responses from a total of 34 SHAs by December 2010.

The following conclusions were obtained from the survey results of both design and construction, and maintenance:
1) Most SHAs sought to eliminate joints where ever possible. Several noted that joint elimination was a goal for new bridge designs. Several have also moved away from using any joints less than one inch wide.
2) Another SHA trend is to discontinue employing joints with armored edges, especially in states with heavy snow plow usage.
3) In joints with openings less than one inch, neoprene strip seals were reported as being the most successful type. Over 75 percent of the participating states included these seals for their upcoming maintenance, with 70 percent rating it as good or very good.
4) In joint openings of between one to three inches, neoprene strip seals were considered the most successful type by most responding states with an average life span of approximately 20 years (typically ranging between 15 - 25 years).
5) In openings three to five (plus) inches long, the two main joint types were steel finger joints (finder dams) and the modular joints. Steel finger joints have the longest operable life, on average ranging from 25 to 50 years. The modular expansion joints
have an average life span of 25 plus years. Each of these joints was used in slightly more than 50 percent of responding states.

6) A primary source of problems with joints, as reported by SHAS, was water runoff through them that causes deterioration of underlying bridge elements. The use of troughs, gutters, diverters and redundant seals (in the case of pourable joints) offered an opportunity to prevent bridge element deterioration.

The KTC research findings provide a guide to revising current Kentucky practices reflecting to joint selection, design, construction and maintenance. KYTC should consider:

- Trial projects incorporating advanced designs
- Partnering with other SHA’s to develop qualifications for advanced products

Several other recommendations are included to improve the instillation, use, and maintenance of joint seals.
1. INTRODUCTION

Both open and closed bridge expansion joints and associated details have proved problematic for state highway agencies (SHAs). While those may constitute a small percentage of the cost of a new bridge, they may contribute to a large portion of its subsequent maintenance costs. Those costs may be borne in terms of repairs of: armored joints that fail or are damaged during normal operation (e.g. snow removal); joint hardware, seals or headers that fail and need to be replaced; and underlying beam ends, bearings or piers that are damaged by deicing-salt laden water runoff from leaking joints.

Good performing joints need to be identified and new joint types and/or materials and/or designs evaluated to determine which will perform properly and provide extended service without need for repair or replacement. Design details need to be incorporated to extend the service lives of closed joints by accommodating leakage (troughs). Joints need to be correctly installed and inspected to ensure maximum long-term performance. During the biennial bridge inspections, joint performance needs to be properly assessed to permit timely repairs. The “no joint” option (joint removal) needs to be considered in bridge rehabilitation decisions.

1.1 BACKGROUND

Joints are intended to: 1) facilitate smooth movement of traffic across them, 2) accommodate longitudinal superstructure movement, 3) possibly protect the edges of the concrete deck and 4) in many cases prevent moisture from impinging on bridge elements below joints. Issues arise, such as over sizing (to accommodate movement), joint design & materials, placement, durability, susceptibility to damage, retention of all functions and maintenance. To maximize effectiveness of joint function most modern bridge designs incorporate closed joints that are also intended to keep deck moisture and debris from falling onto and adversely affecting bridge elements located under deck joints. Those joints incorporate flexible seals in a variety of manners to accommodate joint movement, yet retain a seal between adjoining deck elements. Joint manufacturers stress proper installation, inspection and maintenance to optimize their performance (i.e. retention of functionality and durability).

Several SHAs used specific joint types that (they believe) provided benefits in terms of superior performance, lower costs and/or ease of application compared to other types. Some SHAs have prepared guidance documents for their use. Surveys, synthesis reports (based upon surveys), and research reports based upon field inspections have summarized many of those – along with the opinions of SHA officials in states which have not formalized the joint selection process (1-3). These documents are somewhat dated due to the emergence of new joint designs and technologies. As a consequence, SHAs using these and other out-of-date guidance
documents are limited to employing older technology or are otherwise restricted to relying solely on agency internal experience in their joint decision-making process.

Many SHA officials recognize joints as a problematic detail and some (e.g. the Tennessee DOT) have developed integral abutment bridge designs that (for the most part) eliminate deck joints even on 1,000 ft. long bridges. Others seek to eliminate joints by making existing multi-span bridges continuous. Commonly, this is done in conjunction with the elimination of pin-and-hanger connections on steel deck girder bridges. Those actions are now part of new construction or bridge rehabilitation work (including the replacement of open joints). Generally, selection of these modifications is impacted by design and cost decisions. The preparation of specific guidance for joint elimination decisions would facilitate the project development process and result in better joint selection/elimination decisions. In the execution of this study, the joint-elimination alternative can be considered an improved joint practice so long as it is justifiable by structural and cost decisions (life-cycle costs preferred).

Joints can be broadly classified by the opening/movement that they span/accommodate. Small joints accommodate joint movement less than one inch. Intermediate joints accommodate joint movement from one to three inches. Large joints accommodate movements greater than three inches. Small joints are typically poured materials, such as silicon and polyurethane, though open butt joints may be found on some older bridges. Some SHAs use various types of preformed seals for small joints. There are a wide range of joint types/materials commonly used for intermediate joints including (but not limited to): sliding plates, finger dams, compression seals, preformed seals, strip seals, foam seals, inflatable seals, plank seals and plug joints. Large joints are typically finger dams or modular joints.

Success of deck joints relates to proper sizing, suitable preparation of the bridge deck or abutment backwall and correct installation (including provisions for temperature– if applicable). Joint failures can commonly be related to inattention to these factors. They will be addressed under this study, including the desirability to perform post-installation joint function (watertightness) testing. For optimum service performance, proper inspection of deck expansion joints must identify maintenance needs, including routine maintenance, (elimination of excessive debris in closed joints, removal of debris in drainage troughs of open joints, repair of minor joint damage and leakage of closed joints. The latter could be facilitated at an early stage by a nondestructive test that inspectors could use to assess joint watertightness. That testing could be used to better assess joint performance over time (in follow-on biennial inspections). That would allow timely repair of pourable joints and replacement/repair of seals on others. However, an in-service watertightness test would need to be fairly rapid to avoid traffic closure issues during routine inspections. Optimum joint selection and sizing, combined with proper installation, accurate condition assessment during inspections and timely maintenance can maximize joint
durability, function and service. It would be beneficial to determine typical maintenance requirements and expectations for service lives of joints and their components.

Newer joint types, such as foam joints (and others) have not been widely evaluated. Some manufacturers of common joint types (e.g. plug joints) claim to have high rates of success. At least one SHA (Nevada DOT) has emphasized the development of those joints with different materials and stricter placement controls than normally applied. As a consequence, Nevada has claimed greater success with their technology than is generally attributed to plug joints. One joint manufacturer claims segmental (plank) joints are functioning better than early ones due to employment of chemical (adhesively bonded) anchorages.

KYTC was one of the first SHAs to employ modular expansion joints in the 1970s. Some of those did not perform well and were subsequently removed. Since then, manufacturers have made improvements in those joints and they have been shown to provide better long-term protection to the underlying bridge elements than finger joint/troughs. The newer modular joints need to be investigated to determine whether they will provide suitable performance, especially on heavily travelled bridges.

Other joint types such as strip seals have performed well in many applications, but may be improved by use of more durable seal materials. New joints bear further review. In many cases, other SHAs have experience with them that can be taken into account when selecting joints for follow-up investigations. In some cases, enhancements in joint performance may be possible by minor revisions in design or by changing joint materials (i.e. seals). Joint manufacturers need to be apprised of the need for better joint designs/materials and brought in to the improvement process.

Besides joint types and materials, joint performance may be improved by use of better materials and techniques for blockouts and nosings. Blockouts and nosings refer to the removal of damaged deck material on either side of the joint. The distance from the joint and the depth of the blockout is often determined by the joint gap. This also allows replacement of damaged deck concrete at the nosing with a higher performing material. Also, the use of armored edges was problematic for nine responding states, and they have elected to eliminate them if possible when maintenance is done. Material suppliers have polymer/aggregate materials that are placed in the blockouts and create better performing joint nosings. At this time KYTC does not have a plan for the issues they are having with their armored edges, and this may warrant further study. Strip seals, which have gained much popularity with SHAs, incorporate the use of armored edges in the edge beams where the strip seals are mounted. New York State DOT (NYSDOT) performs much of its deck joint maintenance with in-house crews. Instead of using epoxy in blockouts, NYSDOT crews employ quick-curing polyester that hardens in a few hours enabling repaired joints to be placed under traffic the same day that a joint is repaired/replaced.
Troughs have been used for years with open deck joints. Excessive debris build-up is a common problem with those troughs. Such troughs need steep inclinations to be self-purging and sufficient clearances usually are not present under bridge joints. As a consequence, troughs under open joints need to be maintained periodically to remove debris. In some cases (e.g. the I-64 Riverside Parkway in Louisville), rigid troughs under open finger joints rapidly filled with debris and clogged, resulting in an overflow of rainwater runoff onto adjacent floorbeams causing them to corrode. On the I-65 JFK Bridge over the Ohio River in Louisville, a clogged trough under a large finger joint caused rainwater and deicing salts to spill onto an uplift bearing, resulting in corrosion and failure of one of its anchor bolts. That damage necessitated expensive repairs to properly anchor the uplift bearing.

A better option is to use troughs in conjunction with closed joints. In 2002, KTC researchers visited Perm, Russia and observed the use of several simple types of troughs under poured and sliding plate joints. The use of troughs under closed/semi-closed joints has been recommended by others (Purvis, Ref. 1, page 19). The advantages of using troughs under closed joints is that the troughs have to carry off only water (no debris) and only need a shallow inclination of 1:100. Therefore, they will not encounter clearance problems under most deck joints. Also, they will handle minor leakage and extend the useful service lives of joints for many years. Probably the greatest problem encountered with deck joints relates to corrosion damage of bridge elements under leaking joints.

1.2 WORK PLAN

The study objectives approved by the KYTC Study Advisory Committee were:
1. Obtain up-to-date industry information about expansion joint/header selection, installation, performance and special inspection/maintenance requirements/practices.
2. Obtain relevant data on good-performing/new joints.
3. Obtain guidance for making repair/replacement decisions involving joint elimination versus selection of optimal replacement joints.
4. Assemble guidance on joint selection, enumerating preferred joints for both new construction and maintenance. Identify performance tests that may be used to evaluate new/existing joints.
5. Identify the best performing deck joints/details (based upon Objective 1) and potential areas for joint performance enhancements (including improved installation practices). Seek to implement enhanced joint materials/designs/installation.
6. Support and participate in the development of KYTC experimental projects incorporating bridge expansion joints that offer improved performance.

The tasks that addressed the study objectives were:
1. Conduct a literature review. Based upon that review develop survey questions for SHAs. After KYTC review of questions/topics, survey selected SHAs, consultant engineering firms
and KYTC Districts to obtain information/opinions about expansion joint/header installation, performance and special maintenance requirements/practices (this was to be coordinated with the AASHTO Subcommittee on Maintenance Bridge Technical Working Group).

2. Obtain performance data, specifications, installation instructions and maintenance requirements on specific joint designs from manufacturers/material suppliers and SHAs.

3. Obtain guidelines from the KYTC Division of Bridges on joint elimination (intermediate joints). Formulate guidance to assist KYTC maintenance officials in making repair/replacement decisions involving joint elimination versus employment of optimal replacement joints.

4. Prepare guidance on joint selection enumerating preferred joints for both new construction and maintenance. Develop guidance for KYTC inspection personnel to properly inspect closed joints. Recommend expansion joint preventive maintenance and repair/replacement guidelines to maintain their proper functions.

5. Review the best performing deck joints/details (based upon Objective 1) and identify potential areas for joint performance enhancements (including improved design/material enhancements and incorporation of troughs for closed joints). Interface with joint/material manufacturers to implement enhanced joint designs/materials.

6. Assist KYTC maintenance officials in the programming of experimental projects incorporating bridge expansion joints that offer improved performance. Monitor the placement of experimental joints during construction.

7. Prepare a final report. In the report, provide KYTC with: 1) guidance for joint selection/elimination, 2) recommended joints features for evaluation, 3) recommendations for joint placement, including construction oversight, and 4) recommendations for incorporating troughs with closed joints.

2. WORK ADDRESSING STUDY TASKS

2.1 SUMMARY OF LITERATURE SEARCH

Several previous research studies addressing SHA joint practices have been conducted over the past ten years, including national surveys. Most prominent was the NCHRP Synthesis 319 “Bridge Deck Performance – A Synthesis of Highway Practice” in 2003 (1). Another national survey effort was incorporated in a research study for the Arizona Department of Transportation culminating in the report, “Evaluation of Various Types of Bridge Deck Joints – Final Report 510” in 2006 (2). While those documents were helpful, a more up-to-date survey was considered desirable for the KYTC-sponsored study. The proposed survey was intended to focus on the study objectives and concerns of the KTC research team and the KYTC Study Advisory Committee. The primary objectives of the research study were to: 1) assemble up-to-date industry information about expansion joint/header selection, installation, performance and special inspection/maintenance requirements/practices, 2) obtain relevant data on well-
performing/new joints, 3) develop guidance for making repair/replacement decisions involving joint elimination versus selection of optimal replacement joints, 4) prepare guidance on joint selection, enumerating preferred joints for both new construction and maintenance. Identify joint performance tests that may be used to evaluate new/existing joints, 5) identify the best performing deck joints/details (based upon Objective 1) and potential areas for joint performance enhancements (including improved installation practices), 6) seek to implement enhanced joint materials/designs/installation and 7) support and participate in the development of KYTC experimental projects incorporating bridge expansion joints that offer improved performance.

This required the preparation of an entirely new survey rather than an update of the earlier ones (though some repetition of questions may have occurred in the KTC version).

### 2.2 SURVEY PREPARATION

KTC researchers were aware that when joint maintenance was required SHA maintenance officials did not always retain joint types favored by their design and construction counterparts for new construction. They were also cognizant that installation practices were often as important to joint durability as selection of joint type and size. Factors pertaining to joint installation needed to be addressed to properly develop effective guidance for KYTC officials. After reviewing the available publications, KTC researchers developed a series of questions to elicit the desired information. Questions sought information such as joint selection criteria (ADT, skew, opening, movement, etc.), joint installation practices, qualification of joint contractors and inspectors, warranties, and cost tracking.

After all the questions were prepared, they were then grouped into two basic surveys. Some of the questions were pertinent to design, construction, and maintenance divisions, which typically exist as separate entities within most SHAs. Maintenance divisions may focus on performance, whereas design and construction divisions might focus more on constructability. Costs are probably a greater concern for budget-constrained maintenance work than for new construction projects. During the initial review of SHA responses a division between departments posed issues that researchers wanted to minimize, they recognized the need to prepare the survey questions for submittal to two SHA respondent groups: 1) design and construction and 2) maintenance. Some questions were common to both groups.

The design and construction survey was further divided into three categories that focused on: 1) joint selection and sizing, 2) construction and 3) costs. The maintenance survey was divided into five categories that focused on: 1) inspection criteria, 2) maintenance practices, 3) joint selection and sizing, 4) installation and 5) repair and maintenance tracking.

The National Cooperative Highway Research Program (NCHRP) Synthesis 319 (1) had divided expansion joints into two categories – open joints and closed joints. Closed joints are designed to be watertight, whereas open joints are not. That study classified open joints based on
movement: less than one inch, one inch to three inches and anything greater than three inches. The NCHRP study did not categorize closed joints as to joint movement. KYTC used only two classifications for joints which are noted in their Structural Guidance 501-2. That guidance did not address open or closed joints, but just classified joints for movements greater than four inches and for four inches or less. The survey questions were based on a modification of the NCHRP classification and the KYTC guidance. Joint classification in the survey was based on movements: less than one inch, one inch to three inches and anything greater than three inches without consideration for open or closed joint type.

The method of disseminating the surveys was affected by the anticipated variation in organizational structure of the SHAs, to which they would ultimately be directed. Initially, researchers considered using a web-based survey tool for dissemination to SHAs. In evaluating its function, several drawbacks were identified that could prove problematic in obtaining desired SHA responses. Subsequently KTC researchers prepared a printable PDF-based survey form for e-mail distribution to SHAs. That approach enabled various respondents within an SHA to complete portions of the surveys they were knowledgeable about and subsequently forward the document to other officials within their division or in other divisions for completion. KTC could then survey all of the SHAs without needing to differentiate between their specific organizational structures dealing with deck joints.

Some survey responses required specific “Yes/No” type answers or short “fill in the blank” responses. In several cases, the responders were asked to provide discussion-type responses and solicited to provide additional comments to flesh out fixed-response questions. Subsequently, when the completed surveys were received, KTC researchers were required to collate and summarize the SHA responses. Due to the length of the surveys, this proved to be time consuming.

Once the draft surveys were completed they were submitted to KYTC officials for review to ensure that they would address the KYTC information needs. After making the necessary revisions KTC researchers arranged for the survey to be distributed nationally by the AASHTO Subcommittee on Maintenance (SCOM) Bridge Technical Working Group (BTWG) and it was subsequently sent to the BTWG for review. That review/critique (by bridge maintenance officials from six SHAs) enabled KTC researchers to further modify the survey and incorporate a more diverse perspective. Prior to submitting the survey on a national basis, it was submitted/tested on KYTC officials and the responses were evaluated to assure that the survey wording would obtain the desired responses. After this last test, Peter Weykamp of the New York State DOT (the Bridge Technical Working Group Chairman in June 2010) emailed the survey to SHA officials in all 50 states.
 Eventually, when few responses were provided, KTC researchers had to review the contact list used for that emailing. Some of the listed SHA officials had retired and the surveys had not been forwarded to the proper contacts within their agencies. KTC researchers called all of the SHAs by telephone to identify the appropriate SHA contacts and encourage them to participate in the survey. KTC received survey responses from a total of 34 SHAs by December 2010. Twenty-eight responses were received for maintenance and 29 for the design and construction portions of the survey. Only 23 SHAs completed both portions of the survey. KTC researchers compiled the survey responses and submitted them to the AASHTO Subcommittee on Maintenance BTWG.

3. SURVEY RESULTS AND DISCUSSION

3.1 DESIGN AND CONSTRUCTION OF BRIDGE EXPANSION JOINTS SURVEY

The 28 states that responded to the Design and Construction of Bridge Expansion Joints survey were –Alaska, Arkansas, California, Colorado, Connecticut, Florida, Illinois, Iowa, Kansas, Kentucky, Minnesota, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, and Wyoming

3.1.1 JOINT SELECTION CRITERIA AND SIZING

In the joint selection and sizing category, 23 SHAs stated they have standard drawings for joints. Ten responded that they do not have qualified product lists for proprietary joints. This matched the responses to the same questions on the maintenance survey.

Of the different types of joints discussed for sizing, the following are the summaries from 23 responding SHAs:

Less than one inch: Strip seals, asphalt plugs and compression seals were used by one third of responding SHAs.

One to three inches: Strip seals were used by over half of the responding SHAs. Compression seals were used by one third of responding SHAs. Finger joints, preformed joint seals, elastomeric seals and poured silicone joints were also used by a quarter of responding states.

Greater than three inches: Finger joints, sliding plates, strip seals and modular expansion joints were used by over one half of the responding SHAs.
Seventeen SHAs had guidance for special conditions such as fatigue, skew, variable openings, curves, grades and stops. Only Pennsylvania and North Carolina had guidance for joint selection based on ADT.

3.1.2 JOINTLESS BRIDGE DESIGN CRITERIA

Every responding state employed either jointless bridges or designs that minimized the number of joints. Integral abutments were listed as being used by 16 SHAs to minimize joints. Two SHAs limited jointless construction to span lengths less than 200 feet. Six SHAs designed jointless construction for continuous spans between 300 and 500 feet. Five states designed jointless bridges up to 600 feet. Tennessee and Nebraska were the only two states that employed total span lengths as long as 1200 feet and 1630 feet (respectively) between expansions joints in order to minimize the total number of bridge joints.

3.1.3 ARMORED EDGE AND BLOCKOUT DESIGNS

Twenty-two states used armored edge joints. The states that did not use armored edge joints were: Washington, Wyoming, Nebraska, New Mexico, North Dakota, Virginia and California. The types of armored edge joints still being used in new construction are: steel armor with concrete, Evazote, steel vertical plates, angles with studs, modular joints, finger joints, CIPEC, compression seals, preformed joint seals, poured silicone joints and strip seal anchorages. Wyoming, Nebraska, New Mexico, Virginia and North Carolina are trying to eliminate armored edges on most joints. Seventeen of the states that responded incorporated blockouts into new joint designs. Most of these blockouts were made of concrete or elastomeric concrete.

3.1.4 JOINT INSTALLATION AND WARRANTY

Colorado, Nevada, and Tennessee stated their field inspectors were required to have special training by manufacturers for inspecting joint construction or repairs. Nevada field inspectors usually attended training/orientation provided by each joint manufacturer. In addition, eight SHAs responded that their joint installers were required to have special training or qualifications but they did not mention the training source. Nineteen states required that manufacturer representatives be present for at least the first joint installation to ensure they are placed properly. Alaska, South Dakota, Florida, Iowa, North Dakota, New Hampshire, and Pennsylvania all stated that they do not require a manufacturer’s representative to be present to perform joint installations. The SHAs that did not require a representative be present also did not require the manufacturer’s approval of the joint installation. Of the SHAs that did require a manufacturer’s representative to be present, approximately half required their final approval on the joint installation. South Carolina and New Mexico were the only two SHAs that required joint
manufacturers to provide performance warranties. South Carolina required a warranty for five years that covers all the repair/replacement costs except for traffic control. New Mexico required a one year performance warranty.

Twenty-five of the SHAs responded that they measured both temperatures and joint openings at the time of installation but only five of them kept records of this data for future use. Kentucky, North Carolina and North Dakota said they did not follow manufacturer guidelines for installation temperature.

3.1.5 PERFORMANCE TESTS ON JOINTS

Ten states stated that they conducted performance tests on newly installed joints. Seven SHAs performed water tightness and/or leakage tests. Minnesota and Ohio required certified laboratory testing data or an ASTM standard drawing from the material manufacturer.

Twenty-one SHAs responded that joint installation is a specific bid item on bridge construction projects. Eighteen SHAs commented that they did performance tracking of common joint designs and details.

3.2 JOINT MAINTENANCE SURVEY


3.2.1 INSPECTION CRITERIA

Twenty-two SHAs reported that they performed element level bridge inspections. The survey inquired how the following six joint conditions are rated: seal condition, steel hardware condition, pavement/deck condition, water tightness of the joint, debris accumulation on joint seals and debris accumulation in troughs. Fourteen SHAs inspected for all six of those conditions. Debris accumulations in troughs or joints were the most frequent conditions excluded from joint condition inspections. All responding SHAs except Wyoming made some sort of repair or replacement to currently damaged joints. The main reason for seal repair/replacement was whether a seal was leaking or completely missing, with priority for replacing missing seals. Arkansas stated that they have few issues with their joints and subsequently have no standard criteria for seal repair/replacement. For all joint maintenance
issues, North Dakota incorporated that work with other repairs in bridge rehabilitation projects. New Hampshire stated that most joint damage was caused by snow plows.

### 3.2.2 JOINT REPLACEMENT CRITERIA

Twenty-two SHAs reported replacing joint hardware at some point. Total failure appeared to be more prevalent in northern SHAs due to snow plow damage. The most important (stated) concern when dealing with joint repairs was traffic safety. Seventeen SHAs performed adjacent deck (or D-cracking) repairs if a deck had deteriorated to the point of anchorage failure or was causing a joint to leak. Virginia repaired deck edges or abutment back walls surrounding the joint only when maintenance was performed on the adjacent joint.

The main criterion considered in replacing joints by most SHAs was the extent (percentage) of joint failure. Joint failure can be described as: 1) leaking, 2) posing a rideability issue or 3) presenting a safety threat to the public. New York considered joint replacement options if at least 50 percent of a joint has failed. Entire joint replacement can be avoided if the failed sections (typically seals) can be repaired. Consideration was also given to: 1) the cost of the amount of time taken for repair/replacement, 2) the amount of time the roadway will be out of service and/or 3) the impact of traffic control issues. Joint opening sizes, temperature ranges, cost effectiveness and past performance were all factors used by SHAs in selecting replacement seals/anchorage joint systems. SHA field maintenance crew familiarity in repairing/replacing the varying seal types was taken into consideration when in-house joint maintenance decisions were made. Compression seals were being phased out by many SHAs in preference to strip seals or pourable silicon seals. Open sliding plate joints and asphalt plug joints were considered problematic by some SHAs who were also phasing those joint types out (although KYTC has plans to install asphalt plug joints on the I-65 Kennedy Bridge in Louisville). The more widely used replacement joints for larger openings were finger or modular joints.

Florida reported that for instances involving anchorage failures, they reinforced anchorages when installing the new joints. New York used elastomeric concrete to reinforce headers and anchorages. Conversely, Kansas reported trying to avoid using elastomeric concrete due to numerous short-term failures (4-6 years). Kansas is also working on redesigning their anchorage system for strip seals and recommended modular joint systems or plank joints where appropriate. Eight SHAs tracked their joint replacement/performance costs.

### 3.2.3 JOINT REMOVAL

Washington responded that eliminating joints was entirely outside the scope of their maintenance work using in-house crews. North Dakota sought to combine several bridge maintenance tasks into a rehabilitation project, and eliminating joints was one of the preferred tasks. States that did
not seek to eliminate joints are: Washington, North Dakota, Minnesota, West Virginia, Connecticut, Florida, New Jersey and New York.

The other responding SHAs all stated they have tried to completely eliminate the need for a joint where one had failed. Arkansas and Oklahoma noted that joint elimination was used in special cases and not as a standard practice. Illinois, Colorado and South Dakota all eliminated joints by enclosing gaps with concrete for spans between 50 and 100 feet, while Kansas sought joint elimination on spans of 300 feet and longer. Also, joints were more likely to be eliminated on bridges with little or no movement. In most cases joint elimination was done when decks were resurfaced and 20 responding SHAs were eliminating joints whenever possible.

### 3.2.4 JOINT MAINTENANCE

Twenty-two responding states used state forces to maintain joints (i.e. reseal, repair or replace) while all 28 states stated that they sometimes employ contractors for joint maintenance. The state maintenance crew activities were generally limited to minor repairs, such as cleaning, re-anchoring/replacing armor edges, reattaching strip seals or resealing joints. Most SHAs have the capability to replace joints but choose to employ contractors to perform complete replacements and major joint repairs. State forces in Kansas performed most of these tasks at some point, but usually joint work was contracted out due to time constraints and traffic conditions. Minnesota and Kentucky both used their in-house maintenance personnel to replace poured seals, but contracted out the replacement of other joint types. These contractors generally were hired to perform the entire range of repair, reseal or replacement work as needed. No SHAs appeared to work on finger joints with their own forces. Washington noted joints were resealed as part of their bridge painting contracts. Nine SHAs routinely removed debris from joints or cleaned troughs, whereas eighteen others reported doing nothing.

Sixteen SHAs have joint types that are still in service but no longer used for new construction. Kentucky noted that sliding plate and modular joints were still in use, and Illinois had polymer nosing with silicon still in use. North Carolina had a few para-plastic (hot rubberized asphalt) and silicone joint seals while Nebraska was actually sealing their sliding plate joints with elastic asphaltic materials. Missouri, Oklahoma, Connecticut, West Virginia and New Hampshire were all replacing their silicone joints, opting in some cases to replace those with a proprietary joint (R.J. Watson Silicoflex). South Dakota was phasing out a particular proprietary joint, as well as asphalt plug joints (which are also being phased out in Utah). Poured joints were not being used for new construction in Minnesota and Maine. Kansas used the Polytite Joint Sealants made by Dayton Superior Corporation in both construction and maintenance, with the intent to make all the necessary repairs in the future with state forces. Kansas was replacing old relief slot joints with that joint as well.
Traffic affected SHA joint maintenance, although not every state considered those issues in their decision making. Several SHAs noted that debris accumulation in joints was heavier on more highly travelled routes. New York preferred joint repairs in lieu of replacements, depending on traffic conditions. In New Jersey, the continuity of the joint across a roadway can be affected due to not being able to close the entire span of the bridge to perform repair or replacement. Colorado stated that joint maintenance was nearly impossible in high traffic areas where lane closures are needed. Between that and/or delays with rerouting traffic, Colorado only performed repairs when absolutely necessary and preferably in combination with other repair work. Oklahoma, Maine and Washington all stated a preference for night work and/or longer shift hours in highly trafficked areas. Washington noted that those repairs suffered because of limited visibility and less tolerant material during night work. Contrary to New York, Tennessee would rather replace a damaged joint in high traffic areas than to repair it. New Mexico was trying to completely eliminate joints in high traffic areas. Other states, such as Kansas and Texas, opted for whatever choices impacted traffic the least.

Only New Mexico, Kansas and Oklahoma responded that they have a joint maintenance program with dedicated funding.

4. NEW JOINT DESIGN

KTC researchers contacted joint manufacturers to discuss new and improved joints that would have some redundancy built in case of failure. Potential joint performance improvements were contemplated by the use of new seal materials to replace the commonly used neoprene. Possible seal replacement materials included urethanes and silicon rubbers. Those materials could be used in preformed seals (e.g. compression seals) and strip seals. Another potential improvement could be gained by the incorporation of plies of reinforcing fibers such as Kevlar or nylon. Seal materials envisioned would be more resistant to UV degradation and should retain joint flexibility better than neoprene. The former feature would be useful to extend the lives of compression seals and other preformed seal types which commonly detach from headers when the neoprene loses flexibility. The use of plies of inextensible chord reinforcements would provide the joints with improved tear/puncture resistance than possessed joints composed of a single material. This feature would be especially useful with strip seals, which have a tendency to tear.

Unfortunately, those discussions occurred too late in the study to be effective in achieving anything substantial. Eventually further effort will be necessary to get the desired materials incorporated into joints and tested. Also, KTC researchers determined that a national testing/qualification effort was needed for joints/seals. Since that effort would be important on a national scale, it was believed that AASHTO should become involved as part of its National
Product Evaluation Program (NTPEP). KTC researchers will eventually pursue both of those items.

One of the major joint functions was to protect underlying bridge elements from damage due to deck runoff. This was also a major problem with all types of deck joints. Typically, closed joints begin to leak years before they are flagged for repair or replacement to address the problem. As previously noted, the Russian use of troughs under closed joints indicated that providing a redundant protection for joint leakage was a viable approach for addressing the most common joints. At least one joint manufacturer was providing commercial designs for addressing this issue. In other cases, SHAs must develop drawings and have troughs custom manufactured for specific bridges. That situation may change as more SHAs come to recognize the benefits of redundancy in addressing joint leakage. The costs to add troughs were low compared to waterproofing a joint.

KTC researchers developed some conceptual designs for addressing joint leakage. Open joints leak, but the resulting damage is not severe if the underlying bridge elements are subject to bold exposure. That will minimize the time of wetness and extended water leakage, even though the joints and rain hitting the bridge elements will tend to flush away any deicing salt contamination. Figures 1-3 show the use of diverters to keep seepage from open joints from contacting underlying bridge elements and causing damage. There are other potential designs for new bridges with open joints that could achieve the same results. Bridge designers can study the proposed design and affect improvements for specific bridges/joints.

Figure 4 shows the use of a flexible trough used in conjunction with a variety of closed joints. The trough has a slight inclination to one side of the bridge to promote run off of leaking water. For wider bridge decks, the trough can be designed to incline downward on both sides of the deck centerline to accommodate any depth restrictions. A collector is located at the end of a trough to take the leaking water and route it away from bridge elements.

Water leakage from multi-span concrete T-beam (Type 104) bridges has proven problematic to KYTC bridges. Many of those bridges have openings in the barrier walls that permit drainage directly onto pier caps. Many pier caps on those bridges show significant concrete cracking and spalling due to reinforcing steel corrosion. The poured asphalt joints used on those bridges also leak, adding to the pier cap distress. Figures 5 and 6 show a proposed retrofit for those locations. With this retrofit, a portion of the asphalt joint is excavated and replaced with a poured joint and backer rod. Spouts are inserted below the backer rod to carry runoff away from the pier cap ends. The concrete immediately below the barrier gap is treated with a concrete sealant and a drip edge is installed at the lower portion of the concrete to keep runoff from dripping on the concrete as well.
Poured joints were favored by some SHAs as they can be readily installed by in-house personnel. However, they have some reliability concerns and in the KTC survey several SHAs noted they were discontinuing their use. To improve their performance relative to joint leakage, a dual poured joint/seal installation was proposed (Figure 7). The lower poured joint would carry away any leakage from the top joint. If the top failed, the lower joint would remain intact to permit eventual replacement/repair of the top joint without risking damage to underlying bridge elements.

An alternative to the flexible trough is a gutter attached to the underside of a bridge deck on one span (Figure 8). The gutter would span the deck gap and collect any leakage from the joint. As this would be used under a closed joint, no debris would accumulate in the trough and only a slight inclination would be necessary to carry off any leakage. Again, a collector would be required to keep water drainage from the gutter from falling onto bridge elements.

A modified sliding plate design is shown in Figure 8. While most states are moving away from this design, it can be employed to advantage on bridges where high debris build-up occurs. A good example is the KY 15 Bridge over KY 7 in Southeastern Kentucky and the CSX railroad near Vicco, KY which is also over a coal tipple adjacent to the rail line. Trucks leaving the tipple have built-up debris that deposit on the bridge when the trucks cross it. The resulting debris (dirt and rocks) is significant and too severe to be addressed by reasonable periodic maintenance. One option would be to use a sliding plate joint to keep rocks from damaging a joint seal on a typical closed joint (Figure 9). The proposed joint would possess a closed cell foam insert inside the joint under the sliding plate to prevent the entrance of dirt and other fines under the plate. A trough would be located under the joint to carry away any joint leakage.

For less demanding applications, open cell foam could be positioned under strip seals to collect any debris from a torn seal from clogging an underlying trough or gutter (Figure 10). This would permit extended maintenance on damaged strip seal joints to keep any trough/gutter system functional until the torn seal was replaced.

Troughs can also be placed under larger joints (modular joints). KYTC has several Ohio River bridges in the Covington/Newport area (US 25 and I 471) that have large modular joints. Several of those joints leak, but when last visited by KTC researchers, most of them were intact. The use of troughs/collectors could prevent joint leakage from causing any damage to the underlying bridge elements and probably extend the service intervals/lives of those joints (Figure 11).

Troughs under finger dam joints could be fitted at their base with geotextile fabric over open cell foam (Figure 12). The purpose of this proposed design would be to ensure that
water/debris passing through the open joints would not clog up the trough and any drainage pipes attached to the collector.

All of these designs are provisional and can be revised to be more practical and to provide better installation. Trough systems can be designed for placement where the only access is from the deck down. Hopefully these initial attempts will prompt bridge designers to develop new products that can be routinely installed on most bridges without the need for customized designs.

5. WORK ON STUDY TASKS

KTC researchers addressed most of the proposed study tasks. The major effort was the conduction of the national joint survey in conjunction with AASHTO (Study Task 1). That took more time and effort than originally anticipated. Consequently, work was deferred/minimized on several study tasks. However, the survey was considered vital in providing KYTC with guidance based upon current practice by other SHAs and subsequently it was given priority over other tasks.

KTC reviewed a range of joint types; however the number of joint manufacturers and range of joint types is much larger than originally envisioned and is constantly changing (Study Task 2). This variety and volatility, points to the need for a national program to act as a clearinghouse on joint types. KTC researchers discussed this with several joint manufacturers and AASHTO representatives and both parties stated that they were willing to become involved. However, there was insufficient time during the study to pursue this objective.

Joint elimination was addressed in the joint survey. The initial intent was to also obtain cost data on joint elimination from other SHAs (Study Task 3). However, prior to sending out the survey, questions addressing that topic were removed to pare the survey to a manageable size. KTC researchers did not pursue seeking in-house costs for joint replacement. The SHA survey responses contained useful information/guidance for joint selection, new construction and maintenance (Study Task 4). The survey responses are provided in Section 3 (above) and in Tables 1 &2. Potential joint enhancements (Study Task 5) are listed in Section 4. Several joint manufacturers were contacted about developing improved seal materials and were willing to do that. However, there was insufficient available time to fully address this effort.

During this study KTC researchers contacted several manufacturers about promoting the use of new joint types for consideration by KYTC (Study Task 6), “New” meaning joints that have not been previously used by KYTC. Through those contacts several manufacturers’ representatives met with KYTC officials and arranged for trial installations of their joints. Prior
to the onset of this study, several KYTC districts had conducted trial tests of foam joints, but their location and condition was not determined.

6. CONCLUSIONS

The survey results should be useful to KYTC and SHA officials in other states for developing guidelines/criteria for joint designs and installation, and in the preparation of network-wide programs for joint preservation. They can also use the data from the surveys to optimize their practices related to joint selection, new designs and costs.

The following conclusions were obtained from the survey results for both design and construction and for maintenance:

1) Most states sought to eliminate joints where ever possible. Several states noted that joint elimination is a goal for new bridge designs. Several have also moved away from using any joints less than one inch wide.

2) Another trend is the growing SHA practice to discontinue employing joints with armored edges, especially in states with heavy snow plow usage. Armored joints were more likely to become detached or damaged in those states, posing a threat to the motoring public. However, the popular strip seals always require the use of armored edges for mounting seals.

3) For joint openings less than one inch, neoprene strip seals were reported as being the most successful type of joint. Over 75 percent of the participating states included it in their new maintenance, with 70 percent rating it as good or very good. No states reported a poor experience with its use and the remaining 30 percent of states gave it a rating of average. It was the most commonly used joint type and on average it has a successful operating life of 10-15 years. Results were generally mixed for the other joint types in this range of openings. Sliding plate joints are not used in new construction and are being phased out in most states. Many pourable joints have armored edges that are susceptible to snow plow damage. In states without heavy deicing applications, pourable joints have performed well. However, in states with heavy snowfalls, pourable joints performed poorly and have had to be replaced. States subjected to snow storms, such as Virginia, take into account the greater amount of deicing chemicals used on more heavily trafficked bridges. Since those chemicals are highly corrosive, it is critical that the joints on bridges are eliminated and/or made water tight. Asphalt plug seals have poor maintenance reviews and are not included in new construction in many states as their average life span is less than ten years. South Dakota has stated that their asphalt plug joints have lasted up to fifteen years. As previously noted, KYTC is planning to install asphalt plug joints on I-65 Kennedy Bridge in Louisville. Preformed compression seal joints received poor maintenance reviews, but some states reported that they have worked acceptably, providing service lives up to twenty years.

4) In joint openings of between one to three inches, neoprene strip seals were considered the most successful type by states with an average life span of approximately twenty years,
typically ranging between 15 and 25 years. In this joint opening range, the preformed compression seal joints performed poorly. Only 48 percent of responding states still used those for new construction. Large-scale failures have been reported with this type of joint, with an average life span of about ten years, and some states reported a short life span of 5-7 years. Several states, including Colorado and Wyoming, did report success with the joint, reporting its typical lifespan to be about 15 years. The average life span of pourable joints in this opening range was reported to be less than ten years, but they require maintenance. Elastomeric joints received mixed reviews, with some states being very disappointed with the performance; however Washington reported they have performed well and are still used in new construction. New York provided specific brands they have had success with, including Watson Bowman Wabo® Crete Membrane and RJ Watson Tron-flex Type ME seal system.

5) In openings three to five (plus) inches long, the two main joint types were steel finger joints (finder dams) and the modular joints. Steel finger joints have the longest operable life, on average ranging from 25 to 50 years. The modular expansion joints had an average life span of 25 plus years. Each of these joints was used in slightly more than 50 percent of responding states. On a performance rating scale of 0 to 5 with 5 being the best, the modular joint had an average rating of 3.2, whereas the finger joint had a rating 4.0. Other joints that have been successfully used in this opening size were strip seals and plank joints, but strip seals were normally not employed for this opening size. Several recent joints are being used in new construction including the R.J. Watson Silicoflex system and Watson Bowman Acme Wabo® Evazote seals. Nebraska and New Jersey are trying out the Silicoflex system and North Carolina is investigating the Evazote seal. While there is not enough information pertaining to those two systems from the survey to draw any conclusions, the initial feedback is promising with positive results reported for each so far.

6) A primary source of problems with joints is water runoff through them that causes deterioration of underlying bridge elements. The use of troughs, gutters and redundant seals (in the case of pourable joints) offered an opportunity to prevent bridge element deterioration should joints leak, and allow SHAs sufficient time to detect and remedy the problem.

7. RECOMMENDATIONS

Based upon the findings of this study, the following recommendations are offered for KYTC consideration:

1) Review the survey responses and use those as a guide to revising current in-house practices related to joint selection, design, construction and maintenance. KTC researchers can assist in that effort as well.

2) Conduct experimental projects incorporating joint types not previously used by KYTC, along with some of the KTC-proposed trough designs in conjunction with relevant joint types. Several joint manufacturers offer manufactured (v. custom) troughs/gutters. Those can also be incorporated in experimental projects. Some of these projects should incorporate other experimental requirements, including qualification/certification for both installation and
inspection personnel, performance (leakage) testing of newly installed joints and issuance of warranties by contractors/material suppliers.

3) Partner with other SHAs to seek creation of a NTPEP committee addressing joint testing and qualification on a nationally qualified products list.

4) Fund a follow-on study to enable KTC researchers to partner with material suppliers and joint manufacturers to develop new joint seal materials. KTC would also develop a test device to cycle joints/seals and qualify them as part of the NTPEP joint qualification process. In lieu of that, KTC could partner with any government agency conducting joint testing and conduct field tests of joints qualified by laboratory testing. KTC would also conduct an in-depth survey to gather bridge maintenance costs and more joint seal performance.

5) Partner with firms providing joint materials to create training materials for both joint installers and inspectors. These materials should be incorporated into a training/certification program for KYTC and contractor personnel.

6) Discontinue the use of compression seals and replace them with other joint types (e.g. pre-molded silicon or foam).

7) Investigate the use of header materials to permit rapid joint installation by state maintenance forces or contractors.

8. REFERENCES


9. TABLES

<table>
<thead>
<tr>
<th>Type</th>
<th># SHAs</th>
<th>Type</th>
<th># SHAs</th>
<th>Type</th>
<th># SHAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip Seal</td>
<td>8</td>
<td>Strip Seal</td>
<td>18</td>
<td>Finger Dam</td>
<td>14</td>
</tr>
<tr>
<td>Asphalt Plug</td>
<td>5</td>
<td>Compression Seal</td>
<td>6</td>
<td>Modular</td>
<td>13</td>
</tr>
<tr>
<td>Compression Seal</td>
<td>4</td>
<td>Armored/Elastomeric</td>
<td>4</td>
<td>Strip Seal</td>
<td>7</td>
</tr>
<tr>
<td>Armored/Elastomeric</td>
<td>3</td>
<td>Expansion</td>
<td>3</td>
<td>Armored/Elastomeric</td>
<td>3</td>
</tr>
<tr>
<td>Silicone</td>
<td>3</td>
<td>Poured</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poured</td>
<td>2</td>
<td>Preformed Seal</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foam</td>
<td>2</td>
<td>Foam</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliding Plate</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>5</td>
<td>No Response</td>
<td>6</td>
<td>No Response</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1. Summary of Joints Used in New Design and Construction

<table>
<thead>
<tr>
<th>Type</th>
<th># SHAs</th>
<th>Type</th>
<th># SHAs</th>
<th>Type</th>
<th># SHAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Plug</td>
<td>8</td>
<td>Strip Seal</td>
<td>15</td>
<td>Finger Dam</td>
<td>20</td>
</tr>
<tr>
<td>Silicone</td>
<td>6</td>
<td>Compression Seal</td>
<td>9</td>
<td>Modular</td>
<td>13</td>
</tr>
<tr>
<td>Poured</td>
<td>6</td>
<td>Silicone</td>
<td>5</td>
<td>Strip Seal</td>
<td>9</td>
</tr>
<tr>
<td>Compression Seal</td>
<td>4</td>
<td>Poured</td>
<td>4</td>
<td>Silicoflex</td>
<td>2</td>
</tr>
<tr>
<td>Strip Seal</td>
<td>3</td>
<td>Elastomeric Seal</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silicoflex</td>
<td>3</td>
<td>Preformed Seal</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preformed Seal</td>
<td>2</td>
<td>Foam</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foam</td>
<td>1</td>
<td>Sliding Plate</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Summary of Joints Used in Maintenance Activities
Figure 1. Diverter/Troughs for Open Joints (Top View).
Figure 2. Diverter/Troughs for Open Joints (Front View).

Figure 3. Diverter/Troughs for Open Joints (Side View).
CONCEPT #1

FLEX TROUGH

*INCLUDES PLANK AND ASPHALT PLUG JOINTS

**NEOPRENE/POLYMER SHEET

SECTION VIEW (LONGITUDE)

SECTION VIEW (TRANSVERSE)

Figure 4. Flex Trough

JOINT REPAIR (POURED BITUMEN SEALS)
FOR TYPE 104 T-BEAM BRIDGES

STEP 1.

Figure 5. Joint Repair for Type 104 T-Beam Bridges.
Type 104 T-Beam Bridges

REDUNDANT POLYMER JOINT SEAL

ALL LOOSE AND DETERIORATED CONCRETE UNDERNEATH EXISTING JOINT SEALS IS TO BE REMOVED. ALL SURFACES ARE TO BE CLEANED AND PRIMED IN ACCORDANCE WITH THE SPECIAL PROVISION. POLYMER NOSING MATERIAL FOR THE REPAIRED AREAS SHALL BE PLACED MONOLITHICALLY WITH THE JOINT NOSING.

Figure 6. Joint Repair for Type 104 T-Beam Bridges

Figure 7. Redundant Poured Joint Seal.
RIGID MINI-GUTTER

CONCEPT #2

SECTION VIEW (LONG.)

ALTERNATE 1

SECTION VIEW (LONG.)

ALTERNATE 2

SECTION VIEW (TRANSVERSE)

BOTH ALTERNATES

REQUIRED OPENING

SLIDING SURFACE

CLOSED CELL FOAM INSERT

STUDS

TROUGH OR GUTTER

SLIDING PLATE FOR DEBRIS-LADEN DECKS

Figure 8. Rigid Mini-Gutter

Figure 9. Sliding Plate for Debris-Laden Decks.
Figure 10. Strip Seal

TROUGH FOR MODULAR EXPANSION JOINT

Figure 11. Trough for Modular Expansion Joint.
Figure 12. Trough Liner for Finger Dam.
11. APPENDIX A - Survey of Materials and Practices Related to Bridge Expansion Joint Maintenance

This survey is a national survey of joints submitted by the AASHTO Subcommittee on Maintenance Bridge Technical Working Group. Please contact Sudhir Palle at 859-257-2670 or Sudhir@engr.uky.edu, if you have any questions regarding the survey. Please send the completed surveys to the same email address. We will email all responders a summary of the survey results.

The responder should feel comfortable in generalizing and approximating where specific detailed information is not readily available.

Responder Information

Date
Agency
Responder
Title
Phone
e-mail

Inspection Criteria

1. Do you use element level bridge inspections? Yes No

2. In rating joint condition, do you include:
   - Seal physical condition (torn, crushed): Yes No
   - Steel hardware condition (beams, plates, fingers): Yes No
   - Adjacent pavement/deck condition (spalling, armored edges, rutting): Yes No
   - Water tightness of the joint: Yes No
   - Debris accumulation of joint seals: Yes No
   - Debris accumulation in trough, if present: Yes No
Maintenance Practices

3. What actions do you employ for maintenance of joints?
   Seal repairs/replacement: Yes  No
   If yes, what existing seal condition criteria are used in making that decision?

   Joint hardware repairs: Yes  No
   If yes, what existing joint hardware criteria are used in making that decision?

   Adjacent deck (D-cracking) repairs: Yes  No
   If yes, what existing criteria are used in making that decision?

   Replace entire joints (in kind): Yes  No
   If yes, what existing joint criteria are used in making that decision?

   Replace entire joints with alternates: Yes  No
   If yes, what existing joint criteria are used in making that decision?

   Eliminate joints: Yes  No
   If yes, what criteria are used in making that decision?

4. Who performs the field work for joint maintenance for your agency (Reseal, Repair or Replace)?
   State forces: Yes  No
   If yes, what type of joints and activities? Comments
Contractors: Yes  No

If yes, what type of joints and activities? Comments

Do you routinely remove debris in joints? Yes  No

Do you routinely clean troughs? Yes  No

**Joint Selection and Sizing**

5. Do you have any joints that are used in maintenance but not in new construction? Yes  No

   If yes, list the joints.

6. Which types of joints do you typically use for the following movements? Fill in the appropriate space below.

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Less than 1 inch</th>
<th>Historical Service Life (years)</th>
<th>1 inch to 3 inches</th>
<th>Historical Service Life (years)</th>
<th>Greater than 3 inches</th>
<th>Historical Service Life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Do you employ design standards for joints? Yes  No

8. Do you employ a qualified products list (QPL) for joints? Yes □ No □ or joint material? Yes □ No □

9. Do you use armored edges on joints? Yes  No
10. Are you seeking to eliminate armored edges on most joints? Yes    No
    If yes, how does that policy impact joint repair decisions?

11. Does traffic (volume or type) and route access impact your decision making related to joint maintenance? Yes    No
    If yes, what are the typical impacts?

**Installation and Repair**

12. Do you require special training/qualifications for field inspectors of joint construction/repair performed by contractors? Yes    No
    If yes, describe the training/qualification

13. Do you perform field inspections of joint repairs by state agency maintenance personnel? Yes [ ] No [ ]

14. Do joint installers have special training/qualifications? Yes    No
    If yes, describe the training/qualification

15. Do you require that a joint manufacturer’s representative be present for major joint work? Yes    No

16. Do you require approval of the joint installation by the manufacturer? Yes    No

17. Do you require a performance warranty? Yes    No
    If yes, how long is the warranty and what is covered?

18. At the time of installation, do you take field measurements of
    a. Temperature: Yes    No
    b. Joint opening: Yes    No
    If yes to either of these, do you record and store this data for future reference? Yes    No
19. Do you follow manufacturer’s guidelines for temperature and joint opening at the time of installation? Yes No

20. Do you conduct performance testing of newly installed joint seals? Yes No
   If yes, what types of tests are performed?

**Maintenance Tracking**

21. Do you conduct performance/cost tracking of joints? Yes No
   If yes, what types of data are tracked?
   
   If yes, how is the data used (e.g. maintenance management, determination of life cycle costs)?

22. Do you have a joint maintenance program with dedicated funding? Yes No
   If yes, what is the annual estimated funding?

23. Do you clean/reseal joints on a schedule or based on condition rating? Please check one.

24. List the types of joints you have used/using and rate your experience from 5 (very good) to 1 (never use it again).

<table>
<thead>
<tr>
<th>Joint Types</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25. Do you have ongoing or recent research on joints? Please describe.

26. Any other comments on joints (or this survey) are welcome.
12. APPENDIX B - Survey of Materials and Practices Related to Design and Construction of Bridge Expansion Joints

This survey is a national survey of joints submitted by the AASHTO Subcommittee on Maintenance Bridge Technical Working Group. Please contact Sudhir Palle at 859-257-2670 or Sudhir@engr.uky.edu, if you have any questions regarding the survey. Please send the completed surveys to the same email address. We will email all responders a summary of the survey results.

The responder should feel comfortable in generalizing and approximating where specific detailed information is not readily available.

Responder Information

<table>
<thead>
<tr>
<th>Date</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responder</td>
<td>Title</td>
</tr>
<tr>
<td>Phone</td>
<td>e-mail</td>
</tr>
</tbody>
</table>

Questions 1-10 and 19, 20 pertain to Joint Selection and Sizing

Questions 11 -18 pertain to Construction

Joint Selection and Sizing

27. Do you have standard drawings for joints? Yes No
   If yes, list the types of joints.

28. Do you have a qualified products list (QPL) for proprietary joints? Yes No

29. Which types of joints do you specify for the following movements? Fill in the appropriate space below.
30. Do you have guidance for joint selection for special conditions such as fatigue, skews, variable openings, curves, grades and stops? Yes  No

31. Do you have guidance for joint selection based on ADT? Yes  No

32. What criteria do you use to determine the gap and the movement at joints?

33. Do you employ jointless bridge designs or designs that minimize the number of joints? Yes  No
   If yes, describe types of bridges and spans for jointless designs or designs that minimize the number of deck joints.

34. Do you design joints with armored edges? Yes  No
   If yes, what types of joints are designed with armored edges?

35. Are you seeking to eliminate armored edges on most joints? Yes  No

36. Are blockouts incorporated in new joint designs? Yes  No
   If yes, what types of materials are used in the blockout?
Construction

37. Do you require special training/qualifications for field inspectors of joint construction/repair performed by contractors? Yes  No
   If yes, describe the training/qualification.

38. Do joint installers have special training/qualifications? Yes  No
   If yes, describe the training/qualification.

39. Do you require that a joint manufacturer’s representative be present for major joint work? Yes  No

40. Do you require approval of the joint installation by the manufacturer? Yes  No

41. Do you require a performance warranty from the manufacturer? Yes  No
   If yes, how long is the warranty and what is covered?

42. At the time of installation, do you take field measurements of
   a. Temperature: Yes  No
   b. Joint opening: Yes  No
   If yes to either of these, do you record and store this data for future reference? Yes  No

43. Do you follow manufacturer’s guidelines for temperature and joint opening at the time of installation? Yes  No
   Comments

44. Do you conduct performance testing of newly installed joint seals? Yes  No
   If yes, what types of tests are performed?

Costs

45. Do you specify joint installation as a specific bid item? Yes  No
46. Do state bridge designers track performance of common joint designs and details?
   Yes        No

47. Do you have ongoing or recent research on joints? Please describe.

48. Any other comments on joints are welcome.