Concrete Bridge Deck Joints: State of the Practice
South-East Bridge Preservation Partnership
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Presented by
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Adapted from
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Introduction

- Cooling and heating of decks causes deck contraction and expansion, respectively.
- When contraction is restrained, cracking can occur when the tensile stress exceeds the tensile strength.
- When expansion is restrained, distortion or crushing can occur.
- Joints are often specified to accommodate deck movements without compromising the structural integrity of the bridge.
Introduction, Continued

• Bridge deck joints should protect the interior edges of concrete decks from vehicle loads, seal the joint openings, and accommodate movements resulting from temperature changes and creep and shrinkage of concrete

• Joint failure is a nationwide problem in the United States

• Failure is not necessarily caused by the joint material itself but also by careless design, improper installation, and inadequate maintenance
Problem: Incompressible Debris
Result: Failed Joint Seal
Consequences

- When joints fail, the integrity of the whole structure is affected!
Objectives

• Discuss the types of joints available for use on concrete bridge decks
• Review the performance characteristics of each type, including primary functions and movement ranges
• Discuss recent or current studies of joint performance
NCHRP Synthesis 319 (Purvis 2003)

- Performed a literature review
- Conducted a questionnaire survey – responders included 34 state DOTs and 10 Canadian Provinces about
  - Design procedures
  - Use and experiences
  - Construction practices
  - Maintenance and rehabilitation
  - Problems
Literature Review: Joint Types

Open Joints
- Butt Joints
- Sliding Plate Joints
- Finger Joints

Closed Joints
- Poured Seals
- Asphalt Plug Joints
- Compression Seals
- Strip Seals
- Reinforced Elastomeric Joints
- Modular Elastomeric Joints
Butt Joints

- Accommodate less than 1-in. movements or minor rotations
- Are sometimes installed with armor angles to protect concrete slabs
- Are effective only under the assumption that the passage of water and debris through the opening will not have adverse effects on the supporting substructures
Sliding Plate Joints

- Accommodate movements between 1 and 3 in.
- Are similar to a butt joint except that a plate is attached to one side, extending across the joint opening
- Partially stop debris from passing through openings
- May bend under repeated traffic loads and are susceptible to debris accumulation
Finger Joints

- Accommodate movements greater than 3 in.
- Are comprised of cantilevered fingers loosely interlocking each other over the opening
- Are sometimes installed with drainage troughs to catch and channel away water and debris
- Can jam, bend, or break during service due to horizontal and/or vertical misalignment during construction
Open Joint w/ Trough
Troughs

- Troughs should be designed with adequate slope
- May require frequent flushing to prevent debris accumulation
Poured Seals

- Accommodate movements up to 0.25 in.
- Generally consist of viscous, adhesive, and pourable waterproof silicone installed with backer rods to prevent the sealant from flowing down the joint
- Work best if sealant is poured when the ambient temperature is at the middle of the historical temperature range
Asphalt Plug Joints

- Accommodate movements less than 2 in.
- Are constructed by placing a modified elasto-plastic bituminous binder with mineral aggregate in a block-out centered over the joint, with a backer rod in place
- Can sustain damage when subjected to very rapid changes in temperature
Asphalt Plug Joints
Compression Seals

- Accommodate movements less than 2½ in.
- Are typically classified as neoprene or cellular, both of which are installed using a lubricant that also serves as an adhesive agent.
- Should be sized in a working range of 40 to 85% of the uncompressed width to ensure that positive contact pressure is always exerted against the face of the joint.
Compression Seals
Strip Seals

- Accommodate movements up to 4 in.
- Consist of a flexible neoprene membrane attached to two opposing side rails
- Can be susceptible to tearing, puncturing, or detachment under trafficking when debris accumulation rates are high
- Normally exhibit long service life, very good anchorage, and high degree of watertightness
Strip Seals
Reinforced Elastomeric Seals

- Accommodate movements between 2 and 6.5 in.
- Are classified as sheet seals or plank seals
- Are typically constructed using an epoxy bedding compound and cast-in-place studs
- Are susceptible to leakage at locations of field splices and at interfaces between the seal and the underlying concrete
Reinforced Elastomeric Seals
Modular Elastomeric Joints

- Accommodate movements between 4 and 24 in. and up to 48 in. with special designs
- Consist of sealers, separator beams, and support bars
- Are susceptible to fatigue damage and leakage between compression seals and steel supports
Utah Study (Guthrie 2005)

- Performed a literature review
- Conducted a questionnaire survey of state DOTs nationwide to determine the state of the practice for concrete bridge deck joint selection, maintenance, and replacement
  - Included 38 state DOTs in climates with freezing winter temperatures
Utah Study – Survey (Guthrie 2005)

- Most of the 20 respondents were state bridge engineers or bridge maintenance specialists
Question 1: What is the typical range of movement you design concrete bridge deck joints to accommodate?

<table>
<thead>
<tr>
<th>State</th>
<th>Expansion (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware</td>
<td>1</td>
</tr>
<tr>
<td>Idaho</td>
<td>2 to 5</td>
</tr>
<tr>
<td>Kansas</td>
<td>2 to 12</td>
</tr>
<tr>
<td>Michigan</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Missouri</td>
<td>2</td>
</tr>
<tr>
<td>New Jersey</td>
<td>0 to 4</td>
</tr>
<tr>
<td>New Mexico</td>
<td>0.5 to 2.5</td>
</tr>
<tr>
<td>New York</td>
<td>1 to 2.5</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>2 to 12</td>
</tr>
<tr>
<td>South Dakota</td>
<td>0 to 4</td>
</tr>
<tr>
<td>Utah</td>
<td>1 to 6</td>
</tr>
<tr>
<td>Vermont</td>
<td>2</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>0 to 12</td>
</tr>
</tbody>
</table>

- Most common deck joint movements are in the range of 1 to 4 in.
- Two respondents specify jointless, integral abutment bridges.
Question 2: What types of concrete bridge deck joints do you typically use?

- Strip seals were most accepted type of joint, followed by finger joints
Question 3: What specifications do you use for construction of new decks or rehabilitation of aged decks to ensure good joint performance?

- Substrate preparation applied to repairs, climatic factors were usually minimum temperatures, and manufacturer representation generally involved 1 to 3 days of inspection.
Question 4: What are the most common modes of failure for the deck joints you use?

- Although tearing and seal separation are applicable to only certain types of joints, snowplow damage and debris accumulation apply to all joint types.
Question 5: Do you typically replace one type of concrete bridge deck joint with another type during rehabilitation?

- 11 of 20 respondents answered “yes” to this question
- The majority of the respondents replace compression seals and sliding plates with strip seals
- Some respondents choose to eliminate the use of joints if possible
- Some respondents replace armor-angle joint types with elastomeric concrete headers for use with poured or preformed joint materials
Question 6: Do you specifically avoid using certain types of concrete bridge deck joints?

• 11 of 20 respondents answered “yes” to this question
• Some respondents avoid the use of sliding plate, finger, asphalt plug, compression, and/or modular elastomeric joints for various reasons generally associated with past experience
• Some respondents do not permit the use of bolt-down joint armoring
Question 7: Do you conduct periodic inspection and maintenance of concrete bridge deck joints?

- 13 of 20 respondents answered “yes” to this question
- Most respondents follow the National Bridge Inventory reporting requirements concerning the type and frequency of data collection
- Some respondents schedule bridge cleaning, including joints, in conjunction with bridge inspections
Design Recommendations (Guthrie 2005)

- Design decks with as few joints as possible
- Design joints for movements that are likely to occur
- Consider future inspection, maintenance, and replacement during design
- Subject proposed joints to load tests
- Set drains uphill of joints to minimize water ingress
- Coat steel devices with paint or galvanization
- Specify materials appropriate for the local climate
- Design armor anchors (if used) to resist pull-out and snow plow impacts
- Consider using elastomeric concrete or other shock-absorbing embedment materials around anchorages
Installation Recommendations (Guthrie 2005)

• Give the contractor adequate time to complete joint installations without rushing
• Enforce inspection at all times
• Place joints and armor between 1/8 and 5/32 in. below the deck surface to minimize snow plow damage
• Ensure expulsion of entrapped air from beneath joint-edge armor during concrete placement
• Use continuous seals
• Place troughs with a slope of at least 8 percent to prevent debris accumulation
• Place backer rods at appropriate depth to achieve desirable shape factor
Maintenance Recommendations (Guthrie 2005)

- Replace the entirety of failed joints to avoid field splices
- Repair damaged areas in approach slabs to reduce impact loads on joints
- Clean drains, joints, and troughs at least once a year
- Repaint steel devices periodically to prevent rusting
Other Recent Studies

• “Performance of Strip Seals in Iowa Bridges: Pilot Study” – Bolluyt 2001 for Iowa DOT


• “Evaluation of modular expansion dams” – Sukley 2008 Project #RP97-052 for PennDOT.
Other Recent Studies

• “Material Property and Quality Control Specifications for Elastomeric Concrete Used at Bridge Deck Joints” – Gergely 2009 UNC-Charlotte for NCDOT.

NETC survey  (Malla 2006)

<table>
<thead>
<tr>
<th>State</th>
<th>Types of Joints Employed</th>
<th>Anticipated Movement Range (MR) or Deck Span Length (L)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecticut</td>
<td>a. Asphaltic Plug Joint</td>
<td>MR &lt; 40 mm MR: 40-80 mm MR: 80-100 mm MR &gt; 100 mm</td>
<td>95 % of all joints Elastomeric header Elastomeric header -</td>
</tr>
<tr>
<td></td>
<td>b. Silicone Sealant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Neoprene Strip Seal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Modular and Finger Plate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>a. Compression Seal</td>
<td>- Small MR MR &gt; 100mm</td>
<td>Most preferred Rehabilitation project - Limited success No success, Failure in short period</td>
</tr>
<tr>
<td></td>
<td>b. Silicone -Pour-in-Place</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Gland Seal</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>d. Evazote Seal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Asphaltic Plug Joint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massachusetts</td>
<td>a. Saw Cut Seal</td>
<td>L &lt; 15 m L &gt; 20m, &lt;35m L &gt; 35 m Large spans</td>
<td>- Skew &lt; 25º Armored Neoprene trough</td>
</tr>
<tr>
<td></td>
<td>b. Asphaltic Plug Joint</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Strip Seal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Finger Joint</td>
<td></td>
<td></td>
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## NETC survey (Malla 2006)

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</thead>
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<tr>
<td>New Hampshire</td>
<td>a. Silicone based Sealant</td>
<td>Small MR</td>
<td>Reasonable success</td>
</tr>
<tr>
<td></td>
<td>b. Roadway Crack Sealer</td>
<td>For short spans and on fixed ends</td>
<td>Hot applied, petroleum based</td>
</tr>
<tr>
<td></td>
<td>c. <strong>Asphaltic Plug Joint</strong></td>
<td>L: 80’-140’</td>
<td><strong>Good results</strong>, skew &lt;25º</td>
</tr>
<tr>
<td></td>
<td>d. Finger Joint</td>
<td>L: 140’-180’</td>
<td></td>
</tr>
<tr>
<td>Rhode Island</td>
<td>a. Compression Seal</td>
<td>-</td>
<td>Poor performance, No more in use</td>
</tr>
<tr>
<td></td>
<td>b. Strip Seal</td>
<td>Large MR</td>
<td>Poor performance, Leakage</td>
</tr>
<tr>
<td></td>
<td>c. <strong>Asphaltic Plug Joint</strong></td>
<td>Short Spans (L&lt;100’)</td>
<td><strong>Most preferred</strong>, Exist in old construction</td>
</tr>
<tr>
<td></td>
<td>d. Open Joints, Sliding Plate Joint</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Vermont</td>
<td>a. <strong>Asphaltic Plug Joint</strong></td>
<td>MR: 50-75mm; Short Spans (L&lt;90’)</td>
<td><strong>Most preferred</strong>, -</td>
</tr>
<tr>
<td></td>
<td>b. Vermont Joint</td>
<td>MR &lt; 75mm (L&gt;90’)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>c. Finger Plate Joint</td>
<td>MR &gt; 75mm</td>
<td>Rarely used</td>
</tr>
<tr>
<td></td>
<td>d. Modular Joints</td>
<td>Very Large MR.</td>
<td></td>
</tr>
</tbody>
</table>
Other Ongoing Research

- “Simplifying bridge expansion joint design and maintenance” SC project # 677, at the University of South Carolina.
- “Evaluation of Silicone Joint Sealers” Arkansas TRC Project 0703
- “Investigative Study of In-state Use of Asphaltic Plug Expansion Joints” UNLV for Nevada DOT
Other Ongoing Research

• **SCOM Survey** (Palle, 2010)

• Kentucky Transportation Center and AASHTO SCOM (Subcommittee on Maintenance)

• Part of research to identify and employ the most effective bridge joints for specific applications

• Two surveys - responses from 32 states:
  – Engineers in design and construction (28 responses)
  – Engineers in maintenance (27 responses)
SCOM Survey

• Expect results to be summarized and reported at AASHTO meeting in June
Thank you

Questions?