Outline of Project:

- Literature review
- Evaluate MassDOT PONTIS/NBI bridge data
- Meet with 6 MassDOT districts
- Create and distribute survey to 9 Northeast states
- Compile survey responses
Full Report

- Quinn, B. H. and Civjan, S. A. (2016) *Better Bridge Joint Technology. UMTC 15.01*, Massachusetts Department of Transportation

- Overview of joint types and uses
- MassDOT district information
- Survey results from 9 states

- Detail on MassDOT practices and recommendations
- Detailed comments and recommendations from each state
Effects of Joint Failure

- Superstructure damage (Photos courtesy of MassDOT)
Effects of Joint Failure

- Substructure damage

Rate of corrosion and degree of damage increase with time
Reference Surveys

  
  - Summary of joint types
  
  - 34 states and 10 Canadian provinces
  - 7 states included in this study
  
  - Strip seal successful
  - Construction quality and maintenance were significant factors
Reference Surveys

  - Focus on 2” or less movement
  - 12 states (26 respondents)
  - All 9 states in this study

  - Strip seal common for new construction
  - Strip seal, asphalt plug joint and pourable seal for repairs
  - Compression seal poor performance
  - Construction quality and maintenance were significant factors
Types of Joints: Closed Joints

Saw and Seal ($\leq \frac{1}{2}''$)

Figure Source: MassDOT LRFD Bridge Manual Part II, 2013
Types of Joints: Closed Joints

Asphalt Plug Joint (≤2”)

Figure Source: MassDOT LRFD Bridge Manual Part II, 2013
Types of Joints: Closed Joints

- Rutting/cracking in asphalt plug joint
Types of Joints: Closed Joints

Compression Seal (≤2.5”)

Figure Source: Purvis, 2003
Types of Joints: Closed Joints

- Damage progression of a compression seal
  (Photos courtesy of MassDOT)
Types of Joints: Closed Joints

Strip Seal (≤4")

- ⅜" NON-HEADED STUD ANCHOR, 9" LONG @ 9" O.C.
- OR ⅜" SINUSOIDAL ANCHORAGE

CONTINUOUS NEOPRENE STRIP SEAL

ELASTOMERIC CONCRETE (TYP.)

LEVELING TAB WITH DRILLED-IN ⅜" EXPANSION ANCHOR OR APPROVED ALTERNATE TEMPORARY SUPPORT METHOD

AT ANCHOR LOCATION AT TEMPORARY SUPPORT LOCATION

See Table For Joint Opening At 70°F On Dwg. No. 10.2.9

Figure Source: MassDOT LRFD Bridge Manual Part II, 2013
Types of Joints: Closed Joints

- Damaged strip seal (Photo courtesy of MassDOT)
Types of Joints: Closed Joints

EM-SEAL (≤4”)

Figure Source: EM-SEAL Manufacturer, 2015
Types of Joints: Closed Joints

- EM-SEAL installation *(Photo courtesy of MassDOT)*
  - Pre-formed for curb and barrier installation
Types of Joints: Closed Joints

Pourable Seal (<4”)

- Backer Rod
- Poured Silicone

<4”
Types of Joints: Closed Joints

- Damaged pourable seal (Photo courtesy of MassDOT)
Types of Joints: Closed Joints

Modular Joint (>4”)

Figure Source: Purvis, 2003
Types of Joints: Closed Joints

- Damaged modular joint (Photo courtesy of MassDOT)
Types of Joints: Open Joints

Sliding Plate Joint (< 3”)

- Bar or Plate
- Joint Opening
- End-Welded Studs
- Neoprene Trough
- Sliding Plate
- Deck Slab
- Angle

Figure Source: Purvis, 2003
Types of Joints: Open Joints

Finger Joint (>4”)

Figure Source: Purvis, 2003
Types of Joints: Open Joints

- Improper function of finger joint (75° F) and trough
Jointless Option

Link-Slab

Link-slab

Shear connectors
Massachusetts Bridge Inventory

- Districts of MassDOT and highway system.
Massachusetts Bridge Inventory

<table>
<thead>
<tr>
<th>No. of Bridges</th>
<th>District Number</th>
<th>TOTAL</th>
<th>TOTAL OWNED BY MASSDOT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>703</td>
<td>834</td>
<td>1158</td>
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<tr>
<td>“Jointed Bridges”</td>
<td>185</td>
<td>413</td>
<td>624</td>
</tr>
</tbody>
</table>

Source: PONTIS and NBI Databases
See full report for interstate/turnpike bridges

- District 1: Rural, short span, low traffic volume
- District 2: Medium and short spans
- Districts 3 and 4: Wide variety from rural to urban
- District 5: Many limited access highways, high traffic volume
- District 6: Boston, urban bridges, high volume
Massachusetts District Meetings

- Low volume and shorter spans
  - Lane closures common for repair
  - Full installation time allowed

- High volume and limited access highways
  - 8 PM to 5 AM window for work
  - Quick setting headers are required
  - Less surface preparation

- Turnpike bridges
  - Thin wearing surface (1-1/2 in.) limits joint types
  - Quicker deterioration (wearing surface and traffic volume)
Massachusetts Bridge Inventory

% of Jointed Bridges with Joint Type

Source: PONTIS and NBI Databases
Massachusetts District Meetings

- **New construction – centralized**
  - Design often by consultants
  - Re-deck considered new construction

- **Repair – district specific**
  - Source documents from central office but modified

- **Maintenance – district specific**
  - No manual of practice
  - District decisions based on centralized funding
  - No district has an existing joint maintenance policy
Massachusetts District Meetings

- Wide variety of preferences within state did not match previous survey responses in literature review

- Performance not directly related to traffic volume or bridge span

- Factors in joint selection
  - Expectations of joint performance
  - Installation and inspection practices
  - Regional contractor experience
  - Traffic volume
  - Time window for work completion
Survey

- Survey created in Survey Monkey (44 questions)
  - Joints
  - Headers
  - New installation and repair
  - Maintenance
  - Overall practice

- Distributed to 9 states
  - CT, ME, MA, NH, NJ, NY, PA, RI, and VT
  - 26 responses (45% response rate)
  - Many states had multiple respondents

- Full list of survey questions is available in Final Report
Survey Summary: Overview

- Wide variability in performance, preference, and service lives of any given joint
- Definitions of success and failure of joint varies
- Preventive maintenance and installation workmanship are very important
Survey Summary: Success/Failure Definitions

**Definitions of Success**
- Smooth Riding Surface: 6%
- Accommodate Movements: 8%
- Require Minimal Maintenance: 13%
- Watertight: 34%
- Durable: 7%
- Long Lasting: 24%
- Other: 8%

**Definitions of Failure**
- Leaks: 60%
- Does Not Provide Smooth Riding Surface: 17%
- Does Not Provide Smooth Service Life than Anticipated: 12%
- Damaged/Require Emergency Repair: 11%
Survey Summary: Performance Rating

Joint Performance Rating
1=Absolute Failure, 5=Absolute Success

Average Rating

- Asphalt Plug Joint
- Strip Seal
- Compression Seal
- Pourable Seal
- EM-SEAL
- Sliding Plate Joint
- Finger Joint
- Modular Joint
- Link-Slab
- Open Joint
- Saw and Seal: Deck Over...
- Saw and Seal: Over...

Range of individual responses - Average Rating from All States
Survey Summary: Performance Rating

- **Best performance**
  - Link slab
  - EM-Seal
  - Compression seal (poor in previous study)
  - Saw and seal: deck over backwall
  - Finger joints

- **Worst performance**
  - Open joints
  - Sliding plate joints
  - Pourable seals

- **Every joint was rated high and low by at least one respondent**
Survey Summary: Expected Service Life of Joint Types

<table>
<thead>
<tr>
<th>Years</th>
<th>Asphalt Plug Joint</th>
<th>Strip Seal</th>
<th>Compression Seal</th>
<th>Pourable Seal</th>
<th>EM-SEAL</th>
<th>Sliding Plate Joint</th>
<th>Finger Joint</th>
<th>Modular Joint</th>
<th>Link-Slab</th>
<th>Open Joint</th>
<th>Saw and Seal: Deck Over Backwall</th>
<th>Saw and Seal: Over Existing Joint</th>
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</thead>
<tbody>
<tr>
<td>0-4</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>11</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>2</td>
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<td>8</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

- A successful joint is not necessarily the longest service life
Survey Summary: Typical Service Life of Joint Types

- **Pourable seals**
  - Shortest life (<4 years)
  - Quick installation and repair
  - Less expensive

- **Asphalt plug joints**
  - Short life (5-8 years)
  - Quick installation and repair
  - Relatively inexpensive
Survey Summary:

Adequate performance with routine repair and maintenance (check all that apply)
Survey Summary:

- When maintenance was assumed to occur
- Good performance
  - Asphalt plug joints
  - Strip seals
  - Compression seals
  - Finger joints – but drainage and snowplows are of concern
  - All types selected by at least one respondent
- Joints rated poorly often rated as adequate performance with proper maintenance
Survey Summary: Importance of Factors

Importance of Factors to Joint Performance
1 = Not Important, 5 = Extremely Important

Average Rating from All States

- Joint Type
- Header Type
- Installation Workmanship
- Inspection
- Maintenance Practices
- Weather Conditions at Time of Installation

Range of individual responses

Average Rating from All States
Survey Summary: Comments

- Header installation
  - Old concrete must be sufficiently removed to sound material
    - Difficult to assess, left to contractor
    - 2 feet minimum removal to sides?
  - Apply to fully dry materials
  - Quick setting concrete or elastomeric headers
    - Not as durable
    - Required for overnight construction
Survey Summary: Installation Practices

- Negative influence on joint performance
  - Improper cleaning of joint, surfaces and substrate
    - Sandblasting often skipped due to time constraints
    - Not reaching sound concrete
  - Incorrect opening size or placement of seals
  - Bond agent applied too far in advance of seal placement
  - Application to damp surfaces
  - Failure to install bond breaker tape
  - Phased construction
Survey Summary: Comments

- **Specific joint comments**
  - Saw and seal – proper location of cut is important, mark prior to placing wearing surface
  - Asphalt plug joints perform poorly with high traffic volumes, improper placement of backer rod
  - Compression seal – size seal and opening to always be in compression
  - Pourable seal – joint edges must be completely clean and dry, improper placement of backer rod
  - Anchorage of armored headers and sliding plate joints is critical
Survey Summary: Comments

- New products
  - EM-Seal
    - Detailing for parapets and curbs
  - Asphalt plug joints
    - Pre-bagged materials
    - Modified to use in combination with strip seal or EM-seal
  - Inverted-V strip seal, Silicoflex joints
    - Concrete trough with finger joint (behind abutments)
    - Heavy angles and anchorage for joint armor

RJ Watson Silicoflex system
DS Brown V-Seal system
Survey Summary: Comments

- Watertight testing of new joints (only 3 of 9 states)
  - Warranty post-construction is difficult to enforce

- Maintenance
  - Clean joints and decks (only 5 of 9 states)
  - Funding issues
  - Investment would minimize joint repairs/replacements and bridge element repairs

- Funding
  - Limited
  - Maintenance, construction and repair budgets for joints and structure/substructure are independent
CONCLUSIONS
Recommendations for Implementation

- Pre-construction meetings: address joint installation and expected performance
- Training of contractors, installers and site engineers
  - Proper workmanship
  - Proper installation
  - Proper materials
- Manufacturer representative: on-site/provide training
- Watertight testing of closed joints (new/repair/replacement)
- Warranty joint performance post-construction
Recommendations for Implementation

- Preventive maintenance
- Track joint performance and document repair work (joint and superstructure/substructure) with associated cost
- Budget: consider life-cycle and system costs
- Streamline process for adding new products to approved product lists
Recommendations for Future Research

- Evaluate repair and replacement methods and contracting to determine best practices
- Measure installation tolerances
- Quantify damage from joint and header mis-alignment
- Evaluate header performance under impact, cyclic load, freeze-thaw, etc.
- Develop test methods for approval of joint and header materials
- Determine life-cycle cost comparisons of similar joints with and without preventive maintenance
- Quantify life-cycle cost impacts from failed joints (joint, superstructure and substructure)
References

- Quinn, B. H. and Civjan, S. A. (2016) Better Bridge Joint Technology. UMTC 15.01, Massachusetts Department of Transportation
  - http://www.ecs.umass.edu/umtc/researchUMass.shtml

Contact information
Scott Civjan
civjan@ecs.umass.edu
413-545-2521