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Bridge Joint Performance in Northeastern States

Presentation by:

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The Commonwealth's Flagship Campus

Research Funded by:

Massachusetts Department of Transportation

massDOT

Massachusetts Department of Transportation

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
- Quinn, B. H. and Civjan, S. A. (2016) “Assessment of Bridge Joint Performance in the Northeastern States” *Transportation Research Record.* Vol 2550. pp 46-53.

  - 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

- Purvis, R. (2003) *Bridge Deck Joint Performance – A Synthesis of Highway Practice*. NCHRP Synthesis Report 319.

  - 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

- Milner, M. H. and Shenton III, H. W. (2014) *Survey of Past Experience and State-of-the-Practice in the Design and Maintenance of Small Movement Expansion Joints in the Northeast*. AASHTO TSP2 Report 24
  - 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 (≤ ½")

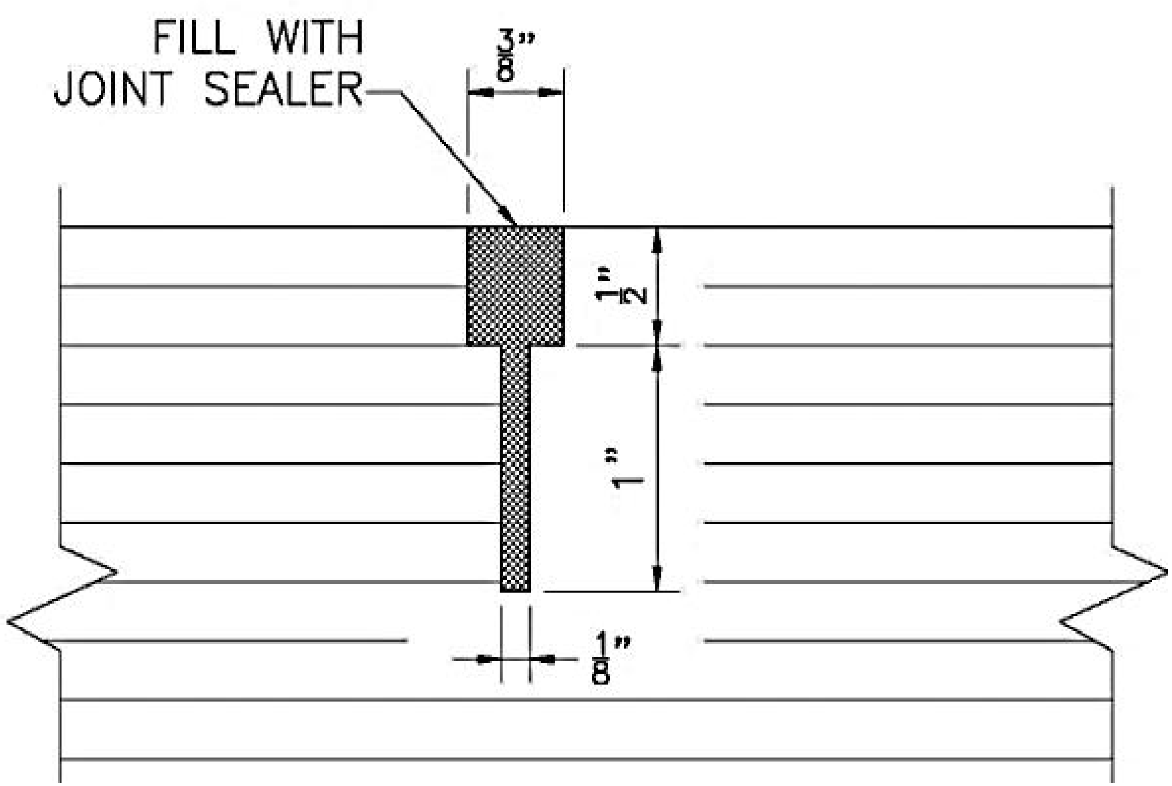


Figure Source: MassDOT LRFD Bridge Manual Part II, 2013

Types of Joints: Closed Joints

Asphalt Plug Joint (≤2”)

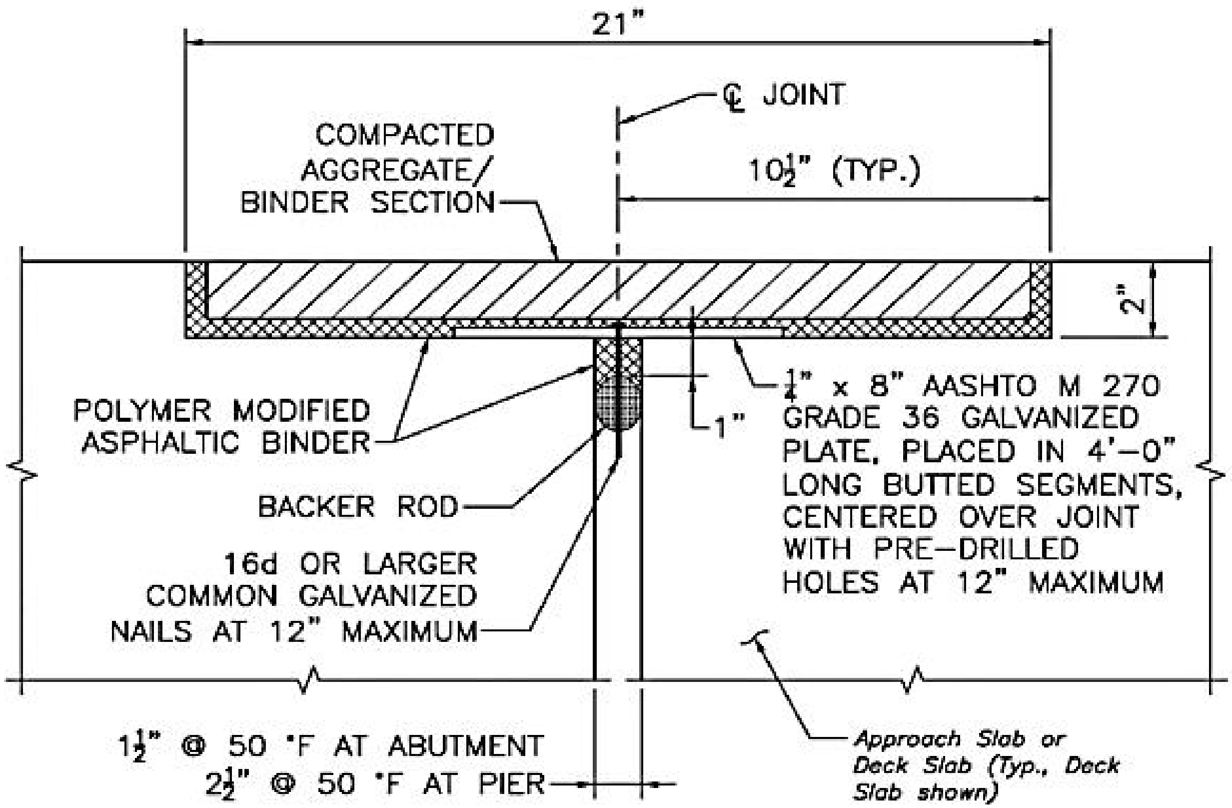


Figure Source: MassDOT LRFD Bridge Manual Part II, 2013

Types of Joints: Closed Joints

- Rutting/cracking in asphalt plug joint

Types of Joints: Closed Joints

Compression Seal (≤2.5”)

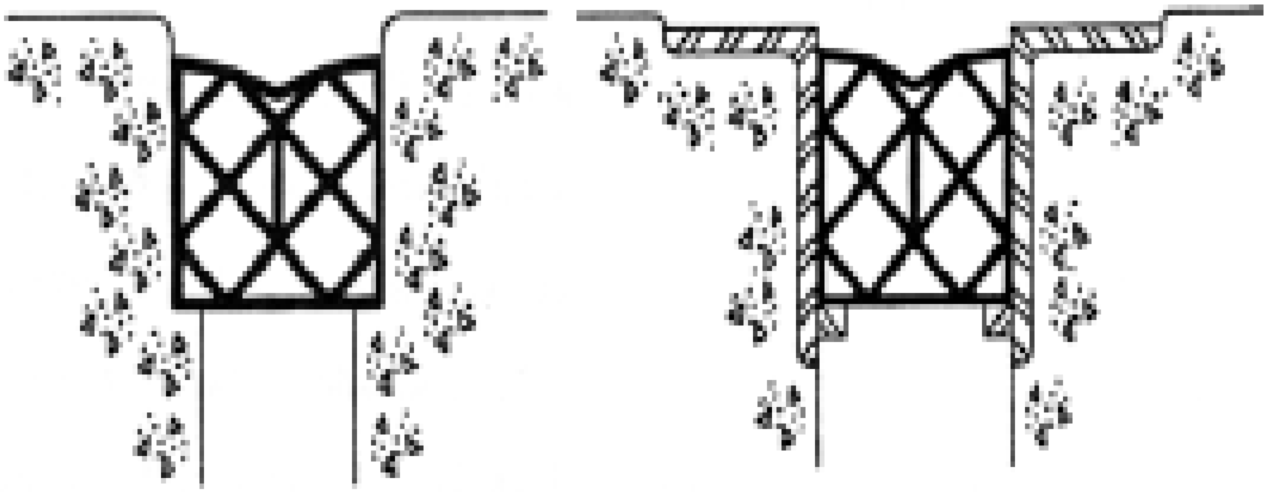
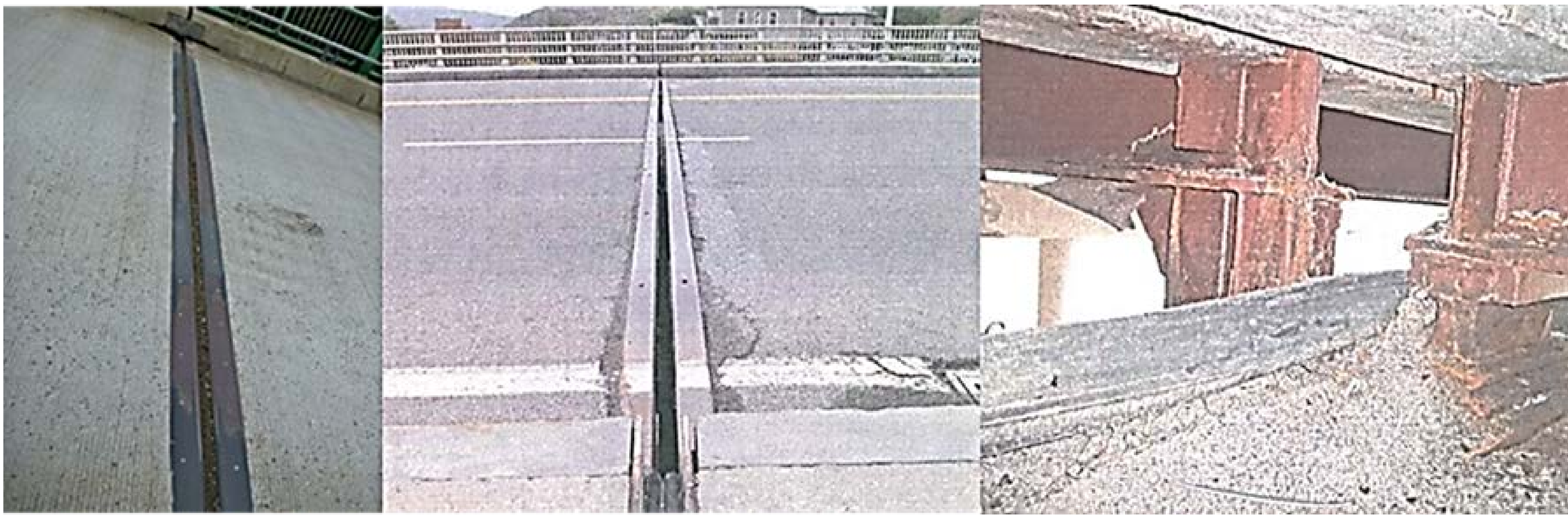


Figure Source: Purvis, 2003

Types of Joints: Closed Joints

- Damage progression of a compression seal
  (Photos courtesy of MassDOT)



Types of Joints: Closed Joints

Strip Seal (≤4”)

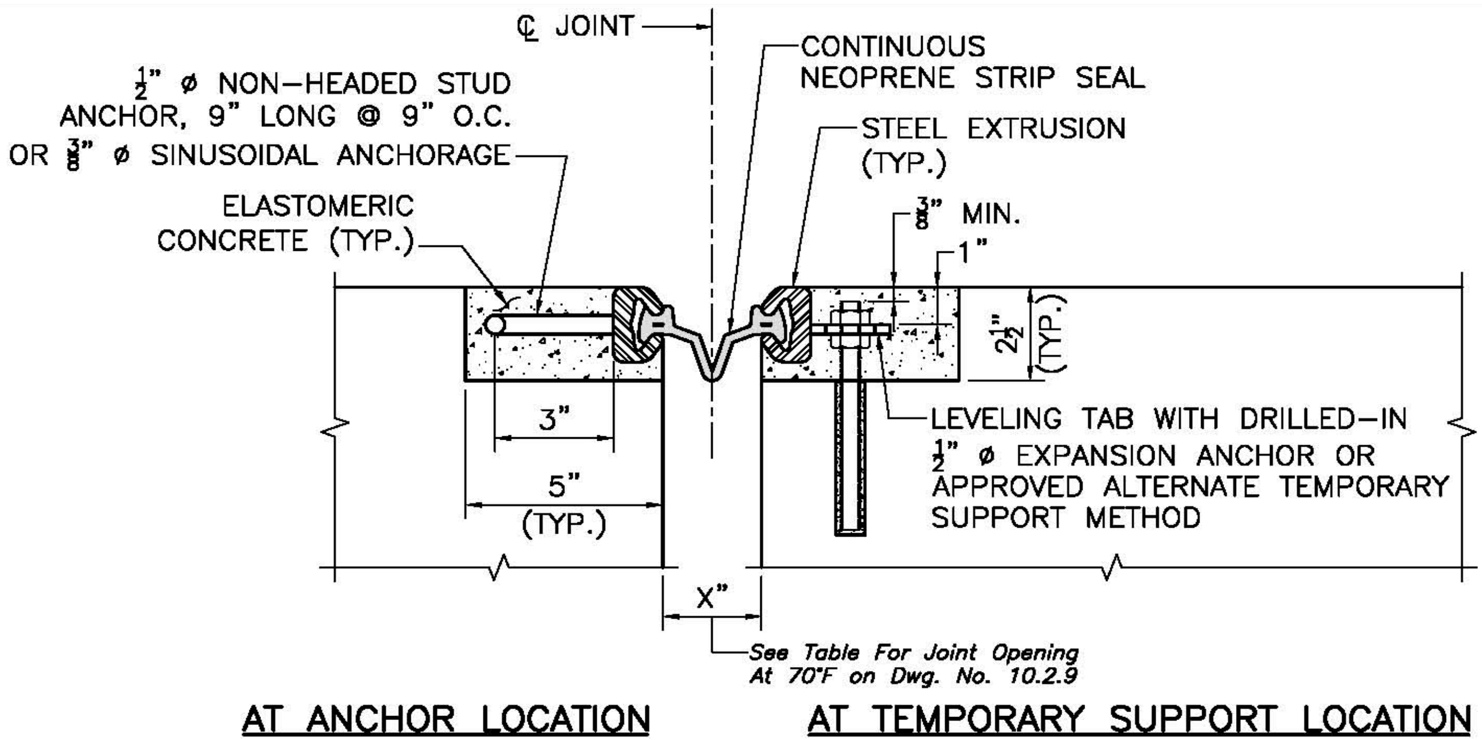


Figure Source: MassDOT LRFD Bridge Manual Part II, 2013

Types of Joints: Closed Joints

- Damaged strip seal (Photo courtesy of MassDOT)

Types of Joints: Closed Joints

EM-SEAL ($\leq$4")

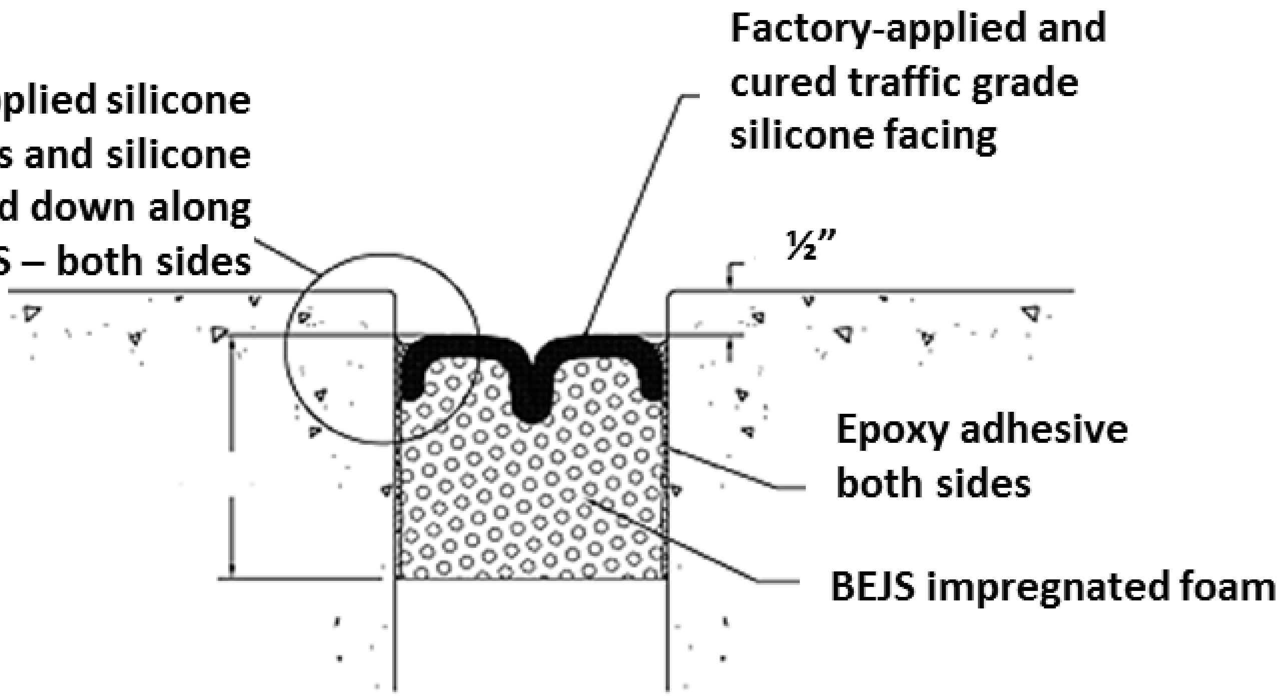


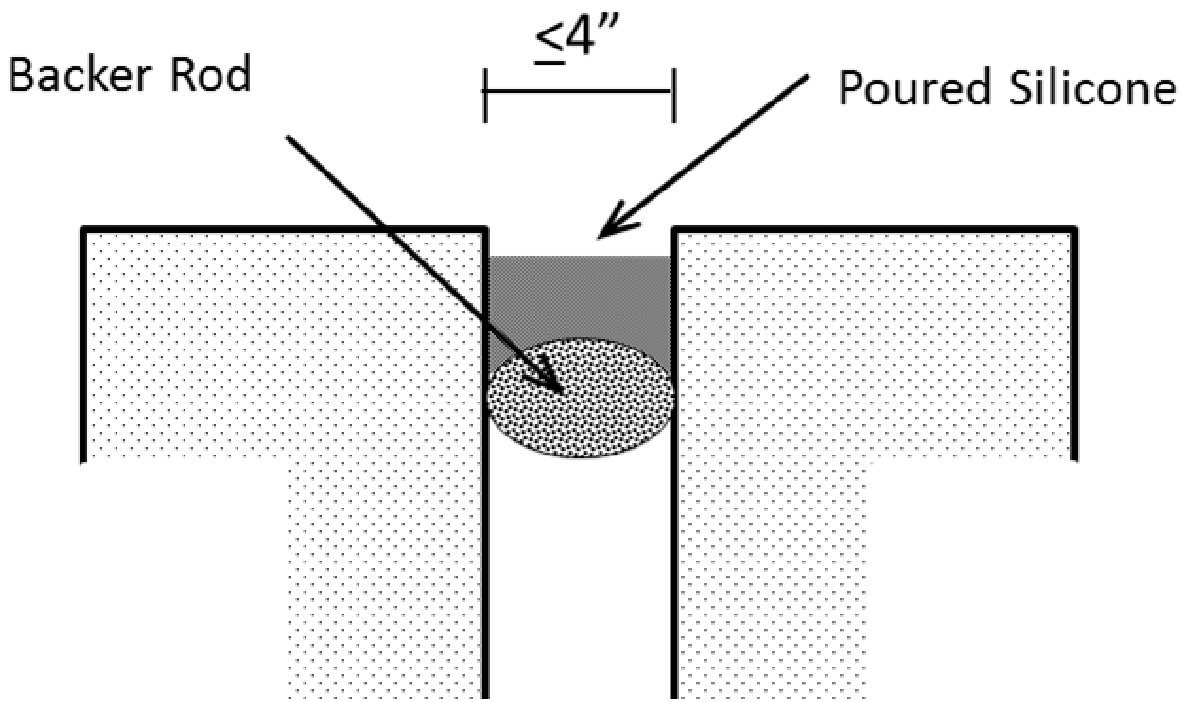
Figure Source: EM-SEAL Manufacturer, 2015

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”)



Types of Joints: Closed Joints

- Damaged pourable seal (Photo courtesy of MassDOT)

Types of Joints: Closed Joints

Modular Joint (>4”)

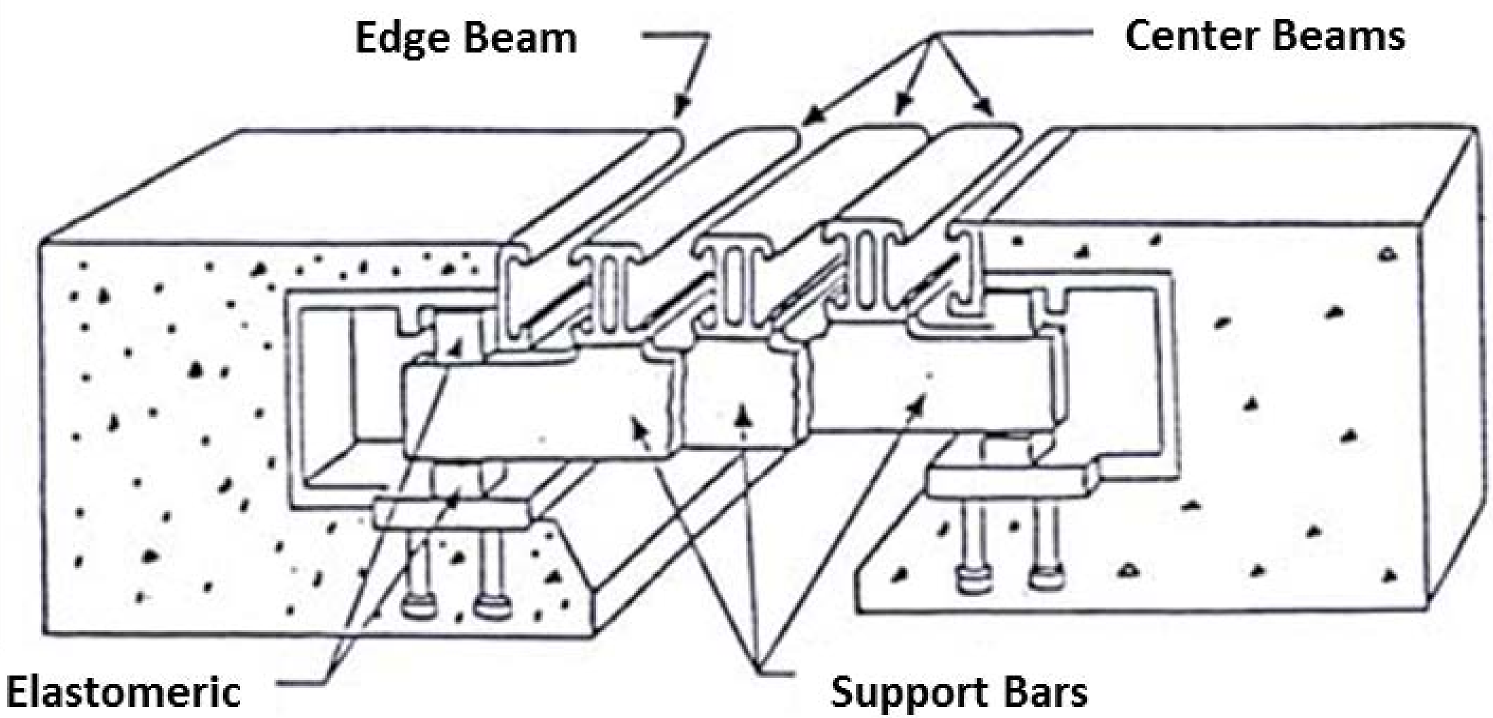


Figure Source: Purvis, 2003

Types of Joints: Closed Joints

- Damaged modular joint (Photo courtesy of MassDOT)

Types of Joints: Open Joints

Sliding Plate Joint (< 3”)

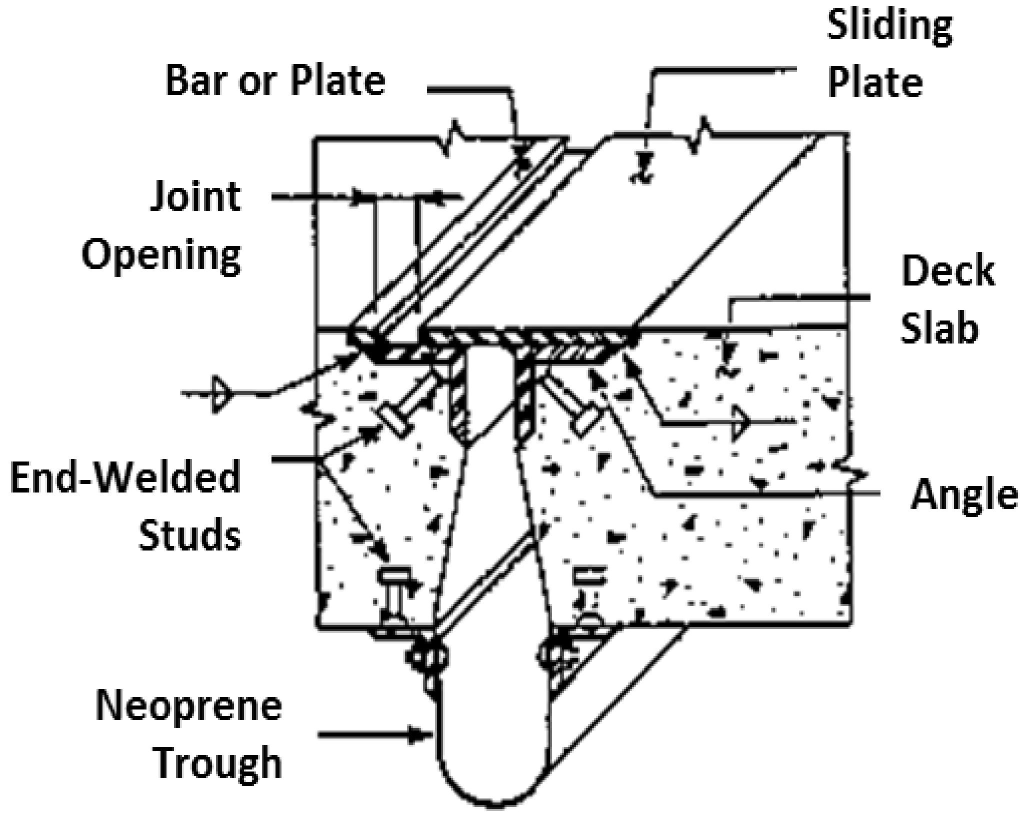


Figure Source: Purvis, 2003

Types of Joints: Open Joints

Finger Joint (>4”)

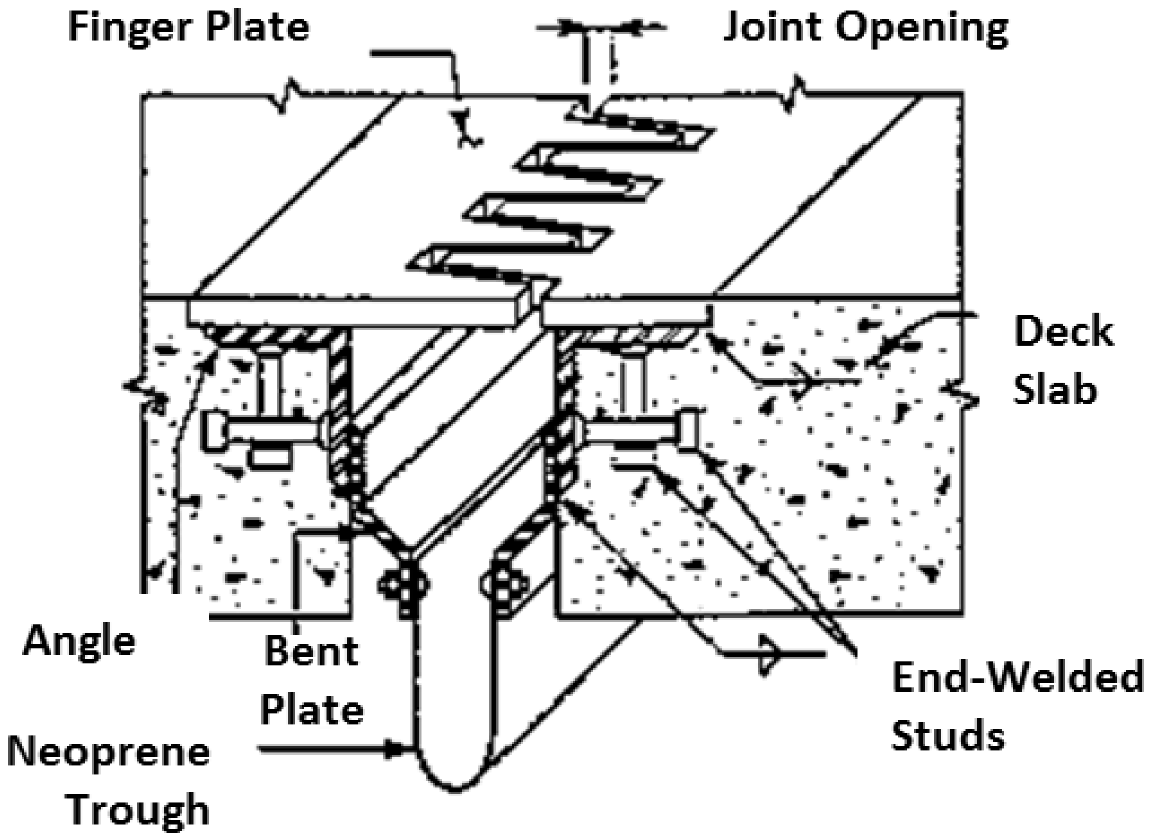


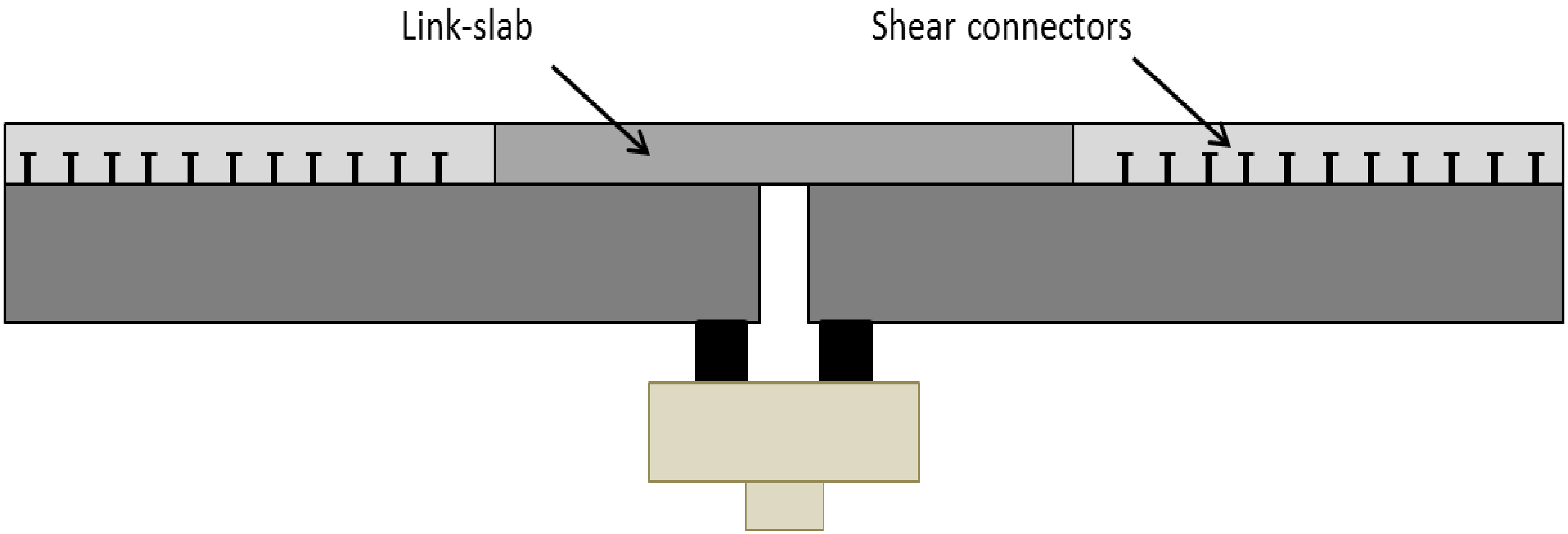
Figure Source: Purvis, 2003

Types of Joints: Open Joints

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

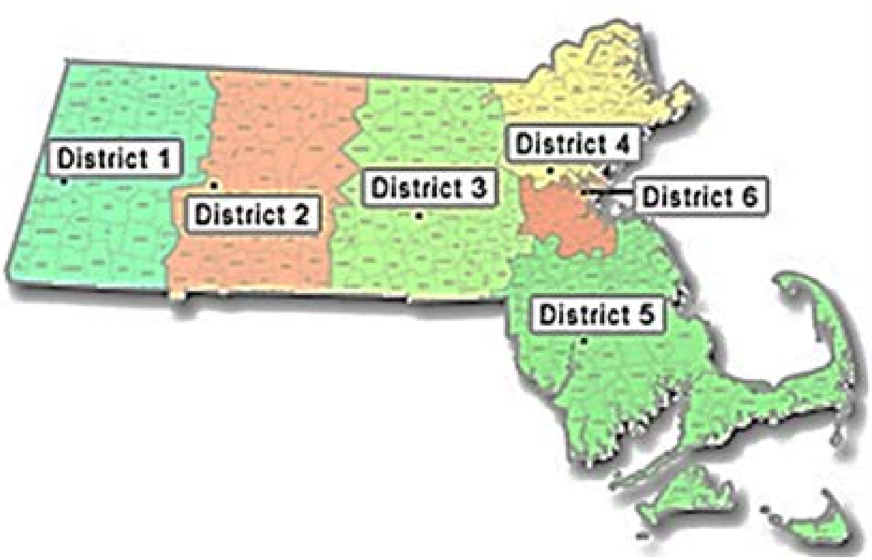
Jointless Option

Link-Slab



Massachusetts Bridge Inventory

- Districts of MassDOT and highway system.



Massachusetts Bridge Inventory

No. of Bridges	District Number						TOTAL	TOTAL OWNED BY MASSDOT
	1	2	3	4	5	6		
Total	703	834	1158	827	858	682	5062	3474
"Jointed Bridges"	185	413	624	558	455	579	2814	2557

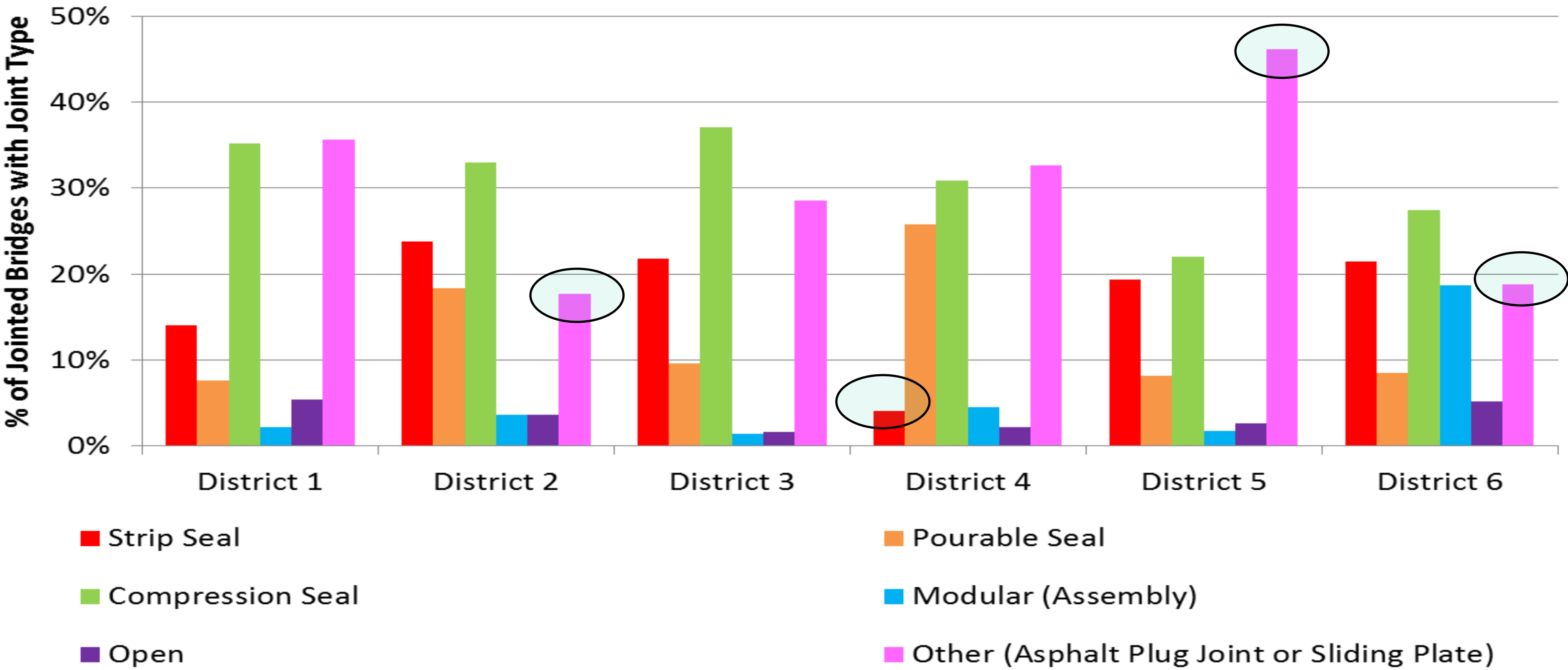
Source: PONTIS and NBI Databases
See full report for interstate/turnpike bridges

- 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



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

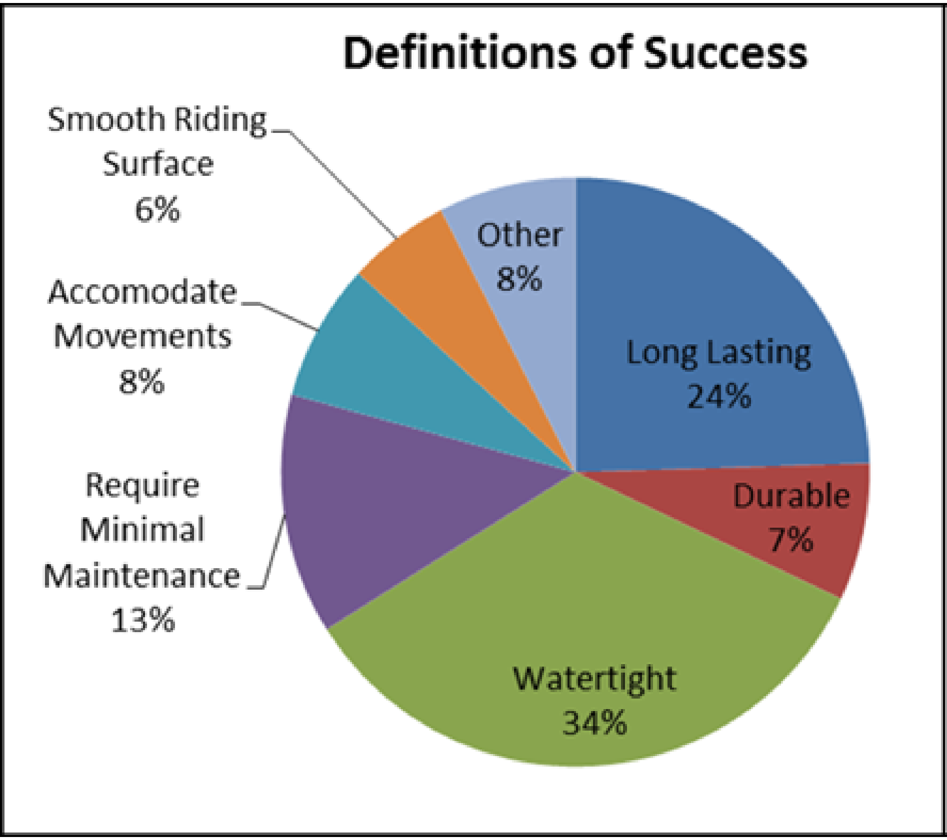
Survey

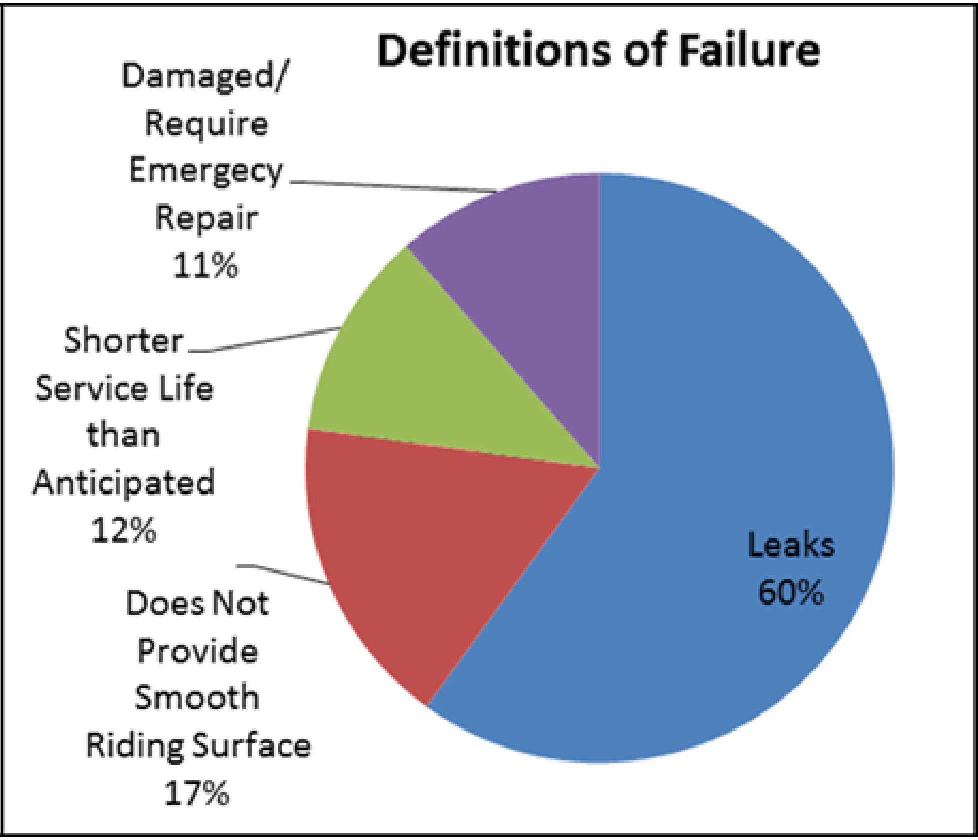
- Survey created in Survey Monkey (44 questions)
  - Joints
  - Headers
  - New installation and repair
  - Maintenance
  - Overall practice
- Distributed to 9 states
  - CT, ME, MA, NH, NJ, NY, PA, RI, and VT
  - 26 responses (45% response rate)
  - Many states had multiple respondents
- Full list of survey questions is available in Final Report

Survey Summary: Overview

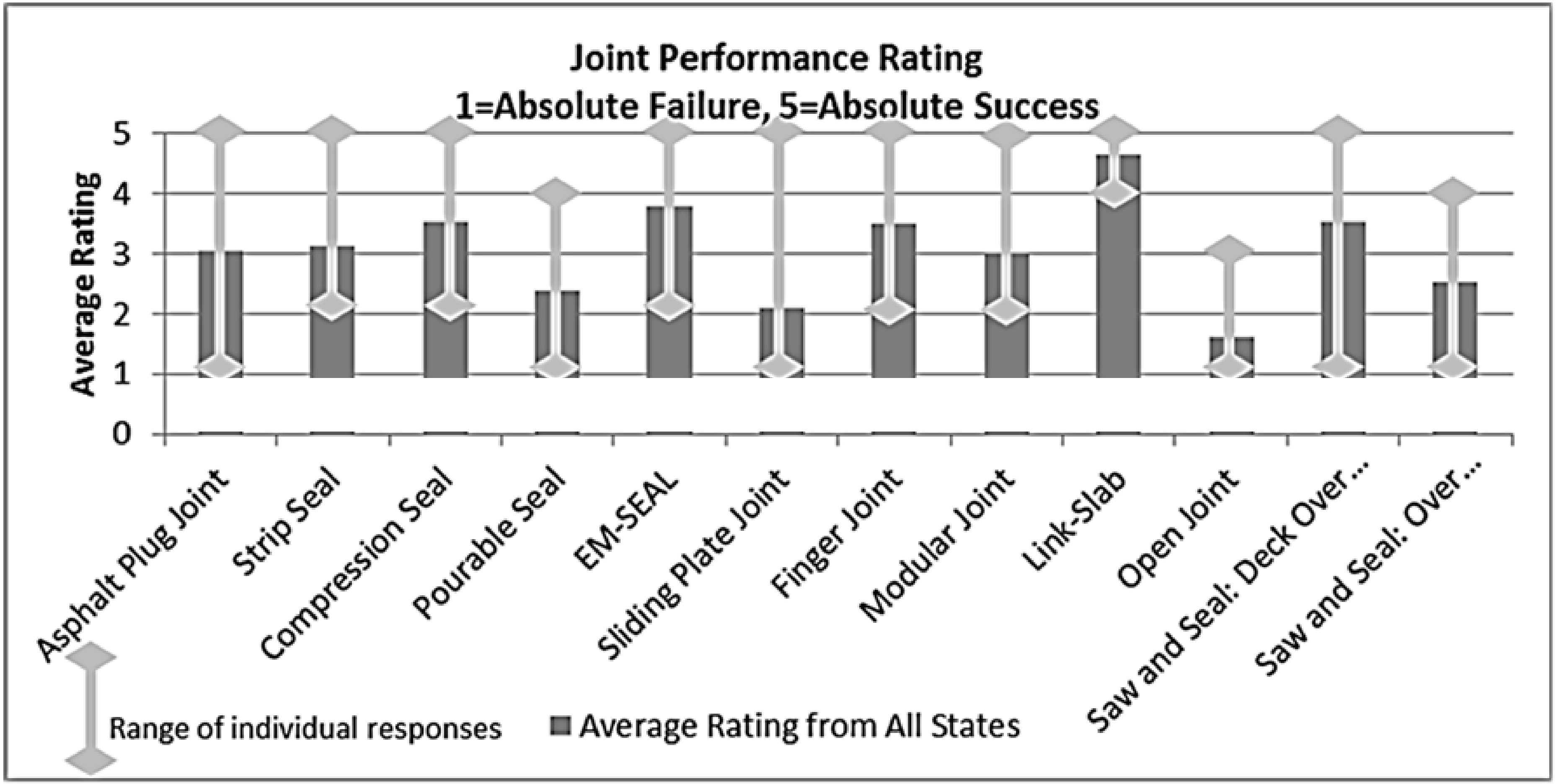
- Wide variability in performance, preference, and service lives of any given joint
- Definitions of success and failure of joint varies
- Preventive maintenance and installation workmanship are very important

Survey Summary: Success/Failure Definitions





Survey Summary: Performance Rating



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

Years	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 Backwall	Saw and Seal: Over Existing Joint
0-4	6	2	2	11	1	0	0	0	0	1	0	1
5-8	13	1	2	0	1	0	0	1	0	0	1	1
9-12	1	5	6	2	1	0	1	3	1	1	5	1
13-16	1	7	5	0	0	3	2	4	2	0	1	0
>16	0	4	2	0	1	3	16	8	4	3	4	0

- 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

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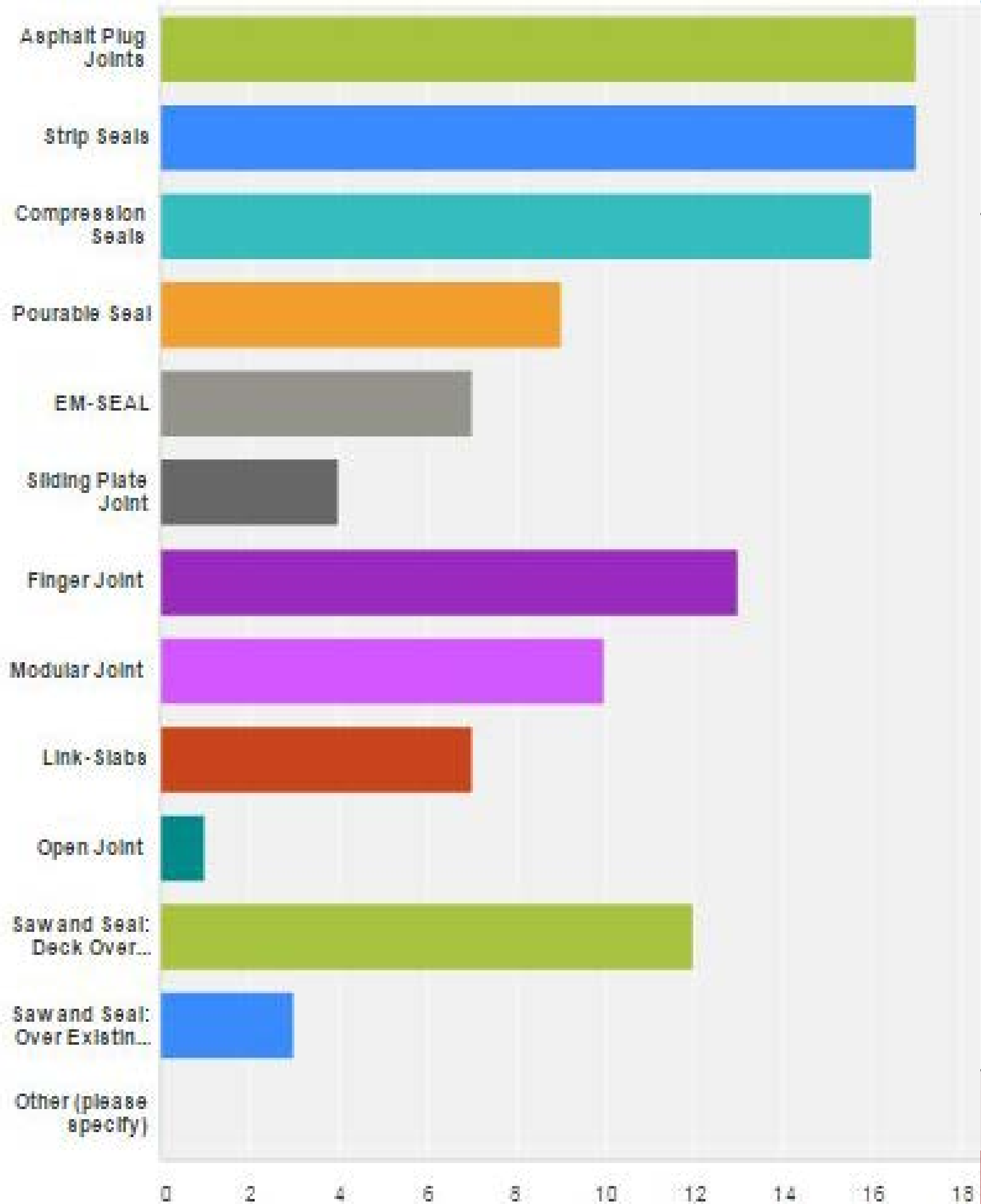
Survey Summary:

Adequate performance with routine repair and maintenance

(check all that apply)

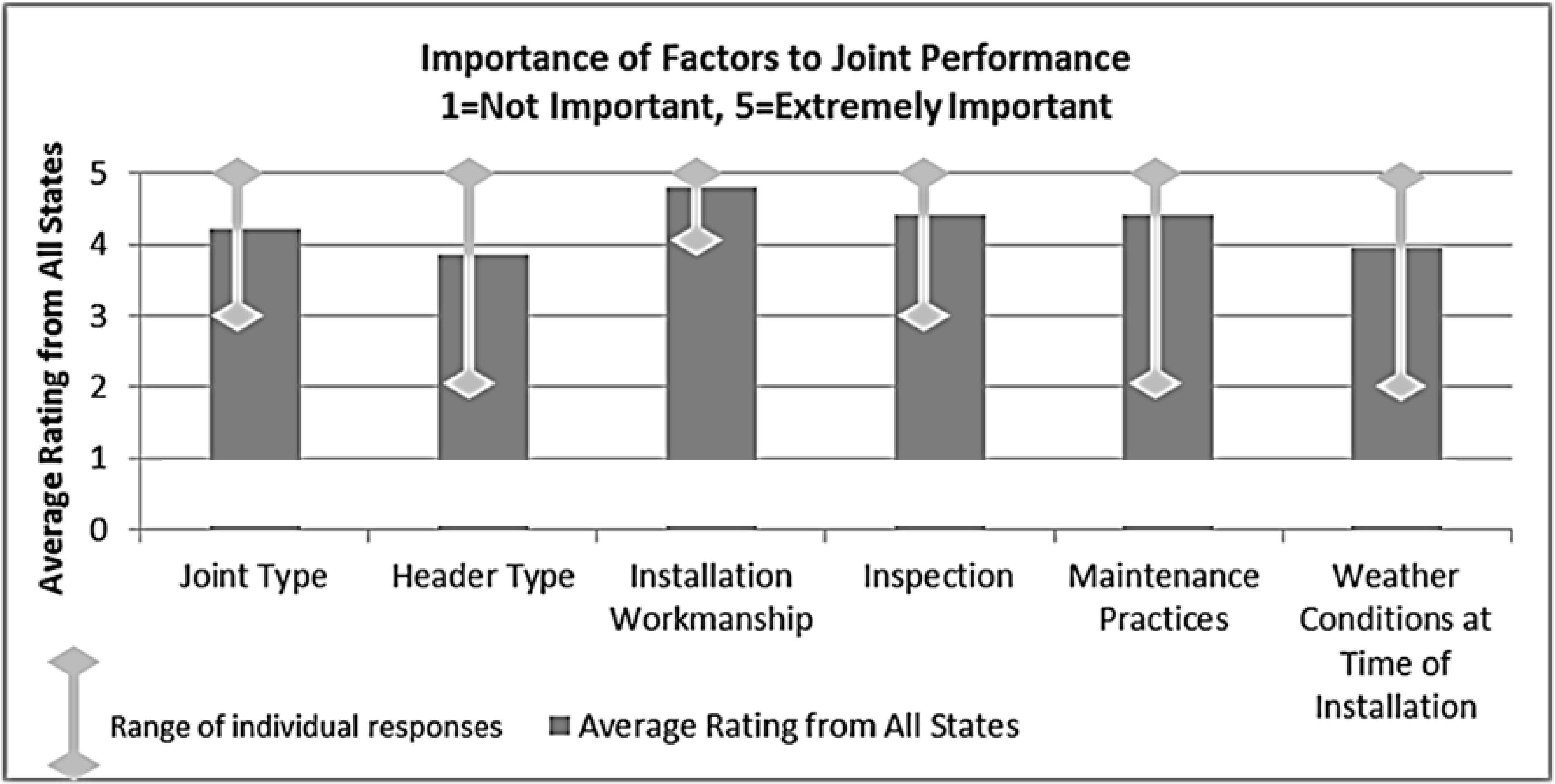


Survey Summary:

- 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



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

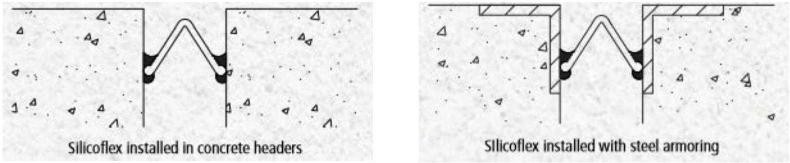
- Negative influence on joint performance
  - Improper cleaning of joint, surfaces and substrate
    - Sandblasting often skipped due to time constraints
    - Not reaching sound concrete
  - Incorrect opening size or placement of seals
  - Bond agent applied too far in advance of seal placement
  -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

Survey Summary: Comments

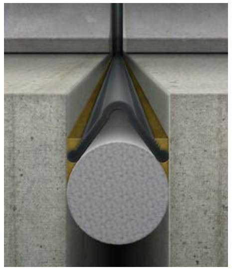
- Specific joint comments
  - Saw and seal – proper location of cut is important, mark prior to placing wearing surface
  - Asphalt plug joints perform poorly with high traffic volumes, improper placement of backer rod
  - Compression seal – size seal and opening to always be in compression
  - Pourable 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



RJ Watson Silicoflex system



DS Brown V-Seal system

  - Concrete trough with finger joint (behind abutments)
  - Heavy angles and anchorage for joint armor

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

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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
- Quinn, B. H. and Civjan, S. A. (2016) "Assessment of Bridge Joint Performance in the Northeastern States" *Transportation Research Record.* Vol 2550. pp 46-53.
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- Milner, M. H. and Shenton III, H. W. (2014) *Survey of Past Experience and State-of-the-Practice in the Design and Maintenance of Small Movement Expansion Joints in the Northeast*. *AASHTO Transportation System Preservation Technical Services Program (TSP2) Report 242*, Newark, Delaware
- *MassDOT LRFD Bridge Manual Part II*. (2013) Massachusetts Dept. of Transportation
- *AASHTO Maintenance Manual for Roadway*
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