NCHRP 12-100
Guidelines for Maintaining Small Movement Bridge Expansion Joints

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Objective of the Project (as stated in RFP):

- Develop proposed guidelines with commentary for evaluating and maintaining small movement bridge joints to support the decisions of bridge owners. The guidelines would cover, as a minimum:
  - joint failure mechanisms;
  - performance metrics;
  - procedures for maintenance, repair, and replacement of bridge joints.
- The proposed guidelines are to be presented in a format suitable for AASHTO consideration.

Project Tasks:

- Phase I – Synthesis report and procedures development
  - Task 1 – Literature Review
  - Task 2 – Stakeholder Survey
  - Task 3 – Technical Memo
  - Task 4 – Develop Procedures for Maintenance, Repair, and Replacement of Joints
  - Task 5 – Outline of the Proposed Guidelines
  - Task 6 – Interim report
- Phase II – Guidelines development
  - Task 7 – Develop proposed guidelines
  - Task 8 – Prepare final deliverables (final report and standalone guidelines)

Task 1 – Literature Review

Task 1 – Literature Review

- Extensive search conducted using multiple databases
- Dearth of research on small movement joints
- Very limited number of sources that are directly relevant to this project

Task 1 – Literature Review

- Selected important sources

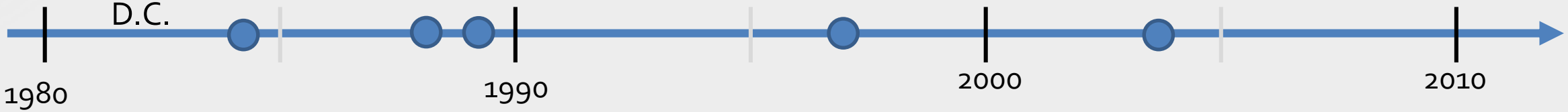
Price, A.R. (1984), *Performance in Service of Bridge Deck Expansion Joints*, TRRL Laboratory Report (Transport and Road Research Laboratory, Great Britain) 1984.

Dahir, Sabir H. and Mellott, D.B. (1987), "*Bridge Deck Expansion Joints"*, Transportation research record 1987: 16-24. Transportation Research Board, Washington, DC

Burke, Martin P. (1989) *NCHRP Synthesis of Highway Practice 141: Bridge Deck Joints*. September, 1989. Transportation Research Board, National Research Council. Washington, D.C.

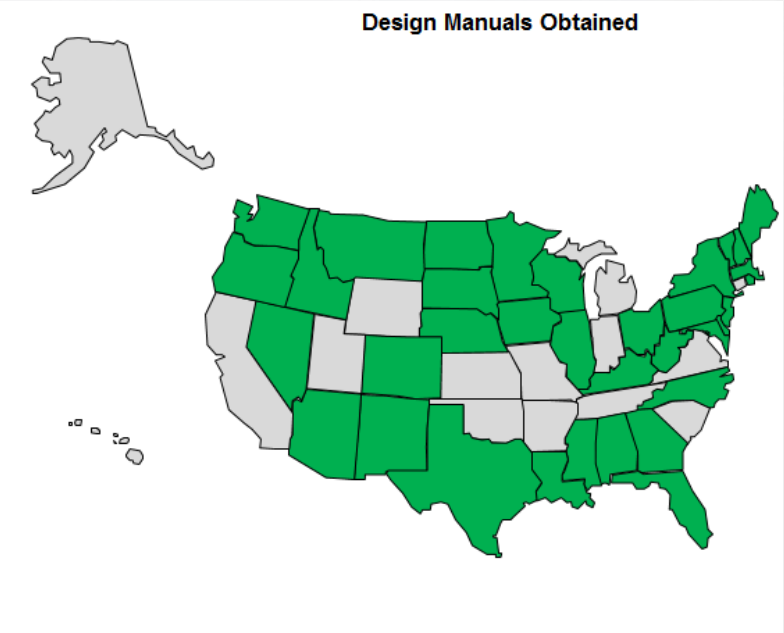
Barnard, C.P. and Cuninghame J.R., (1997), *Improving the Performance of Bridge Expansion Joints: Bridge Deck Expansion Joint Working Group Final Report*, Crowthorne: Transport Research Laboratory Report

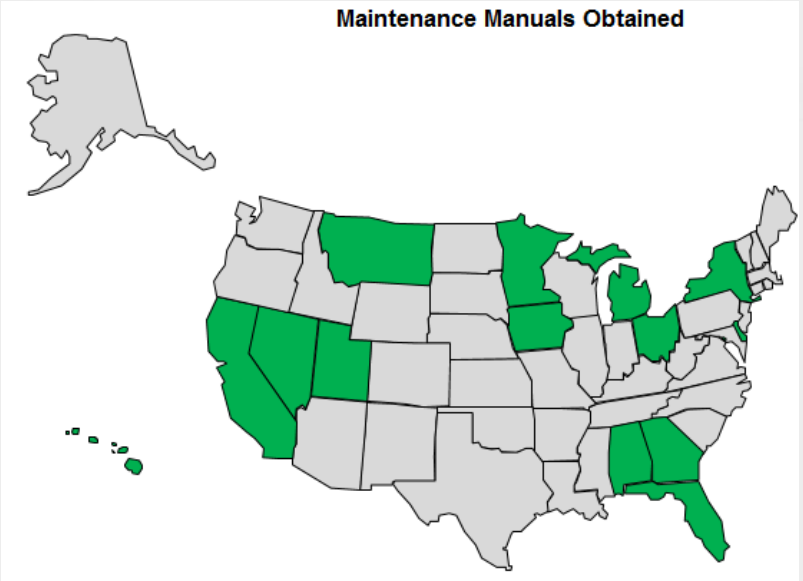
Purvis, Ron. (2003) *NCHRP Synthesis of Highway Practice 319: Bridge Deck Joint Performance*. Transportation Research Board, National Research Council. Washington, D.C.



Task 1 – Literature Review

- Gathered state/agency design and maintenance manuals
  - 36 design manuals
  - 14 maintenance manuals





Task 2 – Stakeholder Survey

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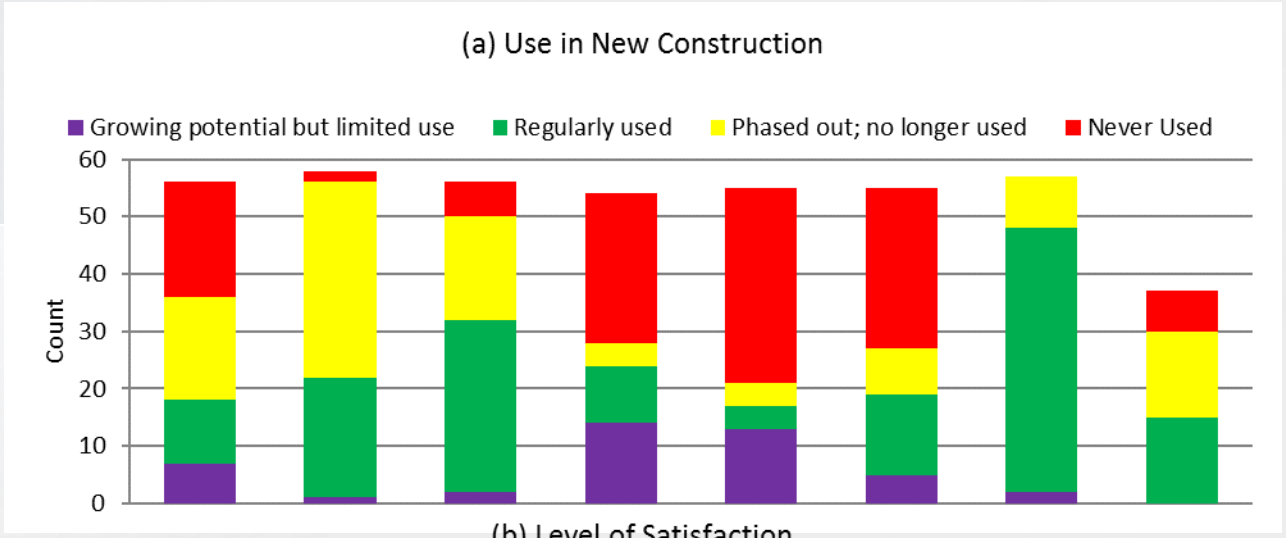
- Online survey was conducted of all stakeholders who have an interest in SMEJ - owners, consultants, contractors, suppliers
- Gather information on their experiences with SMEJ's, performance, challenges
- Breakdown of responses by stakeholder:

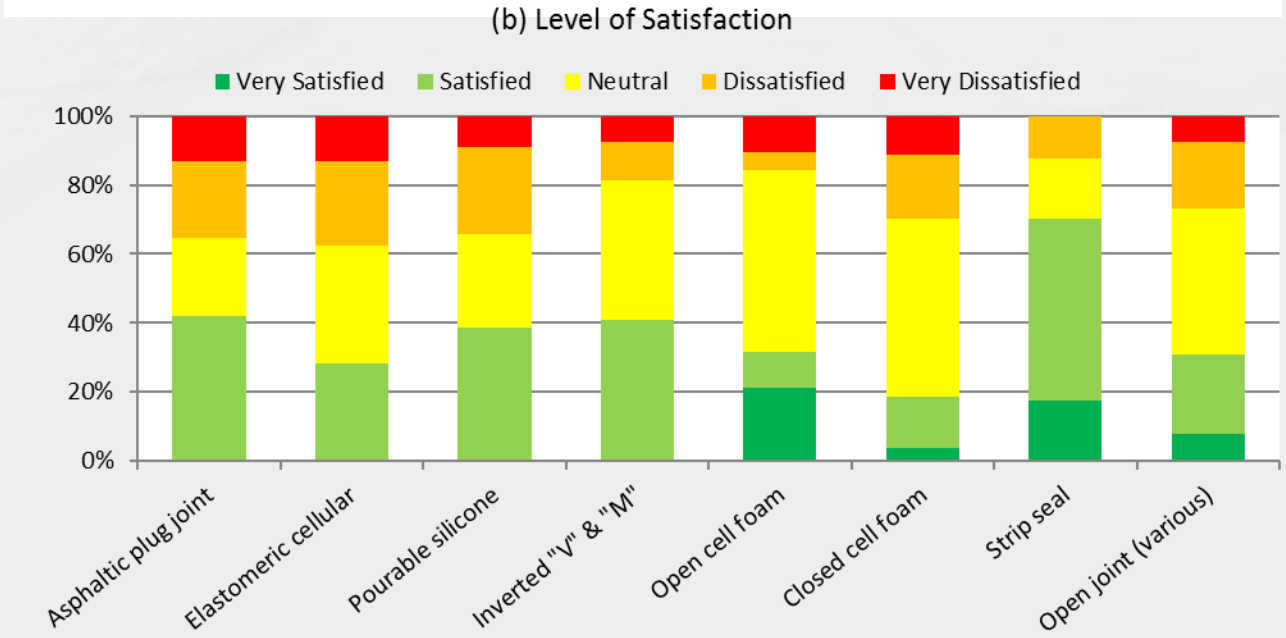
Stakeholder	Number of completed surveys
Bridge owners	73
Consultants	15
Contractors	6
Suppliers/manufacturers	14
Total	108

Represents 37 state agencies

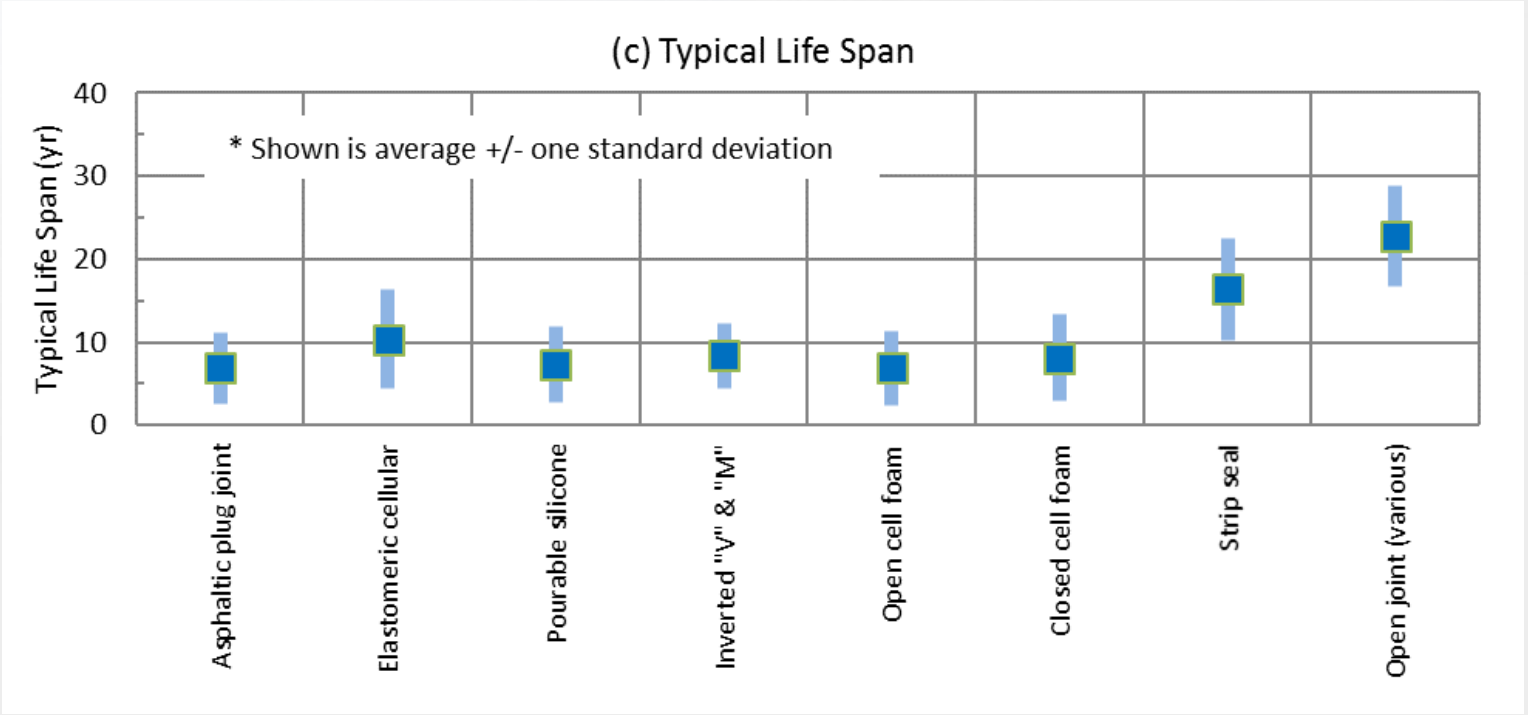
Stakeholder Survey: Results

New Construction



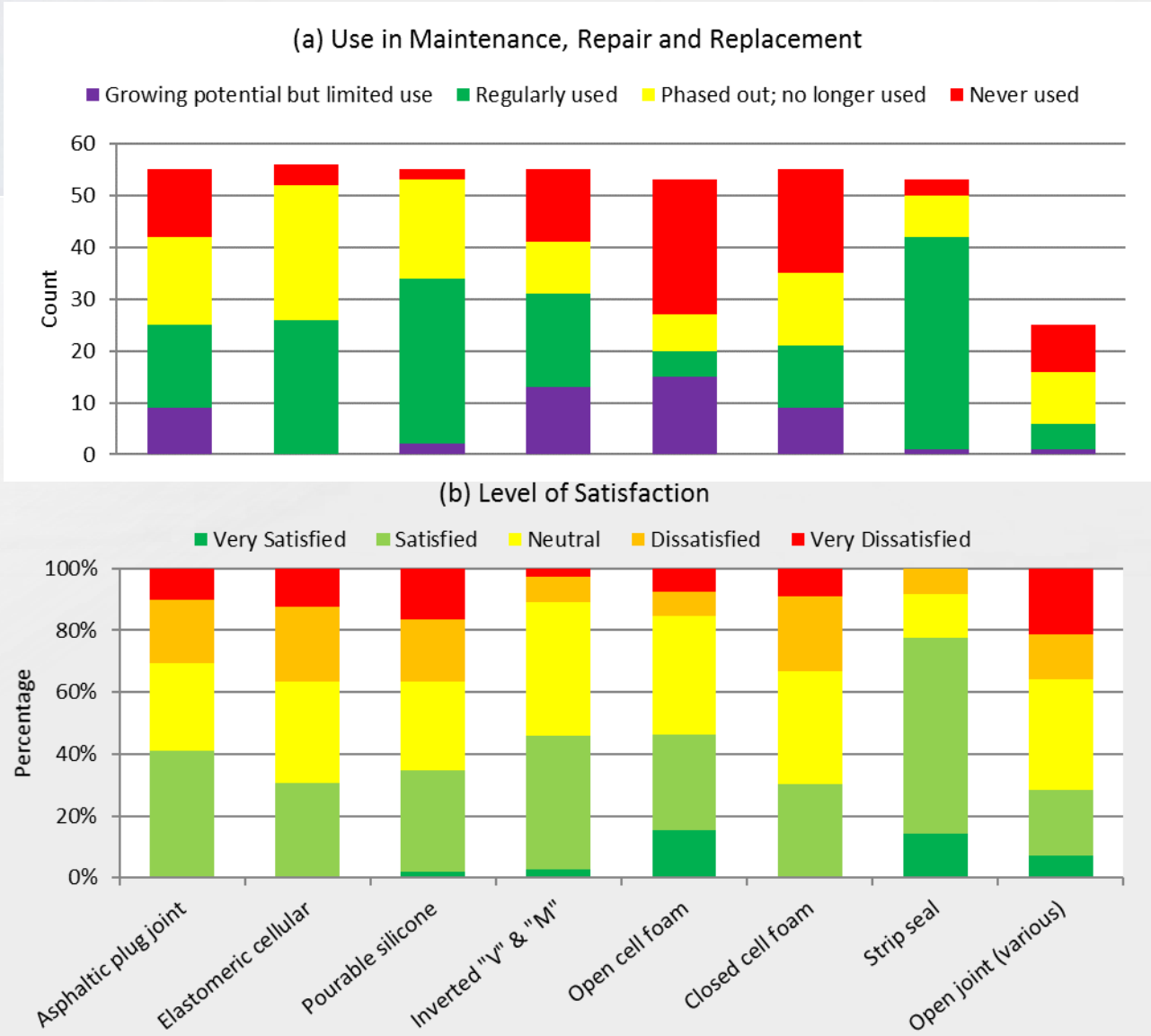


Stakeholder Survey: Results
New Construction

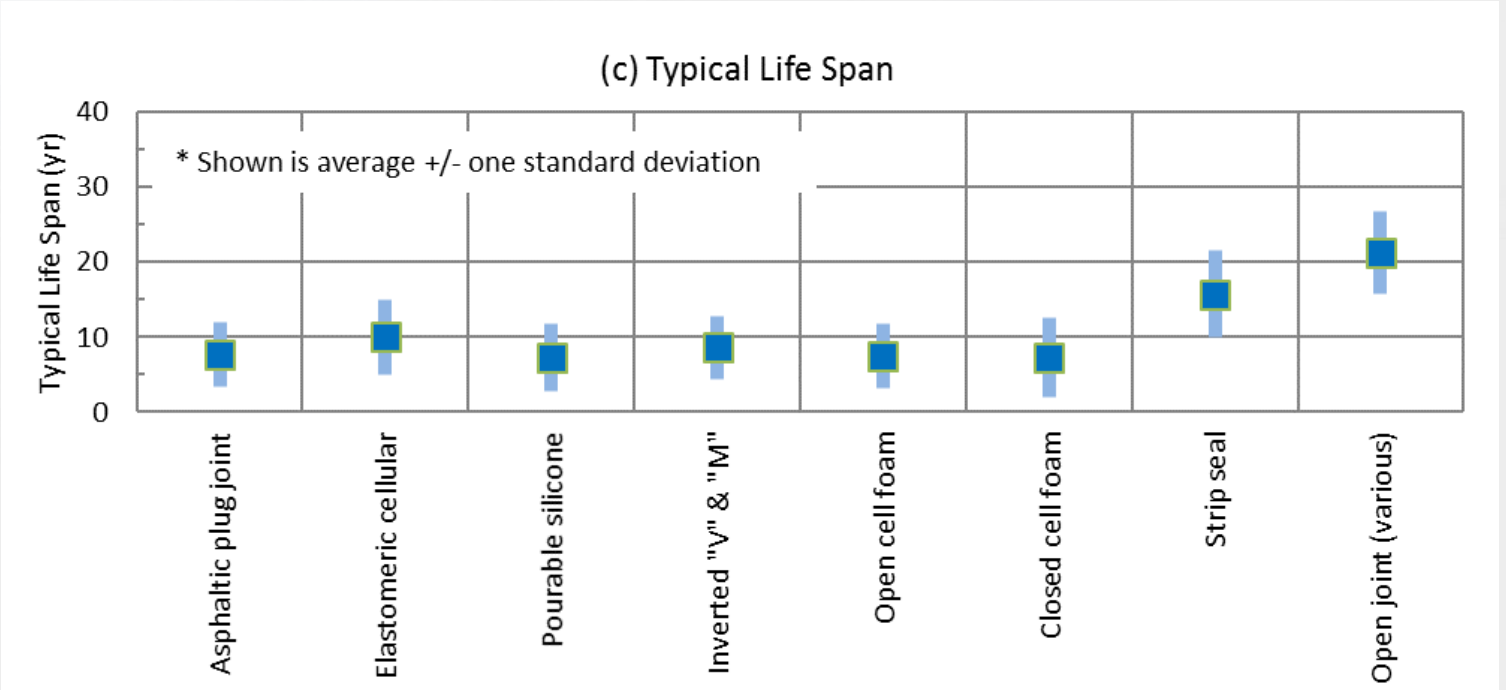


Stakeholder Survey: Results

Maintenance, repair, and replacement



Stakeholder Survey: Results
Maintenance, repair, and replacement

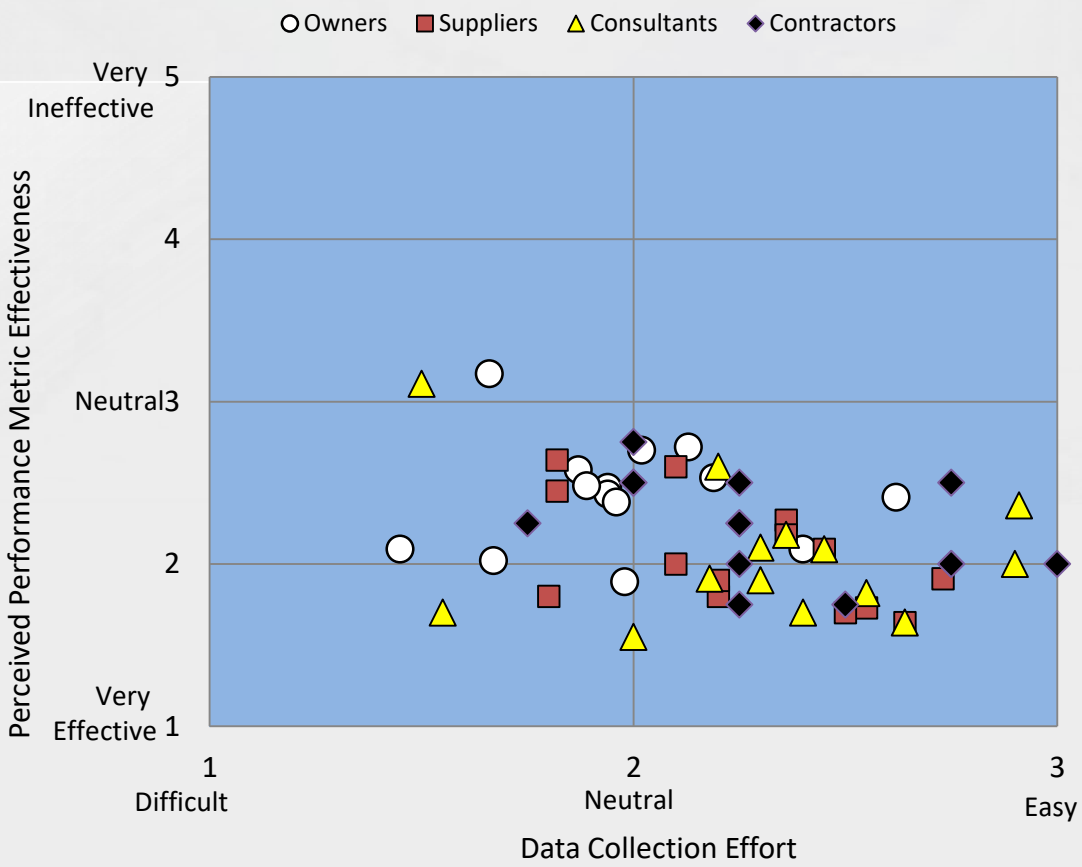


Stakeholder Survey: Common Modes of Failure

Joint	Modes of Failure
Asphaltic Plug Joint	Bond Failure/Separation of Joint from Header (10), Heave (9), Cracking (8), Rutting (8), Improper Material Mix (1), Misaligned Centering Pins (1), Insufficient Depth (1), Deterioration (1), Blowouts (1), Porous Asphalt (1).
Elastomeric cellular	Bond Failure/Separation of Joint from Header (18), Seal Falling Out (14), Debris Impaction (10), Tearing (9), Loss of Rebound (5), Cracking (5), Snowplow Impact (3), Header Failure (2), Poor Installation (2).
Poured Silicone Seal	Bond Failure/Separation of Joint from Header (25), Tearing (6), Debris Impaction (5), Cracking (3), Tire Wearing (3), Snowplow Impact (3), Header Failure (2), Poor Surface Preparation (2), Backer Rod Movement (1), Seal Falling Out (1).
Preformed inverted “V” & “M”	Bond Failure/Separation of Joint from Header (18), Tearing (5), Debris Impaction (4), Tire Wearing (3), Poor Installation (2), Cracking (1), Header Failure (1), Seal Falling Out (1).
Open Cell Foam	Bond Failure/Separation of Joint from Header (7), Debris Impaction (3), Improper Sizing (1), Tire Wearing (1).
Closed Cell Foam	Bond Failure/Separation of Joint from Header (12), Improper Sizing (3), Debris Impaction (3), Compression Set (1), Deterioration (1), Tearing (1), Loss of Elastic Properties Due to Heat (1).
Strip Seal	Tearing (24), Debris Impaction (14), Extrusion/Seal Pushed out of Joint (13), Header Failure (9), Bond Failure/Separation of Joint from Header (4), Cracking (3), Snowplow Impact (3).
Finger/Tooth Joint	Clogged Trough (3), Anchor Bolt Deterioration (2), Teeth Breaking (2), Misaligned Teeth (1), Snowplow Impact (1).

Stakeholder Survey: Results
Strawman Performance Metrics

- 14 unique performance metrics were presented in the survey as strawman metrics
- Respondents were asked to rate the "effectiveness" of the metric and "ease of data collection"



Stakeholder Survey: Results
Strawman Performance Metrics

Summary of more highly ranked performance metrics of those proposed in survey

	Owner	Supplier	Consultant	Contractor
Durability				
Service life of the joint	X		X	X
Service life of the substructure			X	X
Inspectability				
Is the joint easily inspected	X			
Can a leak be detected, and	X			X
Maintainability				
Is the joint easily repaired, and		X		
Is the joint easily cleaned		X		
Rideability				
Does the joint effect ride quality		X	X	
Constructability				
Constructability for repair		X		X
Does quality of installation affect performance	X		X	X
Economy				
Life-cycle cost	X	X	X	

Task 6 – Draft Guidelines

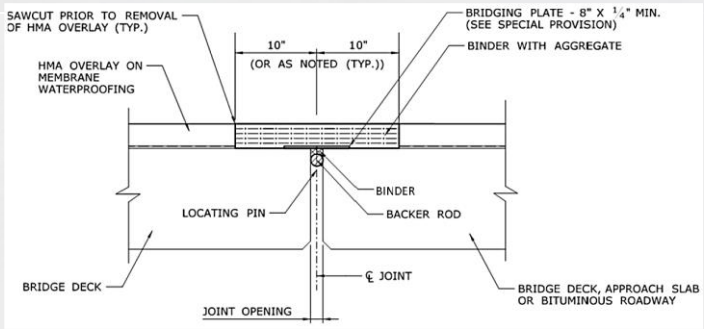
Table of Contents

1. Introduction

- Scope and Objectives of the Guidelines
  - Limited to joint movement 4" or less
  - Brief mention of joint elimination but detailed coverage beyond scope
- Definitions
  - Maintenance - any activity that is done on a regularly scheduled, cyclic basis
  - Repair - any activity that is done on an intermittent basis to bring a joint back to proper functioning; does not constitute a complete reconstruction of the entire joint.
  - Replacement - a complete reconstruction of the entire joint.

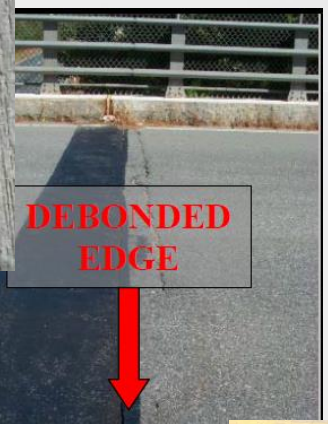
2. Types of Joints

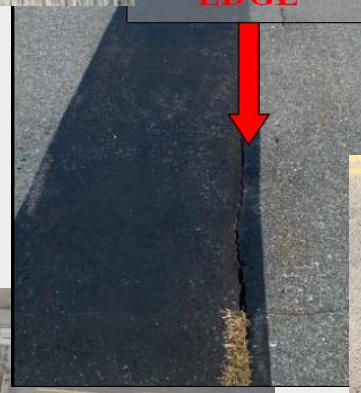
- Five main types:
  - Asphalt Plug Joint (APJ)
  - Compression seal
    - Closed-cell foam, open-cell foam, elastomeric cellular, inverted "V" & "M"
  - Strip seal/armored
  - Pourable
  - Open/sliding plate/butt



3. Modes of Failure

- Narrative descriptions
- Pictures





4. Evaluating Joints

- Assumes familiarity with AASHTO Manual for Bridge Element Inspection; Condition States (CS) and defects for joints

1. Prepare the work zone/traffic control
2. Inspect joint noting defects and damage
3. Measure total Lineal Feet (LF) of joint. Determine Condition States (CS) and quantities (LF) of the joint, per MBEI. Calculate the % of the joint in each CS
4. Determine the action required by entering the table with the highest CS and the corresponding LF by percentage of that CS

%Lineal Feet of Joint in the Highest Condition State	Highest Condition State			
	CS=1	CS=2	CS=3	CS=4
100	Maintain	Repair	Replace	Replace
75	Maintain	Repair	Repair	Replace
50	Maintain	Repair	Repair	Replace
25	Maintain	Maintain	Repair	Repair

5. Calculating the Joint Movement and Sizing the Seal

- Calculate joint movement

$$\Delta = \alpha L \left(T_{\max} - T_{\min} \right)$$ .....Total

$$\Delta_{\perp} = \Delta \cos\left(\phi\right)$$ .....Perpendicular to joint $\left(\phi - \text{skew angle}\right)$

$$\Delta_{\parallel} = \Delta \sin\left(\phi\right)$$ .....Parallel to joint $\left(\phi - \text{skew angle}\right)$

5. Calculating the Joint Movement and Sizing the Seal

- For replacement – adjust gap width for installation temperature

Adjustment in inches/10°F

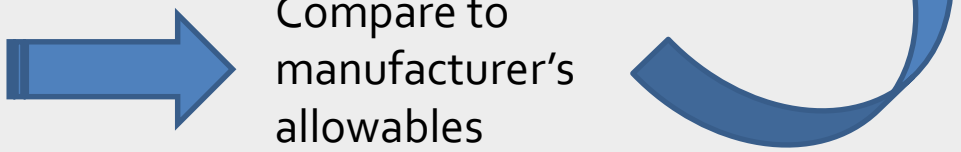
Skew ϕ (degrees)	Steel Span Length (ft)						
	50	100	150	200	250	300	350
0	1/16	1/16	1/8	1/8	3/16	1/4	1/4
5	1/16	1/16	1/8	1/8	3/16	1/4	1/4
10	1/16	1/16	1/8	1/8	3/16	1/4	1/4
15	1/16	1/16	1/8	1/8	3/16	1/4	1/4
20	1/16	1/16	1/8	1/8	3/16	1/4	1/4
25	1/16	1/16	1/8	1/8	3/16	3/16	1/4
30	1/16	1/16	1/8	1/8	3/16	3/16	1/4
35	1/16	1/16	1/8	1/8	3/16	3/16	1/4
40	0	1/16	1/16	1/8	1/8	3/16	3/16
45	0	1/16	1/16	1/8	1/8	3/16	3/16

Adjustment in inches/10°F

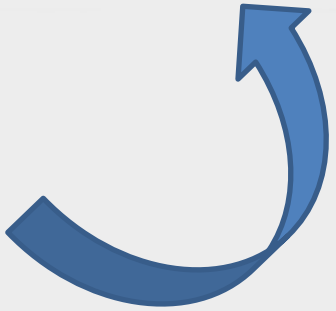
Skew ϕ (degrees)	Concrete Span Length (ft)						
	50	100	150	200	250	300	350
0	1/16	1/16	1/8	1/8	3/16	3/16	1/4
5	1/16	1/16	1/8	1/8	3/16	3/16	1/4
10	1/16	1/16	1/8	1/8	3/16	3/16	1/4
15	1/16	1/16	1/8	1/8	3/16	3/16	1/4
20	1/16	1/16	1/8	1/8	3/16	3/16	1/4
25	1/16	1/16	1/8	1/8	3/16	3/16	1/4
30	0	1/16	1/16	1/8	1/8	3/16	3/16
35	0	1/16	1/16	1/8	1/8	3/16	3/16
40	0	1/16	1/16	1/8	1/8	3/16	3/16
45	0	1/16	1/16	1/8	1/8	1/8	3/16

5. Calculating the Joint Movement and Sizing the Seal

- Calculate max and min gap based on measured gap width and temps
- Calculate shear movement if joint is skewed
- Select a seal width using manufacturer's sizing tables
- Calculate
  - Maximum compression
  - Maximum tension
  - Maximum shear
  - Compression @ install



Compare to manufacturer's allowables



Iterate if needed

6. Selecting a Replacement Joint

- Performance metrics:
  - Joint opening
  - Joint movement
  - Skew
  - Intended service life
  - Installed cost
- Constructability
- Lead Time
- Location
- Traffic
- Durability

6. Selecting a Replacement Joint

	Max Opening (in)	Joint Movement (in)	Skew[1]	Expected Service Life (years)[2]	Installed Cost	Construct-ability	Lead Time	Location/ environment	Traffic[3] (ADT)	Durability
Asphalt Plug Joint	3	<1	L-M	7.5	L	H	M	M	L-M	M
Compression:										
Closed-cell Foam	4	<2-3	M	8.9	L	M	L	H	M	L-M
Open-cell foam	4	<2-3	M	TBD	M	L	M	H	M	TBD
Preformed inverted “V” & “M”	4	<4	M	10.0	M	L	L	M	M	M
Strip seal/ Armored joint	4	<3-4	M	16.0	H	H	H	H	H	H
Pourable joint	3	<1	L-M	7.5	L	L	L	H	M	L
Open/Sliding Plate/Butt joint	3	<2-3	H	23.1	L	L	L-M	H	M	M

1. Skew: L=0º-15º,M=15º-25º,H>25º (but not unlimited)
2. Based on owner survey responses
3. Traffic (ADT): L=0-15,000; M=15,000-45,000; H>45,000 vehicles per day

6. Selecting a replacement joint

Switching from one joint type to another

To / From	APJ	Pourable	Compression Closed Cell & Open Cell Foam	Preformed inverted "V" & "M" (Silicone/Neoprene)	Strip Seal	Open Sliding
APJ		Header reconstruction necessary. Existing 20" width would be larger than the required 10". Chip out an additional 1"-2" depth in the blockout. Drill and grout anchoring bars. Pourable seal could be installed on the same day if elastomeric concrete is used.	Remove existing header, regardless of condition. Existing 20" x 2" header would be larger than the required 10" x 3"-4" header. Header reconstruction with anchorage necessary. Installation of closed-cell foam may have to be done at a later date. Open-cell could occur the same day, if elastomeric concrete is used.	Remove existing header, regardless of condition. Existing 20" x 2" header would be larger than the required 10" x 3"-4" header. Header reconstruction with anchorage necessary. The inverted "V" and "M" seals would not be optimized as they are capable of much larger movement than the maximum 1-1/2" of the APJ.	Not realistic as the APJ has a 1-1/2" movement maximum. The strip seal would not be functionally optimized.	Remove existing header, regardless of condition. Install anchorage and open sliding plate. Construct a trough under joint (could be difficult in small opening).
Pourable	Remove existing header and anchorage to 20" (10" each side of opening). Typical 3"-4" header is deeper than required. Consider [illegible] & time		Existing header could remain, if in serviceable condition and has anchorage. Otherwise reconstruct existing header, with anchorage, as necessary. Installation of closed-cell foam may have to be done at a later [illegible]	Existing header could remain, if in serviceable condition and has anchorage. Otherwise reconstruct existing header, with anchorage, as necessary. The "M"	Not realistic as the pourable seal has a 1-1"-2" movement maximum. The strip seal would not be functionally optimized.	Remove existing header, regardless of condition. Install anchorage and open sliding plate. Installing the trough system would be diffic[illegible]

7. Preparing the Header

- Design considerations
- Determination of header size and gap opening
- Replacement procedure
- In pictures: header construction

Saw cut to the limits of the new header.

...

Hammer out the header material.

...

Clean out the rubble. The crew is taking care to not hammer the rebar.

.....

8. Procedure for Replacement, Repair, and Maintenance of Asphalt Plug Joints

8.1 Replacement of Asphalt Plug Joints
8.2 Repair of Asphalt Plug Joints
8.3 Maintenance of Asphalt Plug Joints
8.4 In Pictures: Installation of an Asphalt Plug Joint

8.1 Replacement of Asphalt Plug Joints

8.1.1 Design considerations

8.1.2 Determination of joint movement

8.1.3 Replacement procedure

1. *Saw cut the blockout*
2. *Prepare the blockout surfaces*
3. *Install backer rod*
4. *Heating the APJ material*
5. *Mixing the APJ material*
6. *Place the bridge plate*
7. *Installing the APJ material*
8. *Apply friction dressing material*
9. *Opening to traffic*

8.2 Repair of Asphalt Plug Joints

8.2.1 Repair of rutting/extensive cracking

8.3 Maintenance of Asphalt Plug Joints

8.3.1 Procedure for sealing crack/minor debonding of Asphalt Plug Joints

8.4 In Pictures: Installation of an APJ









Project status:

- Project completed 9/30/16
- Final report and draft guidelines available at TRB (trb.org; search for project "12-100")
- Guidelines submitted to AASHTO SCOM
  - To be published by AASHTO as a guideline
  - Currently with AASHTO being prepared for publication

Acknowledgments

- National Academy of Sciences and NCHRP for funding the project
- NCHRP 12-100 Panel and Project Manager
- The many stakeholders who completed the survey, and who provided information and data
- Joint manufacturers, vendors, and suppliers who provided material, samples, literature, etc

Questions?