Preliminary Investigation (PI-0231)

Caltrans Division of Research, Innovation and System Information

Maintenance Practices for Bridge Drains and Expansion Joints: Survey of Practice

Requested by
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Table of Contents

Executive Summary

Background

Removing accumulated debris from slotted drains, drainage inlets and expansion joints on bridges is a challenging task for field maintenance crews. Bridges are subject to maintenance constraints that can lead to safety and environmental concerns. Standard sweepers, for example, cannot be used on some bridges because of geometric limitations of the structures. Clogged drains and noncompressible debris in expansion joints can lead to bridge damage and flooding. Barriers at bridge edges can limit the movement of debris off the roadway, allowing trash to accumulate in state rights of way or to enter waterways. Improved debris removal methods for these bridge elements are needed for efficient, effective and safe bridge maintenance operations.

California Department of Transportation (Caltrans) is seeking best practices from other state departments of transportation (DOTs) to maintain these bridge elements. The agency is also interested in investigating available technology and commercial equipment, including estimated costs, recommendations for pilot testing or other procurement and evaluation of available options, or the design and development of a prototype system if a commercial system is not available. The agency will use this information to improve debris removal methods for these bridge elements.

To assist Caltrans in this information-gathering effort, CTC & Associates conducted an online survey of state DOTs that examined these agencies' maintenance practices for bridge drains and expansion joints. A literature search identified publicly available sources of best practices and related research.

Summary of Findings

Survey of Practice

An online survey was distributed to state DOT members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Maintenance about their agencies' maintenance practices for bridge drains and expansion joints. Representatives from 16 state DOTs and two local agencies responded to the survey. Thirteen respondents from these agencies, including the two local agencies, do not use any specialized technology or equipment to clean and maintain bridge drains and expansion joints. Five agencies use commercially available products, and one agency uses tools developed in-house.

Agencies Not Using Specialized Technology or Equipment

Eleven state transportation agencies (Idaho, Indiana, Kentucky, Maine, Michigan, Mississippi, New Hampshire, North Dakota, Ohio District 10, Tennessee and West Virginia) and two local agencies (Los Angeles County Public Works and the City of San Diego Public Works) responding to the survey do not use specialized technology or equipment to clean and maintain bridge drains and expansion joints:

- Pressure washing is used by eight agencies (Idaho, Indiana, Kentucky, Maine, Michigan, New Hampshire, West Virginia and San Diego Public Works).
- Sweeping and shoveling are practiced by three state DOTs (Indiana, Maine and Ohio).

- Expansion joint and bridge drain maintenance is contracted out to other divisions in Mississippi.
- Bridge drains and joints are cleaned as needed in Tennessee.

The respondents from three of these states—Idaho, Kentucky and West Virginia—and from San Diego Public Works reported that their agencies would be interested in using a specialized system or tool to clean and maintain bridge drains and expansion joints.

Agencies Using Commercial Equipment

Agencies in five states—Florida, Kansas, Minnesota, Ohio District 1 and Washington—use commercially available products to clean and maintain bridge drains and expansion joints. Although Kansas DOT and Ohio DOT District 1 did not provide information about the commercial equipment used by their agencies, the Kansas DOT respondent reported that the agency uses culvert cleaners and flush trucks (2,000- to 5,000-gallon water tankers with a pump and fire hose).

Three states—Florida, Minnesota and Washington—provided information about the commercial equipment used by their agencies. Details about this equipment and agency practices are summarized below.

Equipment Description

The commercial equipment described by the respondents included commercial products and hand and power tools. Florida DOT uses a Vac-Con truck with a vacuum and high-pressure water to remove silt and debris and to flush pipes. Florida and Minnesota DOTs use Vactor trucks and trailers for cleaning and flushing. Washington State DOT uses compressed air and low-pressure, high-volume water to remove dirt and debris from joints and drains. The respondent added that this technique is also used to remove winter road treatments from bridge decks and steel structures as part of the agency's bridge preservation program.

Equipment cost ranged from $100,000 (Minnesota) to $450,000 (Florida). The Florida DOT respondent added that the agency rents a Vactor RamJet trailer for $1,090 per week. Costs in Washington are approximately $25,000, which does not include the cost of the tanker and other vehicles.

Equipment Use

Agencies that have been using commercial equipment for a significant length of time:

- Florida: 20 to 30 years.
- Minnesota: More than 30 years.
- Washington: More than 10 years.

While none of these agencies conducted a formal pilot test of the equipment, the respondent from Minnesota DOT noted that field crews typically test a piece of equipment in one district and report their findings to other crews in the state through the agency's bridge maintenance supervisors. Additionally, some new equipment is tested through a research funding program.

Crew members in Florida and Minnesota require a moderate level of instruction before using this equipment. The equipment in Washington is easy to use and requires little instruction before use.

The frequency that equipment is used to perform bridge cleaning and/or maintenance varied among the three agencies. Florida DOT uses the Vac-Con equipment daily and Vactor trucks as needed, Minnesota DOT uses its equipment annually for bridge cleaning and maintenance, and Washington State DOT uses its equipment as needed.

Similarly, the level of maintenance required to keep the equipment in operating condition also varied. Equipment in Florida and Washington requires regular maintenance. In Minnesota, the manufacturer requires an equipment inspection and greasing every 1,000 miles; pumps and hoses are flushed annually.

Agencies in Florida and Washington can use the equipment effectively during all seasons of the year. In Minnesota, however, the equipment cannot be used in winter when temperatures are below freezing.

Equipment Assessment

The respondent from Florida DOT noted that equipment is "vital to our everyday maintenance to keep dirt and debris out of joints and drainage." In Minnesota and Washington, the equipment is key to efficient, effective maintenance operations. The challenges reported by these respondents were high initial costs and maintenance costs (Florida), traffic control and accessibility (Minnesota), and worker safety (Washington).

All of these respondents expressed interest in investigating other systems or tools to clean and maintain bridge drains and expansion joints, noting that they are always open to best practices and technologies to make operations more effective and efficient.

Agencies Using Tools Developed In-House

The Pennsylvania DOT respondent reported using water trash pumps with wand attachments and water trucks with wand attachments developed in-house to clean and maintain bridge drains and expansion joints. The agency also uses pipe flushing equipment and attachments in these maintenance operations. The equipment is easy to use and requires little instruction to field crews before use. Bridge cleaning and flushing are required annually; additional maintenance is performed as needed.

The equipment requires moderate, periodic maintenance and cannot be used in winter when temperatures are below freezing. The respondent noted that the agency is interested in piloting any cleaning equipment that would improve maintenance operations.

Related Research and Resources

A literature search of state and national resources was conducted to gather information about maintenance practices for bridge drains and expansion joints. A 2015 Federal Highway Administration publication includes a discussion of preventive and basic maintenance of finger joints and drainage systems, including cleaning practices. Other national resources address the importance of cleaning and maintenance as part of an agency's bridge preservation program.

Research from 10 state DOTs provides guidance on bridge cleaning and debris removal practices. Of particular relevance to this Preliminary Investigation are several Ohio DOT

publications, including the results of a 2019 study of storm sewer cleaning operations, the results from a 2015 survey of state DOT finger joint bridge maintenance practices and the results of a 2014 survey of state DOT finger joint bridge cleaning practices. A 2006 Utah DOT summary of a domestic scan investigates state practices related to concrete bridge deck management.

Gaps in Findings

The majority of agencies responding to the survey did not use commercial equipment to clean and maintain bridge drains and expansion joints. Reaching out to agencies not participating in the survey, particularly agencies representing high-density areas with conditions similar to those found in California, could provide useful information about other maintenance equipment and practices.

Next Steps

Moving forward, Caltrans could consider:

- Reviewing product information and best practices documentation from Florida, Minnesota, Pennsylvania and Washington State DOTs, which use either commercial equipment or tools developed in-house for bridge maintenance operations.
- Contacting Kansas DOT and Ohio DOT District 1, which both use commercially available products, for additional information about the equipment and maintenance practices used by these agencies.
- Reviewing research reports cited in **Related Research and Resources**, particularly three Ohio DOT resources:
    - A 2016 evaluation of bridge trough maintenance for finger joint bridges.
    - A 2015 Ohio DOT survey of state agencies related to finger joint maintenance and drainage trough cleaning.
    - A 2014 national survey about finger joint bridge maintenance practices.

Detailed Findings

Background

In bridge maintenance operations, removing accumulated debris from slotted drains, drainage inlets and expansion joints on bridges is a challenging task. Bridges are subject to maintenance constraints not shared on mainline highways that can lead to safety and environmental concerns. For example, the tight geometric limitations of some bridges can preclude the use of standard sweepers. Clogged drains and noncompressible debris in expansion joints can lead to bridge damage and flooding. Barriers at bridge edges can limit the movement of debris off the roadway, allowing trash to accumulate in state rights of way or to enter waterways. Improved debris removal methods for these bridge elements are needed for efficient, effective and safe bridge maintenance operations.

California Department of Transportation (Caltrans) is seeking information about best practices used by other state departments of transportation (DOTs) to maintain these bridge elements. The agency is also interested in investigating available technology and commercial equipment, including estimated costs, recommendations for pilot testing or other procurement and evaluation of available options, or the design and development of a prototype system if a commercial system is not available. The agency will use this information to inform efforts to improve debris removal methods for these bridge elements.

To assist Caltrans in this information-gathering effort, CTC & Associates summarized the results of an online survey of state DOTs that examined these agencies' maintenance practices for bridge drains and expansion joints. A literature search was also conducted to identify publicly available sources of best practices. Findings from these efforts are presented in this Preliminary Investigation in two areas:

- Survey of practice.
- Related research and resources.

Survey of Practice

An online survey was distributed to state DOT members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Maintenance. The survey was also distributed to the following local agencies:

- Golden Gate Bridge, Highway and Transportation District.
- Los Angeles City Bureau of Street Services.
- Los Angeles County Public Works.
- City of San Diego Public Works.
- San Francisco Public Works.

Survey questions are provided in Appendix A. The full text of survey responses is presented in a supplement to this report.

Summary of Survey Results

Eighteen agencies responded to the survey, including 16 state transportation agencies:

- Florida.
- Idaho.
- Indiana.
- Kansas.
- Kentucky.
- Maine.
- Michigan.
- Minnesota.
- Mississippi.
- New Hampshire.
- North Dakota.
- Ohio (Districts 1 and 10).
- Pennsylvania.
- Tennessee.
- Washington.
- West Virginia.

The public works departments from two local agencies also responded to the survey:

- Los Angeles County.
- City of San Diego.

Survey results are summarized below in the following topic areas:

- Agencies not using specialized technology or equipment.
- Agencies using commercial equipment.
- Agencies using tools developed in-house.
- Recommendations for implementation.
- Best management practices for environmental challenges.

Agencies Not Using Specialized Technology or Equipment

Thirteen of the 18 agencies responding to the survey, including the two local agencies, do not use any specialized technology or equipment to clean and maintain bridge drains and expansion joints:

- Idaho.
- Indiana.
- Kentucky.
- Los Angeles County Public Works.
- Maine.
- Michigan.
- Mississippi.
- New Hampshire.
- North Dakota.
- Ohio District 10.
- San Diego Public Works.
- Tennessee.
- West Virginia.

Cleaning and Maintenance Practices

Respondents from 11 of these agencies provided information about their organizations' maintenance methods and frequency.

Pressure washing is used by eight agencies (Idaho, Indiana, Kentucky, Maine, Michigan, New Hampshire, West Virginia and San Diego Public Works) to clean and maintain bridge drains and expansion joints. The New Hampshire DOT respondent reported that the state has very few closed drainage systems on bridges, and the agency typically uses a tanker truck with large

amounts of water under pressure to flush drains. Seal-type joints are flushed with a pressure hose; trough-type joints are flushed with a bent nozzle that can be inserted between the gaps in the finger plates so that material can be pushed horizontally to a downspout.

The respondent from Kentucky Transportation Cabinet noted that after bridge drains are power-washed, in-house crews reseal expansion joints with EMSEAL (see *Related Resource* following Table 1). Idaho Transportation Department performs very little bridge maintenance, but when it does, it uses pressure washers and vacuum trucks. Michigan DOT uses high-pressure power washers, vacuum trucks and water jetters. San Diego Public Works uses a snake with plumber's tool and high-pressure water jetting.

Sweeping and shoveling are practiced by three agencies (Indiana, Maine and Ohio DOTs). Indiana DOT cleans annually with shovels, brooms, compressed air and other tools, and then flushes with low-pressure, high-volume or high-pressure, low-volume water. Ohio DOT District 10 uses truck-mounted rotary brooms, air compressors and/or hand tools to clean expansion joints and bridge drains annually. During high-flow periods in Maine, the agency removes sand and debris from the bridge by sweeping or shoveling, and then pressure-washes the deck and bridge seats. (*Note*: High-flow periods in rivers and streams are typically the result of seasonal or weather-related factors.)

In Mississippi, most of the expansion joint and bridge drain maintenance is conducted through contracts that are let to construction each year as part of the agency's bridge preventive maintenance program. The respondent from Tennessee DOT noted that no routine maintenance is scheduled for joints or bridge drains. Instead, drains are cleared as needed, and joints are repaired if damaged.

Survey responses are summarized in Table 1.

Table 1. Cleaning and Maintenance Practices of Agencies Not Using Specialized Equipment or Technology

Agency	Pressure Washing	Vacuum Trucks	Sweeping/ Shoveling	Other	Description
Idaho	X	X			Very little bridge maintenance performed.
Indiana	X		X		• Annually cleans with shovels, brooms and compressed air. • Then flushes with water using low-pressure, high-volume or high-pressure, low-volume water.
Kentucky	X				Reseals expansion joints with EMSEAL.
Maine	X		X		During high flows, sweeps or shovels deck and bridge seats, followed by pressure washing.
Michigan	X	X			Cleans with high-pressure power washer, vacuum trucks and water jetters.
Mississippi				X	Contracts with construction annually as part of bridge preventive maintenance program.

Agency	Pressure Washing	Vacuum Trucks	Sweeping/ Shoveling	Other	Description
New Hampshire	X				• Flushes seal-type joints with pressure hose. • Flushes trough-type joints with bent nozzle inserted between gaps in finger plates.
Ohio District 10			X		Annually cleans with truck-mounted rotary brooms, air compressors and/or hand tools.
San Diego	X			X	Uses a snake with plumber's tool and high-pressure water jetting.
Tennessee				X	Cleans drains and repairs joints as needed.
West Virginia	X				Uses a water truck with a power washer.
Total	**8**	**2**	**3**	**3**	

Related Resource

EMSEAL Bridge Expansion Joints and Sealants, EMSEAL Joint Systems Ltd., undated. https://www.emseal.com/
From the web site: BEJS [Bridge Expansion Joint System] is a traffic-durable bridge and roadway expansion joint which provides a primary watertight seal. It is designed to handle harsh environmental conditions and features greater movement capability, better low temperature flexibility and higher temperature stability than other technologies. Non-invasive anchoring provides for quick turnaround and repairs. The BEJS System helps prevent and/or decrease maintenance costs to bridge bearing pads and support structures. Primarily designed for DOT/[i]nfrastructure markets, it is ideal for new construction and retrofit of old or failed bridge expansion joint systems in: [c]oncrete-to-concrete substrates, rebuilt joint faces, where demolition and removal of existing embedded metal angles [are] not feasible or affordable [and] as a lasting replacement for all failed liquid-sealant joints in parapets, sidewalks, jersey-barriers, etc.

Interest in Using a Specialized System or Tool for Maintenance

Respondents from four agencies expressed interest in using a specialized system or tool to clean and maintain bridge drains and expansion joints: Idaho Transportation Department, Kentucky Transportation Cabinet, West Virginia DOT and San Diego Public Works. The respondent from West Virginia DOT reported that the agency is investigating starting a bridge washing, drainage and expansion joint crew statewide. The respondents from Idaho and Kentucky transportation agencies are interested in learning new, efficient methods.

Agencies Using Commercial Equipment

Agencies from five states responding to the survey use commercially available products to clean and maintain bridge drains and expansion joints:

- Florida.
- Kansas.
- Minnesota.
- Ohio District 1.
- Washington.

Two of these agencies (Kansas DOT and Ohio DOT District 1) did not provide information about the commercial equipment used by their agencies. The Kansas DOT respondent reported that

the agency uses culvert cleaners and flush trucks to clean drains and expansion joints, adding that the flush trucks are 2,000- to 5,000-gallon water tankers with a pump and fire hose.

Three states—Florida, Minnesota and Washington—provided information about the commercial equipment used by their agencies. Respondents addressed the following topic areas:

- Product name, vendor (when provided) and operation of the equipment.
- Initial cost of the equipment.
- Date organization began using the equipment.
- Pilot testing.
- Ease of use for crew members.
- Frequency equipment used to clean or maintain bridges.
- Level of maintenance that the equipment requires.
- Ability to use the equipment throughout the year.
- Benefits of using the equipment.
- Challenges with using the equipment.

Highlights from these topic areas are provided below followed by case studies that summarize survey responses from each of the three state agencies.

Equipment Description

These agencies use commercial products and miscellaneous hand and power tools to remove silt and debris and to flush pipes: Florida DOT uses a Vac-Con truck with a vacuum and high-pressure water; Florida and Minnesota DOTs use Vactor trucks and trailers; the respondent from Washington State DOT did not provide product names but reported that the agency uses compressed air and low-pressure, high-volume water. This technique is also used to remove winter road treatments from bridge decks and steel structures as part of the Washington State DOT's bridge preservation program.

Equipment costs ranged from $100,000 (Minnesota) to $450,000 (Florida). The Florida DOT respondent added that the agency rents a Vactor RamJet trailer for $1,090 per week. Costs in Washington are approximately $25,000, which does not include the cost of the tanker and other vehicles.

Equipment Use

Length of equipment use ranged from more than 10 years (Washington), to 20 to 30 years (Florida) and more than 30 years (Minnesota). None of these agencies conducted a formal pilot test before implementing the equipment. The respondent from Minnesota DOT noted that field crews typically test a piece of equipment in one district and report their findings to other crews in the state through the agency's bridge maintenance supervisors. Additionally, some new equipment is tested through a research funding program.

A moderate level of instruction to field crews is required by Florida and Minnesota DOTs before using equipment. In Washington, the equipment is easy to use, and crew members require little instruction before use.

The frequency that equipment is used to clean and/or maintain bridges varied among the three agencies. Florida DOT uses Vac-Con daily and Vactor as needed, Minnesota DOT uses its

equipment annually for bridge cleaning and maintenance, and Washington State DOT uses its equipment as needed.

Similarly, the level of maintenance required to keep the equipment in operating condition also varied. In Florida and Washington, the equipment requires regular maintenance. (*Note*: The Vactor RamJet trailer is maintained by the rental company.) In Minnesota, the manufacturer requires an inspection and greasing every 1,000 miles; pumps and hoses are flushed annually.

Florida and Washington State DOTs reported that their agencies can use the equipment effectively during all seasons of the year. In Minnesota, however, the equipment cannot be used in winter when temperatures are below freezing.

Equipment Assessment

The respondent from Florida DOT reported that the equipment is "vital to our everyday maintenance to keep dirt and debris out of joints and drainage." The Minnesota DOT and Washington State DOT respondents also noted the benefits of this equipment in efficient and effective maintenance operations.

The challenges reported by the respondents were high initial costs and maintenance costs (Florida), traffic control and accessibility (Minnesota), and worker safety (Washington). The respondent from Washington State DOT emphasized the importance of wearing personal protective equipment (PPE) when using compressed air because of the airborne debris and other harmful particles.

Interest in Other Systems or Tools

All of these respondents expressed interest in investigating other systems or tools to clean and maintain bridge drains and expansion joints, noting that they are always open to best practices and new technologies to enhance maintenance operations and make these operations more effective and efficient.

Case Studies

Below are case studies summarizing the survey responses from each of the three DOTs: Florida (Table 2), Minnesota (Table 3) and Washington (Table 4). Following each case study are publications and other resources received from the respondents about their agencies' equipment and practices (when provided).

Florida Department of Transportation

Table 2. Commercial Equipment Use: Florida Department of Transportation

Topic	Description
Product(s)/Vendor	• *Vac-Con* (vacuum and high-pressure water): Truck-mounted vacuum with water tank. Crew uses vacuum to remove silt and debris, and uses high-pressure water line with head attachment to flush pipes. • *Vactor RamJet trailer*: High-pressure water jetter inserted in the line. High water pressure feeds the head of the jetter through the line and breaks up any blockages.

Topic	Description
Initial Cost	• *Vac-Con*: $450,000. • *Vactor RamJet trailer*: $1,090/week (rented).
Start Date	• *Vac-Con*: 20 to 30 years. • *Vactor RamJet trailer*: May 2019.
Pilot Testing	No
Ease of Use	Moderate level of instruction required.
Bridge Maintenance Frequency	• *Vac-Con*: Daily. • *Vactor*: As needed.
Equipment Maintenance	• *Vac-Con*: Regular maintenance. • *Vactor*: Maintained by rental company.
Year-Round Use	Yes
Benefits	Reduces occurrence of roadway flooding and shoulder washouts.
Challenges	• Initial cost. • High cost of maintenance.

Related Resources

Vac-Con, Vac-Con, undated.
https://vac-con.com/
From the web site: [Vac-Con] vacuum trucks and loaders are used by various companies in the construction, oil and gas, mining, safety, and environmental industry. These machines are equipped to handle the toughest jobs in the harshest conditions. They are suitable for several industrial and construction operations ranging from hydro excavation to daylighting, exposing in-ground utilities, soil trenching, sewer jetting, and debris removal. Also, our industrial vacuum trucks and loaders can also be used for task such as cold weather digging, piling hole excavation, and several other oilfield operations. They are highly reliable and get the job done quickly, safely, and efficiently. In fact, a lot of municipalities, operators, and contractors use these trucks to execute various tasks and save operating cost.

Vactor RamJet Jetter Trailer, Vactor Manufacturing, February 2019.
https://www.myepg.com/wp-content/uploads/2019/02/Rental-Equipment-Flyer_Trailer-Jetter.pdf
This one-page fact sheet briefly summarizes the features of the Vactor RamJet Jetter Trailer.

Minnesota Department of Transportation

Table 3. Commercial Equipment Use: Minnesota Department of Transportation

Topic	Description

Product(s)/Vendor	• *Cleaning*:
	  ○ Polar flushing water tanker.
	  ○ Vactor truck.
	  ○ Fire hose nozzle.
	• *Joint maintenance*: Gland repair products, sandblasters, hand tools fabricated by crews, power tools.

Topic	Description
Initial Cost	• *Polar flushing tanker*: Approximately $100,000. • *Vactor truck*: Approximately $260,000. • *Fire hose nozzle*: Approximately $120.
Start Date	30+ years
Pilot Testing	Yes
Ease of Use	Moderate level of instruction required.
Bridge Maintenance Frequency	Annually.
Equipment Maintenance	• *Equipment*: Inspected and greased every 1,000 miles. • *Pumps, hoses*: Flushed annually.
Year-Round Use	Not in winter (temperatures below freezing).
Benefits	• Allows for more efficient and effective maintenance. • Allows joints and drains to function properly.
Challenges	Traffic control and accessibility.

Related Resources

Polar Tank Trailer, Polar Tank Trailer, undated.
http://polartank.com/
From the web site:

> [Polar Tank Trailer is] a premier manufacturer of tank trailers known for our premium products, simplicity of design, customization and mission-specific engineering. [Tank trailers are used to haul] chemical, food [liquid], petro and bulk transport.

This web site includes brief descriptions of Polar Tank Trailer products. Case studies and video testimonials focus on tank trailer uses for liquid asphalt (hauling to highway paving projects), food grade liquid, petroleum and chemicals.

Chapter 4, Field Guide—Deck, Bridge Maintenance Manual, Minnesota Department of Transportation, July 2019.
http://dotapp7.dot.state.mn.us/eDIGS_guest/DMResultSet/download?docId=2955538
Section 4.1 (beginning on page 4 of the PDF) presents deck preventive maintenance guidance and activities. The discussion addresses criteria and frequency, equipment and materials, and procedures and best practices required for flushing. The step-by-step procedures include detailed guidance for flushing bridge decks, expansion joints and drain structures along with photos illustrating maintenance practices and links to additional resources.

Related Resource:

> **Chapter 5, Field Guide—Joints**, Bridge Maintenance Manual, Minnesota Department of Transportation, July 2019.
> http://dotapp7.dot.state.mn.us/eDIGS_guest/DMResultSet/download?docId=2955555
> Chapter 5 of the Bridge Maintenance Manual describes repair and replacement preventive maintenance associated with joints.

Bridge Flushing—Equipment and Procedures, Minnesota Department of Transportation, 2018.
http://www.dot.state.mn.us/bridge/training.html (Under E-Learning, select "Bridge flushing.")
This on-demand webinar provides an overview of bridge flushing, the importance of bridge flushing, equipment and safety needs, and site preparation and flushing procedures.

Washington State Department of Transportation

Table 4. Commercial Equipment Use: Washington State Department of Transportation

Topic	Description
Product(s)/Vendor	• *Vacuum truck* (used primarily on drains). • *Compressed air* (to blow dirt and debris from joints and drains): Air wand (48-inch), air hose, hand tools, buckets (to remove debris off deck), tow-behind compressor (approximately 80 psi). • *Flushing*: Low-pressure, high-volume water (to remove dirt and debris from joints and drains, and to remove winter road treatments from deck and steel structures). • Water tanker (tanker size varies by project), pump, 1-1/2-inch nylon hose (expect abrasion from deck), nozzles. • *PPE*: Not listed but used with each task.
Initial Cost	Approximately $25,000 (excluding tanker and vehicles).
Start Date	2008
Pilot Testing	No
Ease of Use	Easy to use with little instruction required before use.
Bridge Maintenance Frequency	As needed.
Equipment Maintenance	• *Air compressor, gas engine pumps*: Scheduled maintenance. • *Hoses, fittings*: Inspected before use.
Year-Round Use	Yes
Benefits	• Enables agency to avoid costly corrective maintenance. • Keeps inventory clean and functioning properly.
Challenges	Worker safety: Using compressed air produces airborne debris and harmful particles.

Agencies Using Tools Developed In-House

One agency responding to the survey—Pennsylvania DOT—reported using tools developed in-house to clean and maintain bridge drains and expansion joints. The respondent noted that the agency is interested in piloting any cleaning equipment that would improve maintenance operations.

Survey results are summarized in Table 5.

Table 5. In-House Tool Use: Pennsylvania Department of Transportation

Topic	Description
Tool Description	• Water trash pumps with wand attachments. • Water trucks with wand attachments. • Pipe flushing equipment and attachments.
Initial Cost	Unknown
Start Date	N/A
Pilot Testing	No
Ease of Use	Easy to use with little instruction required before use.
Bridge Maintenance Frequency	• Annually: Required bridge cleaning and flushing. • As needed for unforeseen maintenance needs.
Equipment Maintenance	Moderate maintenance with periodic maintenance cycles to keep equipment in working order.
Year-Round Use	Not in winter (temperatures below freezing).
Benefits	• Simple to use. • Fairly easy to repair and maintain.
Challenges	N/A

Related Resources

Chapter 16, Bridge Maintenance, Maintenance Manual, Bureau of Maintenance and Operations, Pennsylvania Department of Transportation, July 2019.
http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%2023/PUB%2023.pdf (Under the Bookmarks tab, select Table of Contents.)
From the introduction:

> The goal of this chapter is to identify elements or areas of structures that can substantially benefit from preventive maintenance, and to provide policy and guidelines to accomplish this very important activity.

Preventive maintenance, including cleaning and flushing practices, is discussed in Section 16.5, beginning on page 6 of the PDF. Debris removal is addressed in Section 16.6, beginning on page 9 of the PDF, including best practices for maintaining finger joints and drain troughs:

> Drain troughs should be cleaned frequently to prevent clogging, and if extreme difficulty is experienced in cleaning, modifications should be made to the system to facilitate cleaning and flushing. The cleaning of the trough should be completed when the deck cleaning and flushing is completed. If the deck is kept clean, a minimum amount of debris will enter the drainage system and will reduce the need for frequent cleaning.

Operation and maintenance of bridge drainage systems is discussed beginning on page 12 of the PDF.

Bridge Maintenance Manual, Pennsylvania Department of Transportation, July 2019.
http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%2055.pdf
Cleaning practices for finger joints, expansion joints, bridge drains, troughs and other bridge elements are discussed in Chapter 11 (beginning on page 84 of the PDF). Also discussed are repair practices for expansion joints (Chapter 13, beginning on page 104 of the PDF) and drains (Chapter 18, beginning on page 201 of the PDF).

Equipment Maintenance and Management Policies Manual, Fleet Management Division, Pennsylvania Department of Transportation, August 2019.
http://www.dot.state.pa.us/public/PubsForms/Publications/Pub%20177.pdf
Policies related to the agency's fleet and equipment management systems are presented in this manual, including equipment inventory and utilization, preventive maintenance programs and training for equipment operators and mechanics.

Recommendations for Implementation

All respondents were asked to provide recommendations for other organizations seeking to implement new tools or equipment to clean and maintain bridge drains and expansion joints. Recommendations ranged from choosing appropriate equipment for conditions and providing adequate staff training to performing maintenance on a routine schedule. Survey results from respondents providing information are summarized in Table 6.

Table 6. Recommendations for Equipment Implementation

Practice	Agency	Description
Adequate Training for Maintenance Crews	Idaho, San Diego	*Idaho*: • Ensure that the maintenance crews can recognize expansion joints on bridge structures. • Ensure that the maintenance crews understand the benefits of performing these activities.
Appropriate Equipment	Florida, Pennsylvania, Tennessee, Washington	*Florida:* Choose equipment that is custom to the need (e.g., in Florida, sand is the main contaminant). *Pennsylvania*: • Keep equipment simple to use and simple to transport to the field. • Look for safety enhancements with equipment usage. *Tennessee*: Test any new tools or practices before committing time and money. *Washington*: • Keep equipment and practices simple. • Avoid expensive, single-application equipment.
Partnering With Other Divisions and Agencies	Minnesota	• Work with the agency's environmental unit. • Look for research and follow up with agencies that are performing similar activities. • Share information internally among districts and regions.

Practice	Agency	Description
Planning for Maintenance During Design Stage	New Hampshire	• Leave openings in the finger plates to allow insertion of nozzles. • Where possible, use seal-type joints. (New Hampshire uses a modified finger joint with a seal when the skew angle of the joint could cause problems with snowplow blades.)
Regular Maintenance	Florida, Minnesota, Pennsylvania, San Diego	*Florida*: Place known drainage problem areas on a preventive maintenance schedule. *Minnesota:* Perform a regularly scheduled cycle of joint maintenance. *Pennsylvania*: • Develop and maintain cycles for bridge cleaning and flushing activities. • Monitor completion of cycle cleaning activities.

Best Management Practices for Environmental Challenges

In addition to recommendations for equipment implementation, all respondents were asked to describe any best management practices (BMPs) that their organizations use to address environmental challenges associated with maintaining bridge drains and expansion joints, such as pollutant flow into the receiving waters. Responses included practices related to permits, agreements and guidance from environmental agencies; precleaning and pretreatment practices; and timing. Survey results from respondents providing information are summarized in Table 7.

Table 7. Best Management Practices for Environmental Challenges

Practice	State	Description
Environmental Agency Permits, Agreements and Guidance	Indiana, Maine, Minnesota, Pennsylvania, Tennessee, Washington, West Virginia	*Indiana*: A memorandum of understanding with state environmental agencies allows DOT to perform minimally invasive maintenance procedures. *Maine*: A memo with the state department of environmental protection allows agency to perform maintenance. *Minnesota*: Additional BMPs required near state waters. *Pennsylvania*: Erosion and sediment control. (See BMPs in Related Resources below.) *Tennessee*: Collaboration with environmental offices to determine acceptable methods for any activities that may release pollutants into streams or sensitive areas. *Washington*: Permit limits followed by agency. *West Virginia*: Permit from state department of environmental protection.
Precleaning Practices	Michigan, Minnesota, New Hampshire	*Michigan*: Vacuuming or extracting solids before washing. *Minnesota:* • Sweeping two weeks before flushing. • Street sweepings managed appropriately.

Practice	State	Description
Precleaning Practices	Michigan, Minnesota, New Hampshire	*New Hampshire*: Loose sediment and debris removed from bridge decks before flushing any joint or drain.
Pretreatment Practices	Florida	*Florida:* • Material vacuumed from drainage system must be treated before disposal. • Water not normally used, which eliminates the runoff concern.
Timing	Maine, New Hampshire	*Maine*: Bridge cleaning occurs during high-flow periods. *New Hampshire*: Flushing typically not performed during very low-flow periods. (*Note*: The flow of a stream during a prolonged period of dry weather is known as a low-flow period.)
Other	Idaho, Michigan, Minnesota	*Idaho*: No environmental challenges when pollutants are contained. *Michigan*: State Adopt-A-Highway roadside trash collection keeps waste in bridge drains to a minimum. *Minnesota*: • Municipal water source with no additives used. • In certain areas, filters used around drains.

Related Resources

Minnesota

Maintenance Bridge Flushing Guidance, Environmental Investigation Unit, Office of Environmental Stewardship, Minnesota Department of Transportation, March 2018.
http://www.dot.state.mn.us/environment/regulatedmaterials/pdf/bridgeflushingguidance2.pdf
From the guidance:

> This guidance is for routine maintenance of bridge decks using no greater than 120 psi for flushing operations. It is not intended for power washing of new bridges or any pressurized water-based blasting using over 120 psi.
>
> ….
>
> MnDOT bridge flushing maintenance operations produce material that is primarily sand and other assorted debris that will need to be collected. The following guidance allows for beneficial reuse of the sand and proper management of associated debris. Under this guidance bridges will be flushed with a 1.5 inch fire hose that produces 90 to 120 psi using water without any additives such as soap or other chemical cleaning agents. If additives are needed, contact the Environmental Investigation Unit in the MnDOT Office of Environmental Stewardship for additional requirements. Flush water does not need to be collected for disposal if additives are not used.

Additional guidance addresses preflushing activities, sediment collection and the flush water source.

Street Sweepings, Environmental Investigation Unit, Office of Environmental Stewardship, Minnesota Department of Transportation, May 2017.
http://www.dot.state.mn.us/environment/regulatedmaterials/pdf/street-sweepings.pdf
This two-page document addresses street sweeping operations and practices, including material disposal.

Pennsylvania

Maintenance Field Reference for Erosion and Sedimentation Controls, Bureau of Maintenance and Operations, Pennsylvania Department of Transportation, August 2013.
http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%20464.pdf
This manual is a "field-ready source of information commonly needed by roadway maintenance personnel for the installation, inspection, and maintenance" of erosion and sediment control BMPs. Each practice includes application, methods and procedures, schematics, and ways to ensure the practice is followed.

Four BMPs address bridge cleaning:

- **Storm inlet procedures** (page 50 of the manual, page 61 of the PDF): To filter sediment out of the runoff before the water enters the storm sewer system.
- **Vegetative filter strip** (page 56 of the manual, page 67 of the PDF): To remove sediment from runoff before it reaches state water.
- **Rock construction entrance** (page 85 of the manual, page 96 of the PDF): Installed wherever construction traffic will exit the project site onto any roadway, public or private. Access to the site should be limited to stabilized construction entrances.
- **Concrete washout** (page 97 of the manual, page 108 of the PDF): Used for cleaning chutes, mixers and hoppers of a delivery vehicle unless such a facility will be used at the source of the concrete.

Related Research and Resources

A literature search of recent publicly available resources identified publications that are organized into two topic areas:

- National research and guidance.
- State research and guidance.

National Research and Guidance

Bridge Preservation Guide: Maintaining a Resilient Infrastructure to Preserve Mobility, Federal Highway Administration, Spring 2018.
https://www.fhwa.dot.gov/bridge/preservation/guide/guide.pdf
In this guide, debris removal is addressed as part of a successful bridge preservation program.
From the introduction:

> This guide defines bridge preservation terms and identifies commonly practiced bridge preservation activities. It also provides guidance to State governments and other bridge-owning agencies on establishing or improving existing bridge preservation programs as part of an asset management program.

Chapter 8, Deck Expansion Joints, Bridge Maintenance Reference Manual, Bridge Maintenance Course Series, Federal Highway Administration, May 2015.
Chapter 8 is available at https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/maintenance/str/bi/reference-manual/chapter-8-deck-expansion-joints.pdf?sfvrsn=b04ab3dd_0.
The complete manual is available at https://www.fdot.gov/maintenance/bmrm.shtm.
Chapter 8 of this manual addresses preventive and basic maintenance of finger joints and drainage systems, including cleaning practices, which begin on page 21 of the PDF.

NCHRP Report 778: Bridge Stormwater Runoff Analysis and Treatment Options, Scott Taylor, Michael Barrett, George Ward, Marc Leisenring, Marie Venner and Roger Kilgore, 2014.
https://www.nap.edu/catalog/22395/bridge-stormwater-runoff-analysis-and-treatment-options
From the foreword:

> This report presents information and an analysis process for identifying strategies for management of stormwater runoff from highway bridges. Departments of transportation (DOTs) and other public agencies responsible for managing stormwater runoff to reduce pollution loads in receiving waters may use this information and process to assist their selection of a cost-effective strategy for a particular bridge.

Chapter 4.4 of the report (page 24 of the report, page 34 of the PDF) addresses bridge maintenance BMPs, including a discussion of bridge washing and sweeping practices.

"Design, Installation, and Maintenance of Concrete Bridge Deck Joints: State of the Practice," W. Spencer Guthrie, Lik Hang Yuen and Loren A. Ross, *TRB 88th Annual Meeting Compendium of Papers DVD*, Paper No. 09-2947, 2009.
Citation at
https://trid.trb.org/Results?txtKeywords=Design%2C+Installation%2C+and+Maintenance+of+Concrete+Bridge+Deck+Joints%3A+State+of+the+Practice%2C%E2%80%9D+#/View/882011
From the abstract: The purpose of this research was to investigate the performance characteristics of joints available for use on concrete bridge decks, including design, installation,

and maintenance issues. A literature review and a nationwide questionnaire survey of 20 state departments of transportations were performed. …Troughs should be placed with a slope of at least 8 percent to prevent debris accumulation and should be cleaned at least once a year.

State Research and Guidance

The citations below provide information about bridge cleaning and debris removal practices as a necessary component of a bridge maintenance or preservation program. Information is provided from 10 states: Illinois, Indiana, Iowa, Kentucky, Massachusetts, Missouri, Ohio, Pennsylvania, Utah and Washington.

Illinois

Chapter 3.6, Expansion Devices, Bridge Manual, Bureau of Bridges and Structures, Division of Highways, Illinois Department of Transportation, 2012.
http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Bridges/Bridge%20Manual%202012.pdf
This chapter includes a detail of drainage troughs used in the state (page 499 of the PDF). These troughs feature a fabric-reinforced elastomeric flap that directs water and debris into the trough but can be pushed up to allow maintenance crews to manually remove debris or use pressure washers or vacuum trucks to remove debris. (See the results of a May 2014 Ohio DOT survey about cleaning finger joint bridges, page 26, for more information about Illinois DOT's use of this drainage trough design.)

Indiana

Bridge Preservation Treatments and Best Practices, Final Report, Mark Bowman and Luis Moran, Indiana Department of Transportation, October 2015.
https://rosap.ntl.bts.gov/view/dot/37609
From the abstract:

> The objective of this research was to review bridge maintenance activities recommended by specialized literature, to examine maintenance activities currently conducted by the various INDOT [Indiana DOT] districts, and also to review maintenance activities performed by several other DOT agencies. Based on the results of this review, a list of ten new and enhanced bridge preventive maintenance activities was identified to improve the effectiveness of bridge maintenance operations in Indiana. The required conditions and frequency to perform each activity was analyzed, and the cost and benefit of such operations was studied to ensure that the proposed activities are economically feasible and sustainable.

Appendix G provides information about cleaning and flushing joints and drains, including an overview of the process, procedures, supplies (equipment, materials and labor) needed and safety guidance.

Iowa

Bridge Maintenance Manual, Office of Bridges and Structures, Iowa Department of Transportation, January 2014.
https://siims.iowadot.gov/IowaDOT_BridgeMaintenanceManual_01JAN2014_FINAL.pdf
General considerations and cleaning procedures for expansion joints are provided in Chapter 1.3 (beginning on page 10 of the PDF). Chapter 3.3 provides agency guidance on cleaning and repairing expansion joint drainage troughs (beginning on page 21 of the PDF).

Kentucky

Improved Bridge Joint Materials and Design Details, Theodore Hopwood, Chris Van Dyke and Sudhir Palle, Kentucky Transportation Cabinet, June 2017.
https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=2580&context=ktc_researchreports
From the abstract:

> This study investigated materials and design strategies to improve the performance of both open and closed [expansion] joints. Wanting to improve the durability of compression and strip seals, which degrade over time or become detached from bridge decks, Kentucky Transportation Center (KTC) researchers approached several seal manufacturers about developing new seals reinforced with puncture-resistant fibers such as Aramid. Ultimately, researchers were unable to reach an agreement with any manufacturer …. With respect to open joints, KTC investigated the use of self-purging troughs. First implemented by the Kansas Department of Transportation, they leverage the power of air flow and vibrations produced by traffic to improve the routing of water and debris through troughs and away from underlying bridge elements. Conventional troughs receive infrequent maintenance and can become clogged with debris. Self-purging troughs eliminate this problem, which can potentially help extend the service lives of bridges on which they are installed.

A discussion of the self-purging trough begins on page 18 of the report (page 21 of the PDF) and includes design details and general guidance.

Preventative Maintenance Program for Bridges, Theodore Hopwood, Jared Fairchild, Bobby Meade and Sudhir Palle, Kentucky Transportation Cabinet, July 2015.
https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=2565&context=ktc_researchreports
From the abstract:

> Maintenance actions, costs and application interval/repair durability information have been obtained for both cyclical and condition-based bridge PM [preventive maintenance]. Additionally, information rehabilitation actions were acquired from a regional DOT survey and from other literature. As part of this study, the Kentucky Transportation Center (KTC) researchers monitored a KYTC [Kentucky Transportation Cabinet] bridge washing project to assess its level of effectiveness and to identify potential improvements. Based upon these tasks, recommended guidance was provided to KYTC for use when implementing bridge PM programs. The guidance includes a discussion of critical PM activities, strategies to adopt training and work documents (i.e., special notes) for contract work, and the implementation of work standards/special operating procedures for work performed by KYTC personnel. This report also includes details on the tools and training KYTC district-level personnel will need and outlines a roadmap for conducting pilot programmatic PM work in several districts.

Chapter 3 (page 25 of the report, page 27 of the PDF) includes cleaning and flushing practices for expansion joints and drainage troughs.

Bridge Cleaning and Preventive Maintenance, Tom Mathews and Mike Baase, Kentucky Transportation Cabinet, 2014.
https://transportation.ky.gov/Construction/Spring%20Meeting%20Presentations/04%20-%20Michael%20Baase%20and%20Tom%20Mathews%20-%20Bridge%20Preventive%20Maintenance.pptx
Slides 4 through 7 in this presentation highlight debris removal practices.

Massachusetts

Better Bridge Joint Technology, Scott Civjan and Brooke Quinn, Massachusetts Department of Transportation, February 2016.
http://www.umasstransportationcenter.org/Document.asp?DocID=14
This report addresses maintenance best practices for bridge expansion joints in New England states. Section 3.2 (page 35 of the report, page 50 of the PDF) briefly summarizes cleaning practices and district experiences in Massachusetts.

Missouri

Bridge Maintenance Program for the City of Columbia, Missouri, Glenn Washer, Mohammad Hammed and Henry Brown, Midwest Transportation Center, City of Columbia, Missouri, and U.S. Department of Transportation, September 2017.
https://intrans.iastate.edu/app/uploads/2018/03/columbia_mo_bridge-_mtc_program_w_cvr-1.pdf
From the abstract:

> In this project, a bridge maintenance and preservation program was developed for the City of Columbia, Missouri. The program focuses on practical and implementable technologies and procedures that can be applied to extend the service lives of the bridges, reduce maintenance costs, and ensure safety and serviceability. Specific technologies that were considered included bridge deck flushing, fog and seal programs, and crack sealers. The researchers analyzed the state of the practice for bridge preservation through a literature search, consultations with contacts within the preservation community, and interviews with state-level bridge owners who use these technologies. Existing and historical activities undertaken by the city were also evaluated, and current needs were assessed. An informal risk analysis was used to prioritize activities and link the identified procedures with specific structures within the city. A field survey of bridges in Columbia was completed to help identify bridge preservation needs for particular bridges. These data were summarized and used to develop an implementable procedure for short-term (12 to 24 months after program implementation), mid-term (25 to 72 months after program implementation), and long-term (73 to 120 months after program implementation) actions to extend the life of bridges and reduce maintenance costs. Key recommendations for the program include the identification and prioritization of low-cost preventive maintenance (PM) activities such as cleaning, periodic washing of bridges and sealing of bridge decks that are currently in good condition. The identification of condition-based preservation needs through the implementation of a bridge preservation inspection program (BPIP) and the review of maintenance notes in the Missouri Department of Transportation (MoDOT) biennial inspection reports were recommended.

Cleaning procedures for bridge elements are briefly discussed beginning on page 10 of the report (page 24 of the PDF).

Chapter 771.2: Bridge Cleaning and Flushing, Engineering Policy Guide, Missouri Department of Transportation, November 2016.
http://epg.modot.org/index.php/771.2_Bridge_Cleaning_and_Flushing
This general discussion of bridge cleaning includes procedures for cleaning bridge elements along with safety and environmental BMPs.

Ohio

Evaluation of the Ohio Department of Transportation's Current Storm Sewer Cleaning Operations—Phase II, William Schneider, Teresa Cutright, Tyler Mikita and Mallory Crow, Ohio Department of Transportation, January 2019.
https://ohiomemory.org/digital/api/collection/p267401ccp2/id/17635/page/0/inline/p267401ccp2_17635_0
This study reviewed alternative equipment options for storm sewer cleaning operations. The performance and effectiveness of the Recycler, a sewer cleaning unit that includes a recycling system to filter removed wastewater and reuse it for jet cleaning, which saves time and water. Among the equipment options reviewed was the BUCHER RECycler 315. *From Chapter 2 of the report*:

> The system operates by first vacuuming debris/wastewater from the storm sewer where it enters the debris body after passing through a coarse filter that removes contaminants down to ¾" in diameter. The contaminants in the debris/wastewater then settle to the bottom of the debris tank while the top of the water column is transferred to the "clean" water tank through a series of nine cyclones. These cyclones operate without a filter by spinning the water to create a centrifugal force which is used to separate the solids from liquid.

In this study, the Recycler was 52 percent more productive than the traditional vacuum jet truck system.

Evaluation of Trench and Slotted Drain Maintenance and Cleaning—Phase I, Hazem Elzarka and Ce Gao, Ohio Department of Transportation, March 2017.
https://rosap.ntl.bts.gov/view/dot/32039
From the abstract:

> This research report documents the current methods that ODOT utilizes for cleaning trench and slotted drains and recommends alternative cleaning methods that can improve safety, production rate and cost-effectiveness. Currently, ODOT cleans trench drains manually or using a [s]ewer [c]leaner. The manual process is very labor intensive and expensive while the [s]ewer [c]leaner uses large amounts of water for cleaning. Alternative methods recommended and discussed in the report include Horizontal Directional Drilling (HDD), Horizontal Auger Boring (HAB) and robotic cleaners.

A discussion of manual and mechanical cleaning practices for slotted drains begins on page 15.

Bridge Trough Maintenance Evaluation on Finger Joint Bridges, Eric Steinberg, Kenneth Walsh and Nik Sparks, Office of Statewide Planning and Research, Ohio Department of Transportation, February 2016.
https://cdm16007.contentdm.oclc.org/digital/api/collection/p267401ccp2/id/13359/page/0/inline/p267401ccp2_13359_0
From the abstract: Recently, research was conducted to determine if design changes or equipment may provide a better way of performing drainage trough cleaning. Best practices in drainage trough design and maintenance were identified through the following tasks: (1) review drawings and conduct site visits, (2) literature review and (3) survey of state departments of transportation (DOTs). The results of the research revealed that approximately 40 finger joints exist in the state of Ohio, although not all of these joints contain drainage troughs. Furthermore, at least 17 other states still use drainage troughs, although some have made modifications to their trough designs due to issues with cleaning. Examples of design modifications included the installation of foam beneath the finger joints, installation of a side-flap to enhance accessibility and the use of concrete troughs cast into bridge abutments or piers. It was concluded that each

trough is unique with its own design, traffic conditions, debris loading and accessibility, and may therefore require its own unique cleaning process. For troughs that can be cleaned frequently enough to assure proper drainage, methods such as pressurized water, compressed air, vacuum, or a combination of these should be used. Otherwise, consideration should be given to design modifications such as foam inserts, side flaps, or the removal of the trough altogether. In some cases, replacement of the finger joint with another type of joint may be the most efficient solution.

Related Resources:

Bridge Trough Maintenance Evaluation on Finger Joint Bridges, Office of Statewide Planning and Research, Ohio Department of Transportation, February 2016.
https://ohiomemory.org/digital/api/collection/p267401ccp2/id/13360/page/0/inline/p267401ccp2_13360_0
This one-page fact sheet summarizes the key points and research findings of the 2016 research report cited above.

Finger Joint Bridge Maintenance, Ken Walsh, Ohio Department of Transportation**,** August 2015.
Project description at https://research.transportation.org/rac-survey-detail/?survey_id=312
Survey results at https://research.transportation.org/rac-survey-detail/?survey_id=312#
As part of the Bridge Trough Maintenance Evaluation on Finger Joint Bridges project, a short survey was distributed to AASHTO Research Advisory Committee (RAC) members to determine state practices for finger joint bridge maintenance. Eighteen states responded to the survey; 79 percent of these states used finger joints. Respondents described effective methods for cleaning drainage troughs; their responses from the survey results are reproduced below:

Table 8. Preferred Method for Cleaning Drainage Troughs

State	Practice
Alabama	We will flush with water.
Arkansas	No—but we use flushing trailers.
Connecticut	Shovels with Vactor (suction hose).
Iowa	No.
Kansas	We do very little maintenance on troughs, troughs are stiffened by bond external material to the trough to prevent them from closing.
Maine	High pressure water and lots of it. Hoes and other creative homemade tools.
Maryland	We don't clean unless there is a problem. We haven't found an efficient means of doing this.
Massachusetts	The manual method of scooping out the debris.
North Dakota	The 1 to 1 troughs are self-cleaning.
Pennsylvania	No.
Texas	Increasing the slope of the trough would be the best method in my opinion.
Virginia	No.

State	Practice
Washington 1	[A] shovel, broom and a bucket. We are not allowed to flush until we first thoroughly hand clean.
Washington 2	Hand cleaning with a shovel or use a 4-inch hose hooked to a Vactor to suck the material from the trough.
Wyoming	No. Our maintenance folks will try to flush the trough if they can access the high end.

Source: Finger Joint Bridge Maintenance survey, Ohio Department of Transportation, 2015.

Respondents also discussed the drainage trough designs that worked well in their states, the typical slope of drainage troughs and other types of bridge expansion joints used on highway bridges.

Cleaning of Finger Joint Bridges, Cynthia Gerst, Ohio Department of Transportation**,** May 2014.
Project description at https://research.transportation.org/rac-survey-detail/?survey_id=265
Survey results at: https://research.transportation.org/rac-survey-detail/?survey_id=265#
AASHTO RAC members also participated in a survey to determine an efficient, cost-effective way to clean debris that accumulates in drainage troughs underneath finger expansion joints.
From the project description:

The following information was solicited as part of this survey:

- Ways to provide greater access to the drainage troughs, either through the top or underneath the bridge deck (modification of design).
- Discovery of tools or methods to clean the drainage trough (mechanically or manually-powered) with no modification to the current design.

Four state DOTs responded to the survey:

- In Illinois, current detailing for troughs includes a fabric-reinforced elastomeric flap that directs water and debris into the trough. Maintenance personnel can lift the flap and scoop out the debris or use pressure washers or vacuum trucks to remove debris. The respondent reported that this task is "relatively easily accomplished at abutment locations but at pier locations snoopers, man lifts or ladders will be required." A detail of the trough is included in the survey response (see page 21 of this report.)

  The respondent added that before the agency adopted this detail, maintenance crews typically used "pressure washers and tried to insert the pressure wand between the fingers on each side of the joint. This was best done in cooler weather when the superstructure was in a 'contracted' position and the joint openings were larger. The results of this method were dubious at best but it was better than nothing."

- Pennsylvania DOT obtained greater access to the drainage troughs by using a tooth dam standard design. (*Note*: The link to this design provided by the respondent is no longer active.) He added that the agency "typically use[s] high pressure water to flush the dams on an annual basis."

- Respondents from Montana and Utah DOTs noted the difficulty with efficiently cleaning these troughs. The Montana DOT respondent added that "many of our troughs do not

get cleaned in a timely manner, or at all. Sometimes we are able to coordinate cleaning with our NBI [National Bridge Inventory] bridge inspectors when they are on-site with our UBIT [under bridge inspection truck] during regular inspections. This sporadic cleaning history has resulted in many failed troughs under our finger joints. We have not done any modification of joint design details to remedy this access issue." The Utah DOT respondent noted that because of the difficulty cleaning the troughs, the agency had removed these types of joints from its bridges.

Pennsylvania

Bridge Maintenance and Cleaning, PennDOT Maintenance First Series, Pennsylvania Department of Transportation, August 2016.
http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%20370J.pdf
From the fact sheet: Bridge cleaning is an important element of the state's Bridge Preventive Maintenance Program. The deck and substructure must be kept clean, with the drainage systems free of debris. PennDOT mandates that most bridges be cleaned annually. PennDOT cleans over 16,000 bridges each year. A basic bridge cleaning crew is comprised of a foreman, equipment operator and four crew members. Required equipment includes a crew cab, dump truck, sweeper and flusher.

Utah

Concrete Bridge Deck Management Practices: Summary of Scanning Tour, W. Spencer Guthrie and Loren A. Ross Utah Department of Transportation, May 2006.
https://www.udot.utah.gov/main/uconowner.gf?n=7901330589844928
From the abstract: The purpose of this research was to investigate concrete bridge deck management practices through a scanning tour, including visits with the New York City Department of Transportation (DOT), the Port Authority of New York and New Jersey, the New York State Bridge Authority, the New York State DOT, the New Jersey DOT, the Pennsylvania DOT, and the Colorado DOT. The scanning tour focused primarily on agency organizational structure and experience, quality control procedures, bridge maintenance protocols, and new product evaluation protocols associated with bridge deck joints and surface treatments.

Washington

WSDOT Bridge Maintenance and Preservation, Hydraulic Project Approval, Washington Department of Fish and Wildlife, Issue Date: January 18, 2018; Project End Date: January 17, 2023.
https://www.wsdot.wa.gov/sites/default/files/2018/02/13/Env-perm-HPABridgeMaint.pdf
From the project description:

> This work consists of performing the following maintenance and preservation activities on statewide WSDOT [Washington State DOT] owned bridges: drain cleaning, cleaning and washing, painting (including abrasive blasting and prep washing), general maintenance and repair, and deck overlay replacement. This work minimizes the degradation of these bridges to keep the structures safe and functional for the traveling public.

Cleaning provisions are discussed in Section A, beginning on page 2 of the document (page 4 of the PDF).

Standard Practice for Washing and Cleaning Concrete Bridge Decks and Substructure Bridge Seats Including Bridge Bearings and Expansion Joints to Prevent Structural Deterioration, Jeffrey Berman, Charles Roeder and Ryan Burgdorfer, Washington State Department of Transportation, December 2013.
https://www.wsdot.wa.gov/research/reports/fullreports/811.2.pdf
From the abstract:

> This study examined the perceived costs and benefits of routine washing of both steel and concrete bridges, with emphasis on substructure seats and bridge decks, by exploring current practices around the U.S. A literature review was conducted in order to learn more about these elements and their failure mechanisms. Then a nationwide survey was conducted with state DOTs around the U.S. regarding the washing practices of decks, expansion joints and bearings. A follow-up survey was conducted soon afterward to collect more detailed information. A summary of the common washing practices is given in conclusion.

The state-of-the-practice summary of washing practices begins on page 48 of the report (page 60 of the PDF).

Contacts

CTC contacted the individuals below to gather information for this investigation.

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Appendix A: Survey Questions

The following survey was distributed to members of the AASHTO Committee on Maintenance and selected California local agencies to gather information from transportation and other agencies about their maintenance practices for bridge drains and expansion joints.

Description of Practice

(Required) Please describe the specialized technology and/or equipment your organization uses to clean and maintain bridge drains and expansion joints by selecting the best option below.

- We don't use any specialized technology or equipment to complete this type of maintenance (directs respondent to **Organizations Not Using Specialized Technology or Equipment**).
- We use commercially available product(s) (directs respondent to **Commercial Equipment: Description** and remaining questions in this question set).
- We use tool(s) our organization developed in-house (directs respondent to **In-House Tool: Description** and remaining questions in this question set).

Organizations Not Using Specialized Technology or Equipment

1. Please briefly describe the maintenance method(s) your organization uses to clean and maintain bridge drains and expansion joints.
2. Does your organization have any interest in using a specialized system or tool to clean and maintain bridge drains and expansion joints?
    - No
    - Yes (please describe your organization's interest)

Note: *The survey respondent is directed to **Wrap-Up** after responding to the questions above.*

Commercial Equipment

Description

1. Please name the commercial equipment your organization is using, and the vendor supplying it.
2. Please describe how the equipment works.
3. What was the initial cost of the equipment?
4. If available, please provide links to documentation related to your organization's maintenance methods and the commercial equipment used to clean and maintain bridge drains and expansion joints. Please send any files not publicly available online to carol.rolland@ctcandassociates.com.

Use

1. When did your organization start using this equipment?
2. Did your organization engage in pilot testing of the equipment?
    - No
    - Yes (please describe how your organization tested the equipment)

3. Please describe the learning curve for crew members using this equipment by selecting the best option below.
    - The equipment is easy to use and requires little instruction prior to use.
    - A moderate level of instruction is required prior to use.
    - A significant level of instruction is required prior to use.
4. How often do your organization's maintenance crews use the equipment to perform bridge cleaning and/or maintenance?
    - Daily
    - Weekly
    - Monthly
    - Quarterly
    - Annually
    - As needed
    - Not known
    - Other (please describe)
5. Please describe the level of maintenance required to keep the equipment in appropriate operating condition.
6. Can the equipment be used effectively during all seasons of the year?
    - Yes
    - No (please describe the limitations on use)

Assessment

1. Please describe the benefits to your organization of using the equipment.
2. Please describe any challenges your organization has encountered using this equipment.
3. Does your organization have any interest in investigating other system(s) or tool(s) to clean and maintain bridge drains and expansion joints?
    - No
    - Yes (please describe your organization's interest)

In-House Tool

Description

1. Please describe the tool(s) your organization developed and how it works.
2. What was the initial cost to develop it?
3. If available, please provide links to documentation related to your organization's maintenance methods and the in-house tool(s) used to clean and maintain bridge drains and expansion joints. Please send any files not publicly available online to carol.rolland@ctcandassociates.com.

Use

1. When did your organization start using the tool(s)?

2. Did your organization engage in pilot testing of the tool(s)?
    - No
    - Yes (please describe how your organization tested the tool)
3. Please describe the learning curve for crew members using the tool(s) by selecting the best option below.
    - The tool(s) is/are easy to use and require(s) little instruction prior to use.
    - A moderate level of instruction is required prior to use.
    - A significant level of instruction is required prior to use.
4. How often do your organization's maintenance crews use the tool(s) to perform bridge cleaning and/or maintenance?
    - Daily
    - Weekly
    - Monthly
    - Quarterly
    - Annually
    - As needed
    - Not known
    - Other (please describe)
5. Please describe the level of maintenance required to keep the tool(s) in appropriate operating condition.
6. Can the tool(s) be used effectively during all seasons of the year?
    - Yes
    - No (please describe the limitations on use)

Assessment

1. Please describe the benefits to your organization of using the tool(s).
2. Please describe any challenges your organization has encountered using the tool(s).
3. Does your organization have any interest in investigating other system(s) or tool(s) to clean and maintain bridge drains and expansion joints?
    - No
    - Yes (please describe your organization's interest)

Wrap-Up

1. What recommendations do you have for an organization seeking to implement new tool(s) or practice(s) to clean and maintain bridge drains and expansion joints?
2. Please describe any best management practices (BMPs) that your organization uses to address any environmental challenges (such as pollutant flow into the receiving waters, etc.) associated with maintaining bridge drains and expansion joints.
3. Please use this space to provide any comments or additional information about your previous responses.