Pavement Preservation Program Benchmarking

FHWA-HIF-24-024

Federal Highway Administration
Office of Preconstruction, Construction, and Pavements
1200 New Jersey Avenue, SE
Washington, DC 20590

U.S. Department of Transportation
Federal Highway Administration

January 2024

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-HIF-24-024	None	None

4. Title and Subtitle	5. Report Date
Pavement Preservation Program Benchmarking	January 2024
	6. Performing Organization Code None

7. Author(s)	8. Performing Organization Report No.
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9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Applied Pavement Technology, Inc. 115 W. Main Street, Suite 400 Urbana, IL 61801	None
	11. Contract or Grant No. **693JJ319D000018** HIF200123PR
	13. Type of Report and Period Covered Final Report August 2020-April 2022
12. Sponsoring Agency Name and Address Federal Highway Administration 1200 New Jersey Ave SE, Washington, DC 20590	**14. Sponsoring Agency Code** None

15. Supplementary Notes

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16. Abstract

In an effort to encourage the use of strategic pavement preservation on all roadways, the FHWA conducted a study of State Departments of Transportation (DOTs)' pavement preservation practices and conducted a gap analysis focusing on successful implementation strategies to evaluate the effectiveness of pavement preservation processes. The study of practices was accomplished by reviewing current publications on pavement preservation and analyzing the results of a survey of practice completed by 50 DOTs (OMB Control Number 2125-0628). The gap analysis considered key attributes of pavement preservation policies and practices and what is expected or desired. Suggestions for additional study also included a more detailed examination of the preservation program gaps and an in-depth effort to identify useful tools and practices. The need for better monitoring of preservation performance, modeling of that performance, and incorporating the results into improved treatment and project selection is also noted.

17. Key Words	18. Distribution Statement
Pavement Preservation, Preventive Maintenance; Performance; Program Benchmarking; Gap Analysis	

19. Security Classify. (of this report)	20. Security Classify. (of this page)	21. No of Pages	22. Price
None	None	46	None

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

ADT – Average Daily Traffic
ADA – Americans with Disabilities Act
AASHTO – American Association of State Highway and Transportation Officials
CCI – Critical Condition Index (Virginia)
CIR – Cold in place Recycling
CPM – Capital Preventive Maintenance (Texas)
CRS – Condition Rating Survey (Illinois)
DN – Do Nothing (Virginia)
EDC-4 – FHWA's Every Day Counts Program, Round 4
EUAC – Equivalent Uniform Annual Cost
FN – Friction Number
FDR – Full Depth Reclamation
GPR – Ground Penetrating Radar
HMA – Hot Mix Asphalt
HIR – Hot in place Recycling
IFI – International Friction Index
IRI – International Roughness Index
LCC – Life Cycle Cost
LCCA – Life Cycle Cost Analysis
LCP – Life Cycle Planning
LTPP – Long-term Pavement Performance program
M&R – Maintenance and Rehabilitation
MCE – Marginal Cost Effectiveness
MPD/MTD – Maximum Profile Depth / Maximum Texture Depth
NCHRP – National Cooperative Highway Research Program
PCC / PCCP – Portland Cement Concrete
PCI – Pavement Condition Index
PCR – Pavement Condition Rating
PI – Pavement Index
PM – Preventive Maintenance
PMS – Pavement Management System
PSI – Pavement Surface Index
PSR – Pavement Surface Rating
SHRP2 – Second Strategic Highway Research Program
SMART – Surface Maintenance at the Right Time
SPS – Specific Pavement Study (LTTP project)
TAMP – Transportation Asset Management Plan
TRB – Transportation Research Board
TRIS – Transportation Research Information Service

CHAPTER 1: INTRODUCTION

Background

A review of the references in the Appendix suggests that a number of terms have been used to describe long-standing practices to enhance performance and extend the life of highway pavements. Whether referred to as preventive maintenance, pavement preservation, or some other term, there is no definitive, widely accepted understanding of what constitutes pavement preservation. A 1999 survey of agency practices by the Strategic Highway Research Program (SHRP) reported that 41 responding agencies were using preventive maintenance treatments (AASHTO 1999). The report noted that some agencies interpreted having a "program" quite narrowly, while others suggested that the use of treatments was synonymous with having a program. Thirty-one of the agencies indicated that pavement preservation programs were integrated with pavement management. Twenty-six States (including three without established programs) had established guidelines; preservation treatments were reported as being applied to pavements ranging in condition from poor to good.

There have been several subsequent, nationwide, strategic examinations of pavement preservation practices, including:

- National Cooperative Highway Research Program (NCHRP) 20-07, Task 184 (Peshkin and Hoerner 2005): Identified many preservation-related research needs.
- SHRP2 Study on Preservation for Highly Trafficked Roads (Peshkin et al. 2011): Synthesized a broad range of content and tools to improve on agency preservation practices.
- Survey by Tighe and Gransberg (2011): Focused on sustainable preservation and maintenance practices.
- Regional survey (Luhr 2012): Conducted under the auspices of the Rocky Mountain West Pavement Preservation Partnership.

In addition to cataloging key measures of existing practices, these studies highlight challenges associated with differences in terminology and use of preservation treatments.

- Definitions: There still appears to be a lack of agreement within the community about pavement preservation, how treatments are used, or how preservation fits into agency practices.
- Funding: An important issue associated with preservation is determining whether and when a preservation project is eligible for Federal funding. There is broad language in 23 U.S.C. 116(e) related to eligibility of preservation projects for Federal funding, but no requirements for use of preservation or prioritization in Federal-aid programs. Further language in 23 U.S.C. 119(d)(2)(A) indicates that preservation is an eligible expense for projects funded by the National Highway Performance Program.
- Monitoring: Unlike capital projects, monitoring of preservation projects is not typically considered a priority. Because of costs and technical requirements, State DOTs do not always track where the treatments were placed, the conditions of the pavements on which they were placed, or the outcomes from the preservation treatments.

- Analysis: Many of the current pavement management systems are not used to analyze the impact of pavement preservation treatments. This limits agencies' ability to include pavement preservation as a strategy in the investment programs and ensure appropriate use of the treatments.

Report Organization

In addition to this introductory chapter, this report is organized as follows:

- Chapter 2: Summary of relevant literature on preservation programs, tools, monitoring, and planning, primarily covering the past 20 years.
- Chapter 3: Summary of responses to the survey of State practice (OMB Control Number 2125-0628).
- Chapter 4: Discussion of gaps between current preservation policies and practices and expected or desired policies and practices.
- Chapter 5: Summary and conclusions.

CHAPTER 2: LITERATURE REVIEW

Introduction

The literature search focused on work performed in the past 20 years. The search included a review of the Transportation Research Information Service (TRIS) database, the Transportation Research Board's (TRB's) Research in Progress database, selected State DOT specifications, and several other sources. The literature review presented in this chapter is organized into the following topic areas:

- Pavement Preservation Overview.
- Existing Preservation Research, Guidance, and Tools.
- Preservation Program Monitoring.
- Project and Program Planning.
- Life-Cycle Planning Analysis.

Pavement Preservation Overview

This section identifies pavement preservation practices and programs through the FHWA Every Day Counts 4 (EDC-4)[1] and other outreach programs.

Previous Surveys

As noted in chapter 1, since the late 1990s there has been a series of surveys of State DOT practices related to various aspects of pavement preservation (AASHTO 1999, Peshkin and Hoerner 2005, Peshkin et al. 2011, Luhr 2012, Tighe and Gransberg 2011). These surveys identified how agencies perceive preservation or preventive maintenance activities, the different treatments in use, approaches to funding and budgeting for preservation, measuring performance of preservation programs, and so on. The survey completed as part of this project is discussed in the next chapter (OMB Control Number 2125-0628).

In a survey conducted in 2020 by the California Department of Transportation's (Caltrans) Division of Research, Innovation and System Information (2020), respondents provided feedback on quantification of routine and preventive maintenance benefits for different asset classes, including pavements. While nine State DOTs responded to the survey, not all provided responses for the pavement class of assets. Summarizing responses of interest, the following is noted:

- The ability to quantify effectiveness is limited by a small sample size.
- Several techniques are used to quantify cost savings from maintenance and preventive maintenance.
- Management systems are being used to model the impact of maintenance activities.

[1] Every Day Counts | Federal Highway Administration (dot.gov)

FHWA When and Where Peer Exchange Report

As part of FHWA's EDC-4 Pavement Preservation When and Where initiative, three peer exchanges were held in 2018 and attended by representatives from 23 State DOTs. The "when and where" initiative covered topics related to the timing of pavement preservation (the "when") and the project selection process (the "where"). Topics covered during these peer exchanges (Groeger, Visintine, and Brantley 2018) included:

- Participating agency when/where practices.
- Establishing a good program delivery process for selection and evaluation of pavement preservation projects as a strategic investment.
- Suggested practices for using a pavement management system (PMS) that includes decision trees to aid in the selection of pavement preservation treatments.
- Pavement preservation as a component of a strategic Transportation Asset Management Plan (TAMP).
- What a tool can do or should consider for analyzing the long-term effectiveness of preservation strategies as investment program alternatives.
- Metrics for gauging the effectiveness of pavement preservation for the overall asset to the agency's program.
- Input for how the results of the project should be communicated and delivered.

FHWA How Peer Exchange Tech Briefs

The EDC-4 Pavement Preservation How initiative focused on quality construction and materials practices associated with the treatments themselves. Through a series of 10 regional peer exchanges and participation by 37 State DOTs, participants reported on successes and challenges associated with asphalt and concrete pavement preservation treatments. Table 1 summarizes some of those successes and challenges, with more details available on the FHWA pavement preservation webpage.

Table 1. Successes and challenges extracted from EDC-4 Pavement Preservation How peer exchanges.

Successes	Challenges
• Equipment certification. • Use of a statewide trainer. • Agency/industry alliances. • Competitive bidding and contracting strategies. • Timing of maintenance before preservation. • Improved specifications. • Innovative use of materials, better control of materials. • Budget commitments. • Innovative construction practices. • Improved crack sealing practices. • Improved design procedures. • Incentives/disincentives.	• Loss of experienced inspectors. • Lack of training. • Contracting and competition. • Lack of contractors. • Aggregate quality, cleanliness, gradations. • Delay between project identification and construction, changes in condition. • Moratoriums. • Small number of available treatments. • Sufficient funding for improvements required by the Americans with Disabilities Act. • Considering surface condition during construction. • Leadership support for preservation. • Modeling preservation in pavement management. • Reflective cracking. • Effect of snowplows. • Agency budgets.

Existing Preservation Research, Guidance, and Tools

Several national-level studies developed research reports and manuals on this topic. The following sections summarize the tools developed in these studies and the subsequent manuals adopted by selected State agencies. [2]

Optimal Timing of Pavement Preventive Maintenance Applications (NCHRP 14-14)

NCHRP 14-14 presents a framework for determining the optimal timing for the application of preventive maintenance treatments for flexible and rigid pavements. The methodology considered a variety of treatments and different approaches to monitor performance. The research focused on developing a methodology that would assist agencies in placing the right treatment on the right pavement at the right time (Peshkin, Hoerner, and Zimmerman 2004).

The benefit associated with each treatment is based on the improvement in condition compared to the "do-nothing" scenario. An illustration of the benefit associated with the application of a preventive maintenance treatment is shown in figure 1.

[2] Use of these tools and manuals is not a Federal requirement.

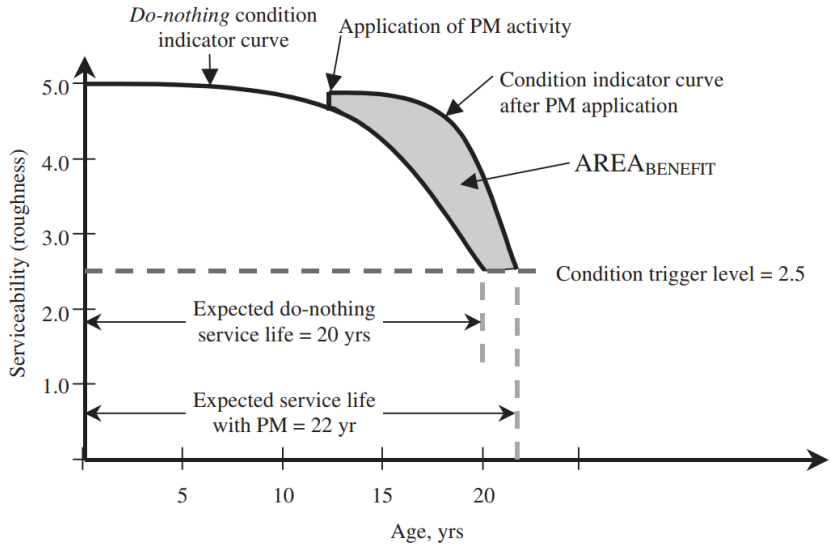


Figure 1. Illustration of benefit associated with the application of a preventive maintenance (PM) treatment.

The study also included information on designing experiments to determine the optimum timing of various preventive maintenance treatments, some of which is listed in table 2. The optimal time to apply a selected treatment is obtained by analyzing scenarios in which the selected treatment is applied at different stages of the pavement life. The methodology also accounts for situations in which multiple indicators are parts of the analysis, such as condition index, roughness, or friction. In these cases, the methodology is to assign weighted values to each variable and calculate an overall weighted ratio to account for all variables using the individual benefit ratios.

Table 2. NCHRP suggested timing cycles for monitoring preventive maintenance treatments.

Pavement Type	Treatment	Recommended year of Initial Treatment	Treatment Monitoring Cycle
Bituminous-Surfaced Pavements	Crack Sealing	1 to 3	Annually
	Slurry Seals	2 to 6	Annually
	Microsurfacing	3 to 7	2 years
	Chip Seals	2 to 5	Annually to 2 years
	Thin HMA Overlay	5 to 8	2 years
	Ultrathin Overlay	2 to 6	2 years
Portland Cement Concrete Pavements	Joint and Crack Sealing	4 to 10	2 years
	Diamond Grinding	5 to 10	3 years

Timings shown in table 2 may be influenced by other factors such as climate, traffic, and construction quality. In addition, a spreadsheet tool was developed to simplify the application of the methodology described in the report.

Quantifying the Effects of Preservation Treatments on Pavement Performance (NCHRP 14-33)

NCHRP 14-33 presents a methodology that identified performance measures that can be used to understand the contribution of preservation treatments to the overall performance of a pavement facility (Rada et al. 2018). The study suggested that agencies could use the following measures for evaluating the performance of preservation treatments:

- Individual pavement condition measures[3], including:
  - Ride quality (IRI) (asphalt and concrete pavements).
  - Cracking (asphalt and concrete pavements).
  - Rut depth (for asphalt pavements, and possibly for concrete pavements where surface abrasions from studded tires or chains is a concern).
  - Faulting (for concrete pavements).
- Composite pavement condition measures: Measures that are based on a combination of one or more individual pavement condition measures or distresses.
- Equivalent uniform annual cost (EUAC): Discounted EUAC, expressed as dollars per lane-mile per year.

Additionally, the study developed a guide that can be used to facilitate implementation of such metrics and support the pavement management decision making process. The guide may be helpful in determining how to justify the short- and long-term benefits of preventive maintenance treatments.

Guidelines for the Preservation of High-Traffic-Volume Roadways (SHRP2 R26)

SHRP2 Project R26, *Guidelines for the Preservation of High-Traffic-Volume Roadways* (Peshkin 2011), focused on selecting and evaluating preservation treatments for use on high-volume facilities. These types of facilities present challenges that are not shared with lower volume facilities. Shorter closure windows, increased risk of failure, greater liability, increased performance requirements, and lack of experience are among some of the challenges presented by high-volume highway facilities. Figure 2 presents an overview of the overall treatment evaluation and selection framework outlined in the SHRP2 R26 report.

[3] The NCHRP 14-33 study included the investigation of whether preservation treatments influenced the measurements established in 23 CFR 490. The study is published in NCHRP Research Report 858.

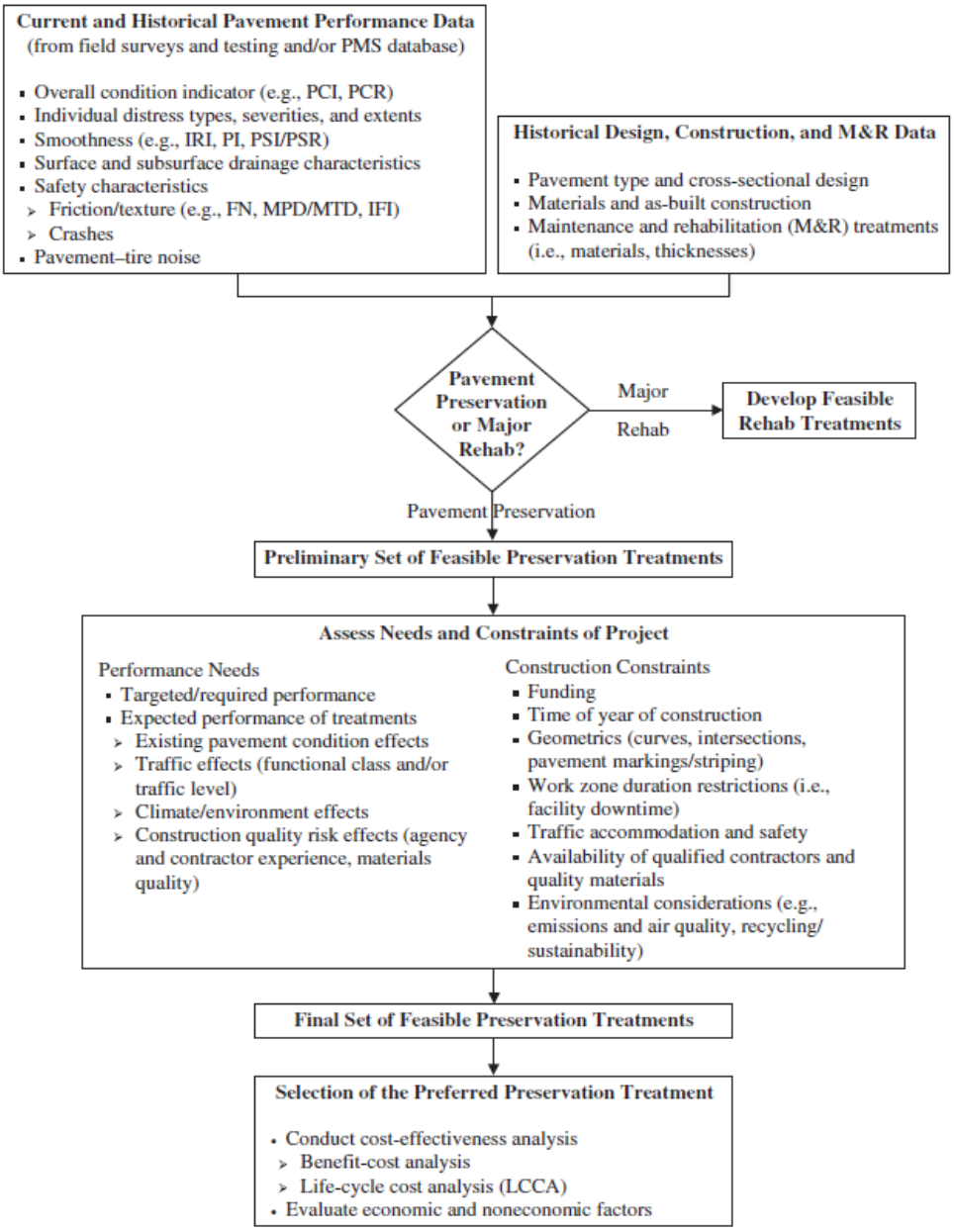


Figure 2. Treatment selection process overview for high-volume roads.

The report presented a list of treatments commonly used by State DOTs on high-volume facilities and classified them based on application timing, types and severities of distresses exhibited by the pavement, climatic zone, traffic levels, expected performance, and relative performance cost. In addition to technical and economic considerations, some non-economic factors related to agency or district experience and the local availability of qualified contractors and materials should be considered. The report suggested using a treatment decision matrix with weighted scores to help in comparing multiple treatment options. Table 3 presents an example of a treatment decision matrix.

Table 3. Example of preservation treatment decision matrix.

Attribute and Selection Factor	Attribute Weight	Factor Weight	Combined Weight	Treatment 1 Rating Score	Treatment 1 Weighted Score	Treatment 2 Rating Score	Treatment 2 Weighted Score
Economic	40	-	-	-	-	-	-
Initial cost	-	30	12.0				
Cost-effectiveness	-	30	12.0				
Agency cost	-	10	4.0				
User cost	-	30	12.0				
Economic Total	-	100	-	-	-	-	-
Construction/materials	25	-	-	-	-	-	-
Availability of qualified contractors	-	20	5.0				
Availability of quality materials	-	20	5.0				
Conservation of materials/energy	-	30	7.5				
Weather limitations	-	30	7.5				
Construction/materials Total	-	100	-	-	-	-	-
Customer Satisfaction	25	-	-	-	-	-	-
Traffic disruption	-	40	10.0				
Safety issues	-	40	10.0				
Ride quality and noise issues	-	20	5.0				
Customer Satisfaction Total	-	100	-	-	-	-	-
Agency policy/preference	10	-	-	-	-	-	-
Continuity of adjacent pavements	-	20	2.0				
Continuity of adjacent lanes	-	20	2.0				
Local preference	-	60	6.0				
Agency policy/preference Total	-	100	-	-	-	-	-
Cumulative Weighted Score	-	-	-	-		-	

Note: Basis for treatment rating scores (1-to-5 scale); initial cost: 1=highest , 5=lowest; cost-effectiveness: 1=least cost effective, 5=most cost effective; agency cost: 1=highest, 5=lowest; user cost: 1=highest, 5=lowest; availability of qualified contractors: 1=low/none, 5=high; availability of quality materials: 1=low/none, 5=high; conservation of materials/energy: 1=low, 5=high; weather limitations: 1=major, 5=low/none; traffic disruption: 1=major, 5=low/none; safety issues: 1=serious, 5=none; ride quality and noise issues: 1=serious, 5=none; continuity of adjacent pavements: 1=does not match at either end, 5=matches at both ends; continuity of adjacent lanes: 1=does not match, 5=matches; local preference: 1=inconsistent with preference, 5=consistent with preference.

The report also provides technical summaries for several pavement preservation treatments, which include treatment descriptions, key pavement conditions addressed, construction considerations, relative treatment cost, expected treatment life and pavement service life extension, and resources for additional information.

Concrete Pavement Preservation Guide

In 2014, FHWA published the second edition of the *Concrete Pavement Preservation Guide*, which provides information for selecting, designing, and constructing preservation treatments for concrete pavements. The report covers topics regarding the overall strategy behind pavement preservation, which includes preventive maintenance, minor rehabilitations, and some routine maintenance activities.

The guide suggests that the benefits of implementing a pavement preservation plan include higher user satisfaction, improved pavement conditions, cost savings, and improved safety. These benefits can be achieved by applying the most appropriate treatments at the appropriate time within the pavement condition life cycle to reduce traffic impacts, optimize the amount of funding required, and maintain or improve the facility's safety.

The guide focuses on the following concrete pavement preservation treatments: slab stabilization and slab jacking, partial-depth repairs, full-depth repairs, retrofitted edge drains, load transfer restoration, diamond grinding and grooving, joint resealing, crack sealing, and concrete overlays. It discusses the purpose and limitations of each treatment, life cycle considerations, materials and design methods, construction best practices, and costs associated with each treatment.

INDOT Treatment Guidelines for Pavement Preservation

In 2010, the Indiana Department of Transportation (INDOT) published *Treatment Guidelines for Pavement Preservation*. The report covers 10 treatments for asphalt and composite pavements and eight options for concrete pavements. Table 4 lists the treatments covered in the INDOT guidelines along with considerations, suggested construction practices, benefits, limitations, and selection recommendations for each treatment.

Table 4. Pavement preservation treatments (INDOT 2010).

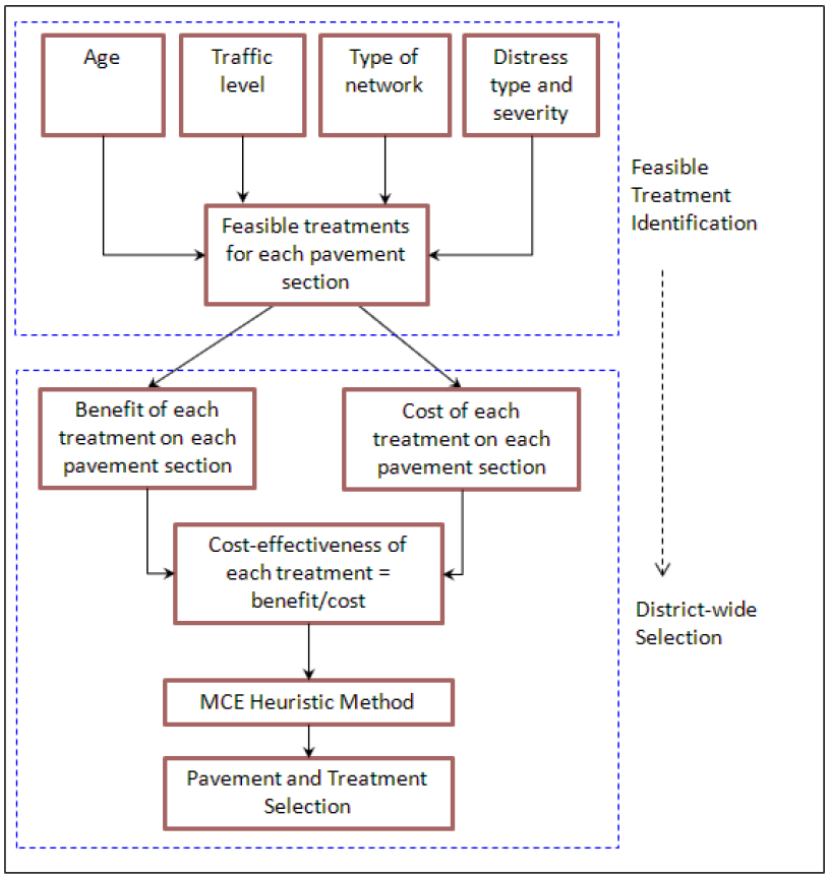
Asphalt or Composite Pavement	**Portland Cement Concrete Pavement (PCCP)**
• Crack sealing/routing and filling. • Fog seal. • Scrub seal (sand seal). • Seal coat (chip seal). • Flush seal. • Microsurfacing. • Profile milling. • Thin hot mix asphalt overlay with profile milling. • Ultra-thin bonded wearing course (UBWC). • Thin hot mix asphalt mill/fill (thin HMA inlay).	• Crack sealing/filling PCCP joint resealing. • Retrofit load transfer. • Cross-stitching. • PCCP profiling (diamond grinding). • Partial depth patching. • Full-depth patching. • Undersealing.

Source: 2010 INDOT SPR-3114 *Treatment Guidelines for Pavement Preservation* (Table 2-1, Page 3)

Best Practices and Performance Assessment for Preventive Maintenance Treatments for Virginia Pavements

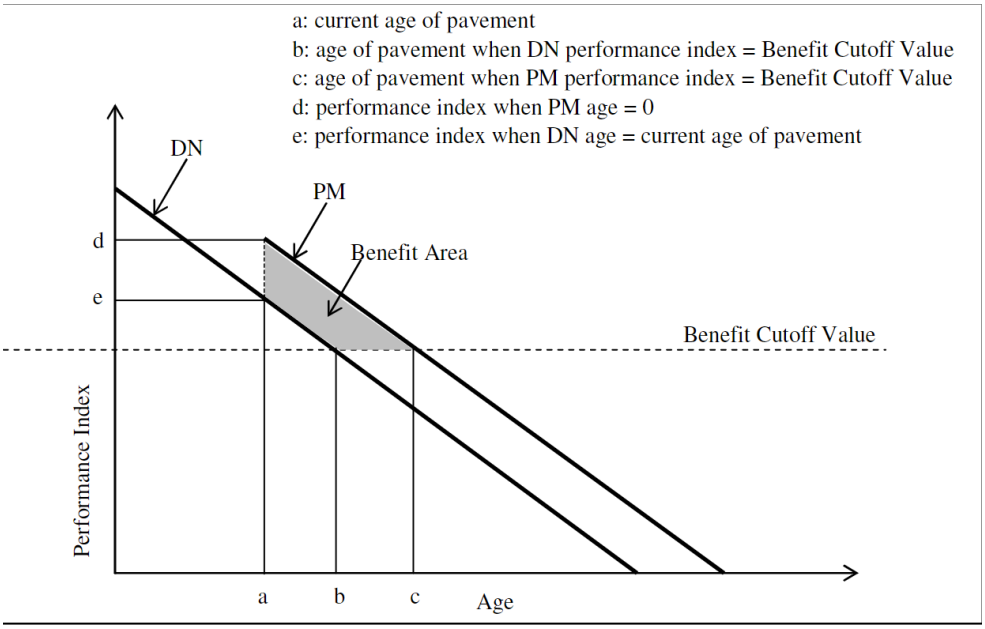
A suggested strategy for pavement preservation as practiced in Virginia is described in the 2015 research report *Best Practices and Performance Assessment for Preventive Maintenance Treatments for Virginia Pavements*. This guide uses a treatment selection tool based on a two-step process: first, identifying feasible treatments and, second, performing a districtwide selection. Figure 3 shows a graphical summary of the process.

Treatment feasibility is based on the pavement section's age, traffic level, type of network, and distresses used in the decision matrices. The benefit of each treatment on each section is calculated as the product of lane-miles, and the area between the do-nothing (DN) and preventive maintenance (PM) curves above a specified benefit cutoff value, shown in figure 4. In Virginia, this benefit cutoff value is based on typical deficient pavement criterion, which considers pavements with a Critical Condition Index (CCI) below 60 as deficient.



Note: MCE = Marginal cost-effectiveness
Source: 2015 Virginia Center for Transportation Innovation & Research (Figure 12, Page 23)

Figure 3. A two-step approach to preventive treatment selection.



Note: DN = Do Nothing, PM = Preventive Maintenance
Source: 2015 Virginia Center for Transportation Innovation & Research (Figure 13, Page 25)

Figure 4. Computation of Treatment Benefit.

Selected State DOT Pavement Preservation Practices

Since there are no Federal requirements for pavement preservation and no specific Federal guidance, State DOTs have developed internal procedures for selection, design and construction of pavement preservation treatments. The following sections describe information available from a selected set of State DOTs.

Illinois Department of Transportation (IDOT)

Chapter 53 of IDOT's *Bureau of Design and Environment Manual* (IDOT 2022) describes the State DOT's approach to pavement preservation. Chapter 53 defines the different preservation activities linked to the Transportation Asset Management Plan and factors that must be considered during the selection and/or design of pavement preservation projects. It further identifies the different preservation treatments used by IDOT for flexible and rigid pavements.

IDOT's manual contains specific treatment selection matrices for flexible, composite, and rigid pavements to determine the most effective treatment based on the relationship between the preservation treatment and distress types and severity in the existing pavements.

Minnesota Department of Transportation (MnDOT)

MnDOT's most recent revision of its *Pavement Preservation Manual* (MnDOT 2020) presents comprehensive treatment selection information for asphalt pavements using a decision matrix that considers the type and severity of distresses, ride quality, traffic level, and friction condition. The MnDOT manual contains a decision matrix that identifies different pavement conditions and potential treatments. The matrix specifically indicates whether the treatment is "Recommended," "Feasible," or "Not Recommended." For example, for pavement conditions involving medium severity transverse cracking, crack sealing treatments with crack filling or mastic are "Recommended"; microsurfacing, chip seals, and micromilling may be "Feasible"; but thin HMA overlays, ultrathin bonded wearing courses, rut filling, and fog seals are "Not

Recommended." A second example is for pavement conditions with medium or high alligator cracking, all possible treatments are considered "Not Recommended."

According to MnDOT's manual, the most suitable treatment is the one that is expected to have the best cost-to-benefit ratio from a pool of potential treatments while meeting the project's objectives. Project engineers typically rely on pavement management systems to help perform this analysis. After the list of treatments has been narrowed, MnDOT's methodology also suggests that the project engineers incorporate local considerations such as local contractor qualifications, availability of materials, local experience, weather or season, pavement noise, facility downtime, and surface friction. This suggests the importance of having experienced staff dedicated to selecting and developing pavement preservation projects and not relying solely on outputs from a pavement management system.

South Dakota Department of Transportation (SDDOT)

SDDOT's approach to pavement preservation strategy is described in its 2021 *Pavement Preservation Guidelines* (SDDOT). The first step is to decide if a particular project is a good candidate for preservation by assessing the general condition of the site, considering variables such as current or historic structural problems and presence of any material-related distresses. If a site is deemed to be a good candidate for preservation, the guide then points to a series of tables that consider the type, severity, and extent of specific distress. The tables recommend specific treatments to address the distresses and identify alternate feasible treatments that might be appropriate for the project.

Texas Department of Transportation (TxDOT)

TxDOT developed the *Seal Coat and Surface Treatment Manual* (TxDOT 2017) to define and describe the pavement preservation approach used by the agency. In the guide, the treatment selection process considers several variables: the current pavement condition, local treatment costs, traffic volume, traffic levels, and pre-treatment repair needs. The manual highlights the importance of leveraging the TxDOT Pavement Management Information System (PMIS) to assess the current pavement condition, identify potential implementation problems, and estimate the effort needed to achieve the maintenance goals. The manual does not provide any decision tree or selection matrix to determine the most appropriate treatment. TxDOT applies seal coats and surface treatments as the only preventive maintenance options.

New York Department of Transportation (NYSDOT)

New York's *Comprehensive Pavement Design Manual Chapter 10 – Preventive Maintenance* (NYSDOT 2005) outlines the importance of pavement preservation for the State's highway network in the context of preventive maintenance. It has a description of the different types of preservation treatments, including the pavement conditions under which each treatment should be used. The design manual does not specify the treatment types appropriate for a project under specific traffic or performance conditions.

Preservation Program Monitoring

A large volume of literature exists on selection of pavement preservation treatments and individual treatment performance. However, there is not much literature available on monitoring the performance of a preservation program at the agency level. A few informational resources are summarized in this section.

Cost-Effectiveness of Michigan DOT's (MDOT) Preventive Maintenance Program

Ram and Peshkin (2013) evaluated both the performance of individual preservation treatments used by the MDOT and the overall performance of the preventive maintenance program. The study evaluated the impact of the first preventive maintenance treatment placed after a major rehabilitation/reconstruction activity and the treatments placed after the first application of the preventive maintenance treatment. All subsequent treatments were grouped into a single category, "post-first treatments." A simplified life-cycle cost analysis was conducted for both a rehabilitation strategy and a preventive maintenance strategy using the statewide average rehabilitation and preventive maintenance treatment costs provided by MDOT. The results of the study show that MDOT's CPM program generated an average savings of almost $310,000 per lane-mile for flexible pavements and around $265,000 per lane-mile for composite pavements when compared to a rehabilitation-only strategy, while providing service life extensions of around 16 years. The study concluded that MDOT's preservation program is economically sustainable, helps preserve the State's pavement assets, and delays the need for major rehabilitation or reconstruction activities.

Arizona Department of Transportation ADOT) Surface Treatment Program

ADOT has a long history of using surface treatments to improve pavement performance, especially on asphalt-surfaced pavements. A notable example was ADOT's participation in the Long-Term Pavement Performance (LTPP) program's Specific Pavement Study-3 (SPS-3), initiated in the late 1980s to evaluate the effectiveness of crack sealing, chip seals, slurry seals, and thin overlays as preventive maintenance treatments. The performance of the different treatments was monitored on several sections in Arizona until mid-1998. Dufalla et al. (2017) reported on the performance of Arizona's SPS-3 sections, including a discussion of the many limitations of the study. In addition to construction problems, monitoring problems, and problems with the experimental design, the study concluded that the selected sites for the experiment may have been too deteriorated to be considered good candidates for preventive maintenance.

A second example of ADOT's commitment to improving pavement preservation practices was the 1995 maintenance cost-effectiveness study (ADOT SPR-371). This project resulted in the construction of over 200 bituminous test sections covering three different phases to study the contributions of wearing courses (Phase I), surface treatments (Phase II), and sealer-rejuvenators (Phase III). Building these sections was a collaborative effort of materials suppliers, contractors, and ADOT, resulting in the construction of test sections at 10 sites around the State between 1999 and 2002 (Peshkin 2006).

In June 2022, ADOT published a study (ADOT SPR-769) suggesting a framework for long-term monitoring and evaluation of surface treatment performance. ADOT intends to apply the study results to guide the use of existing pavement management data collection efforts to monitor preservation treatment effectiveness. ADOT also expects to enhance the analysis capabilities of its pavement management system to monitor the performance of pavements after the application of surface treatments.

Illinois DOT Pavement Preservation Program

IDOT conducted a study in the early 2010s to track the performance of pavement preservation projects throughout the State and evaluate treatment performance. The following treatments were included in the monitoring efforts:

- Bituminous surface treatments.
- Single-pass slurry seal.
- Single-pass microsurfacing.
- Two-pass microsurfacing.
- Cape seal.
- Surface Maintenance at the Right Time (SMART) overlays (thin asphalt overlays).

The study found that the following issues were adversely affecting IDOT's ability to monitor performance of pavement preservation projects:

- Surface treatments were placed on pavements that were not suitable candidates for preservation (extensive amounts of structural distress).
- The condition rating survey (CRS) methodology did not capture the effect of preservation treatments accurately because the condition rating value would only receive a slight adjustment following a preservation project. In many cases, the CRS values associated with the preservation treatment could not be distinguished from the CRS value of adjoining control sections due to limitations with the data collection methodology at the time. Additionally, the CRS is a composite condition indicator derived from several pavement surface distresses, but it does not include factors such as texture and friction which can be important when monitoring effectiveness of surface treatments.

Since the time of that study, IDOT corrected the rating method to more accurately track condition values following pavement preservation treatments and includes specific deterioration curves to track performance.

Project and Program Planning

Performance Measures for Pavement Preservation

As discussed earlier, Rada et al. (2018) conducted a study to identify and validate pavement performance measures that consider the impact of preservation treatments on overall pavement performance, service life, and life-cycle cost. The study also resulted in the development of a methodology for assessing alternate performance measures that can be used for project and program planning purposes. A framework for assessing alternate performance measures was developed and is shown in figure 5 (Rada et al. 2018).

1. Does alternate performance measure capture performance indicators not addressed by these measures being considered for replacement (e.g., skid resistance may be only measure that captures friction of pavement surface)?	No	Do not consider alternate performance measure unless there are other considerations (e.g., agency plans on transitioning to another measure that captures same performance indicator).
Yes		
2. Are data available to support development of performance models for alternate measure?	No	Do not consider performance measure; take steps to generate needed data, or identify alternate data sources.
Yes		
3. Is data quality adequate to support development of performance models for the alternate measure?	No	Do not consider performance measure; take steps to address quality issues or identify alternate data source(s).
Yes		
4. Can risk impacts be assessed using measure models?	No	Do not consider performance measure or identify alternate data source(s) to estimate model errors.
Yes		
5. Are effects of preservation treatments on pavement performance quantified by the alternate measure?	No	Do not consider performance measure.
Yes		
6. Is agency familiar with measure and is it easy to implement within agency's pavement management system (PMS)?	No	Consider other alternate performance measure.
Yes		
Performance measure may be used by agency		

Figure 5. Approach for assessing alternate performance measures.

A three-step process was laid out for implementing the performance measures into the agency planning process, as shown in figure 6 (Rada et al. 2018):

- Step 1: Select appropriate performance measures.
- Step 2: Assess effectiveness of preservation treatments using selected measures.
- Step 3: Incorporate promising measures into the agency's pavement management practices.

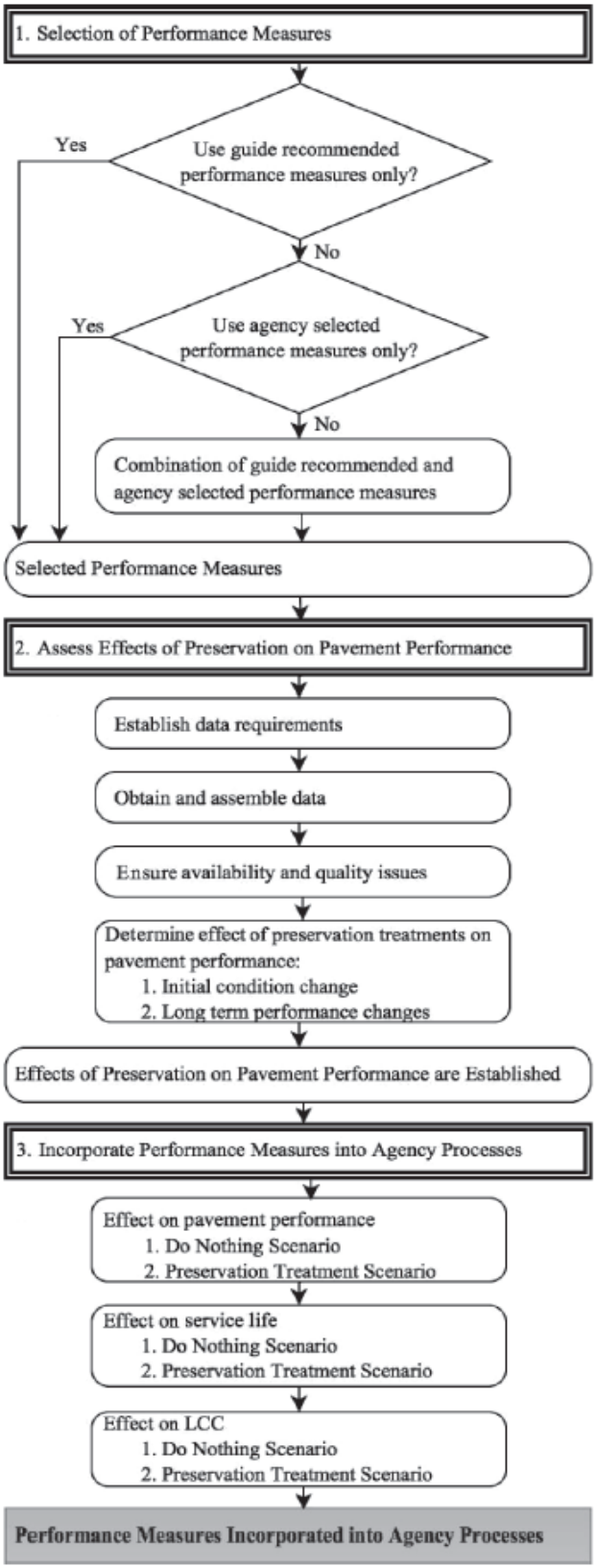


Figure 6. General approach to implementation of pavement preservation performance measures.

Life-Cycle Planning Analyses

According to 23 CFR 515.5, life-cycle planning (LCP) is defined as "a process to estimate the cost of managing an asset class, or asset sub-group, over its whole life with consideration for minimizing cost while preserving or improving the condition." An LCP analysis can help agencies better understand the impact of different treatment strategies on pavement performance (short and long term) and can also help agencies determine the optimum level of funding for pavement preservation activities.

Ohio DOT (ODOT) Life-Cycle Planning Analysis

ODOT conducted an LCP analysis to evaluate the financial impact of increasing the use of chip seals on low-volume roads that met certain criteria. The analysis was conducted using the assumption that facilities with average daily truck traffic levels less than 250 and average traffic less than 2,500 vehicles were eligible for chip seals, which in turn determined that approximately 48 percent of Ohio's low-volume roads were eligible for chip seals. Historically, asphalt mill and inlay has been the most common treatment applied on the low-volume roadway network. The analysis showed that replacement of 50 percent of the overlay projects with chip seals would result in cost savings of more than $300 million dollars over a 4-year period (ODOT 2019).

Arizona DOT (ADOT) Life-Cycle Planning Analysis

As part of its transportation asset management plan development effort, ADOT conducted a life-cycle planning analysis to determine the optimum level of funding for the pavement preservation program. ADOT reviewed the outputs from the pavement management system analysis to determine the total amount of preservation funding that was unspent at the end of the analysis period due to the lack of qualified candidates. This analysis was repeated for varying levels of preservation funding. As illustrated in figure 7, preservation funding levels between 27 and 30 percent of the total program funding resulted in the maximum use of preservation funds (> 99 percent). Based on this analysis, ADOT allocated approximately 28 percent of the total funding toward preservation treatments.

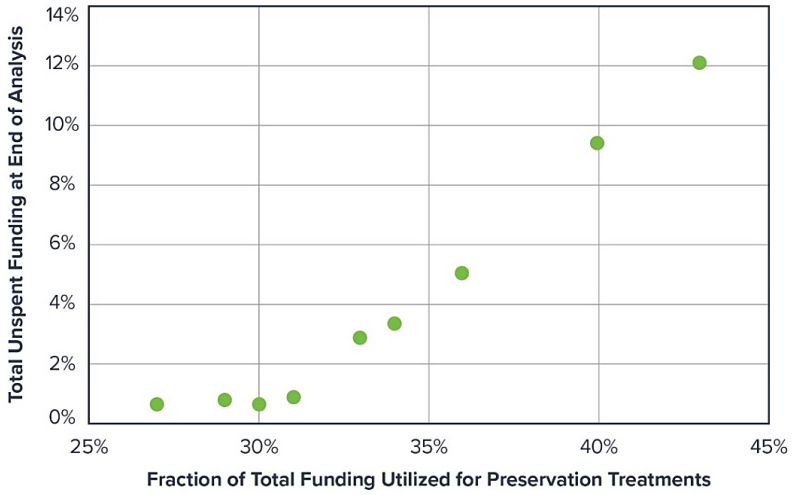


Figure 7. Illustration of the approach used in ADOT to determine the optimum funding allocation for preservation treatments.

Summary

Pavement preservation programs have been studied extensively over the past 20 years. Surveys of practice have helped to identify the existence and size of preservation programs and what preservation treatments are commonly used. A significant finding is that pavement preservation programs have matured in most agencies as evidenced in the reporting on program successes and their ability to deal with preservation challenges.

CHAPTER 3: BENCHMARK SURVEY RESPONSES

Overview

To document the state of pavement preservation practices in the United States, FHWA conducted an online survey of 50 State DOTs in 2021 (OMB Control Number 2125-0628).

The survey questions were organized into the following categories:

- Overview of the agency pavement preservation program.
- Preservation guidance and tools.
- Program monitoring.
- Project and program planning.
- Opportunities.

Each of the multiple-choice or check-box questions in the survey included the ability to provide expanded explanations of the responses.

This chapter presents the results of the survey, both graphically and in a summary. The results can be used both to better understand current practices in pavement preservation at the State level and to identify possible improvements.

Survey Responses

Program Overview

Responses to the first set of questions were intended to generate a broad overview of agency preservation programs and practices. The first of six background questions were formulated to characterize the agency's pavement preservation practices. The responses are summarized in figure 8. Twenty-seven respondents reported the existence of a formal pavement preservation policy, either documented well or not, while 22 reported the State had no such policy. One of those 22 States said there is no preservation program.

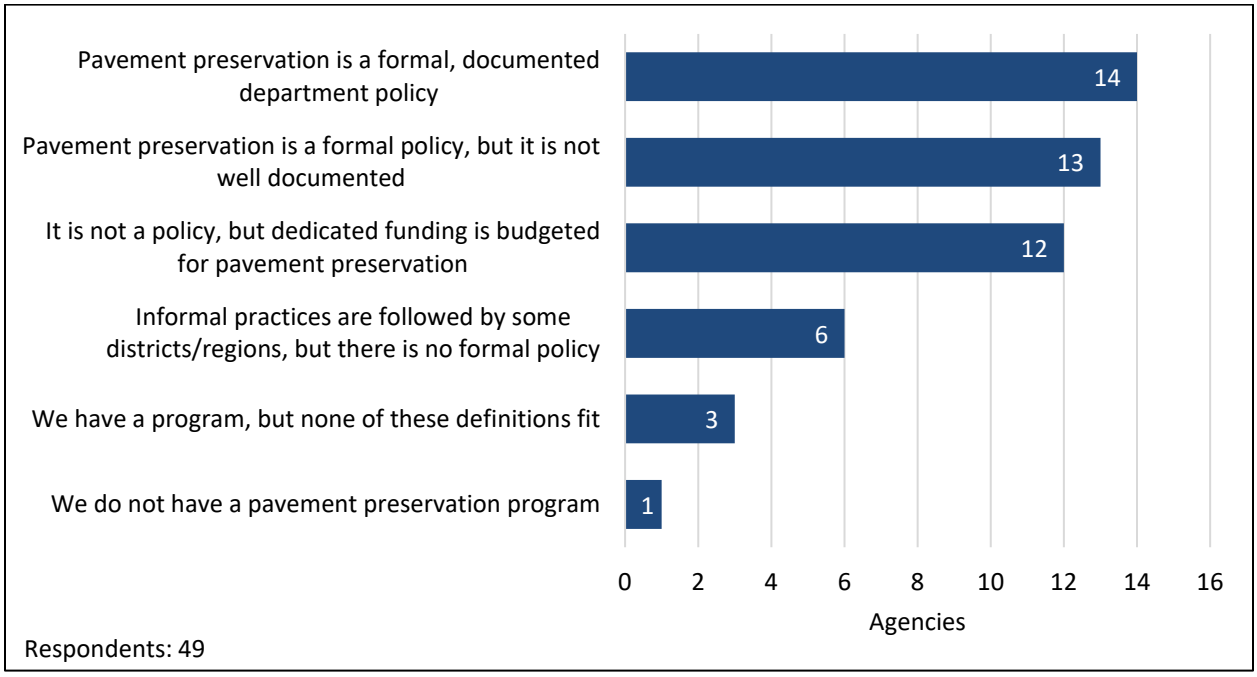


Figure 8. Responses to Q1: Which of the following statements best characterizes your agency's pavement preservation program?

The next question asked how long agencies have had a pavement preservation program. The responses are shown in figure 9 and indicate that all but one of the agencies have a program at least 3 years old; 35 of the 48 States noted a program older than 10 years.

Agencies were also asked to describe the maturity of the pavement preservation program. The choices and responses are indicated in figure 10. Nine of the 50 responding agencies indicated the program was advanced enough that others could learn from and follow it, 12 stated the agency had a good program although not fully mature, and 27 stated there was room for improvement. Only two agencies described programs as being in their infancy. The responses to these first three questions suggest that while the programs and practices associated with pavement preservation have been around for many years, not all of these are mature programs based on formal, documented practices, or represent what the States feel are best practices.

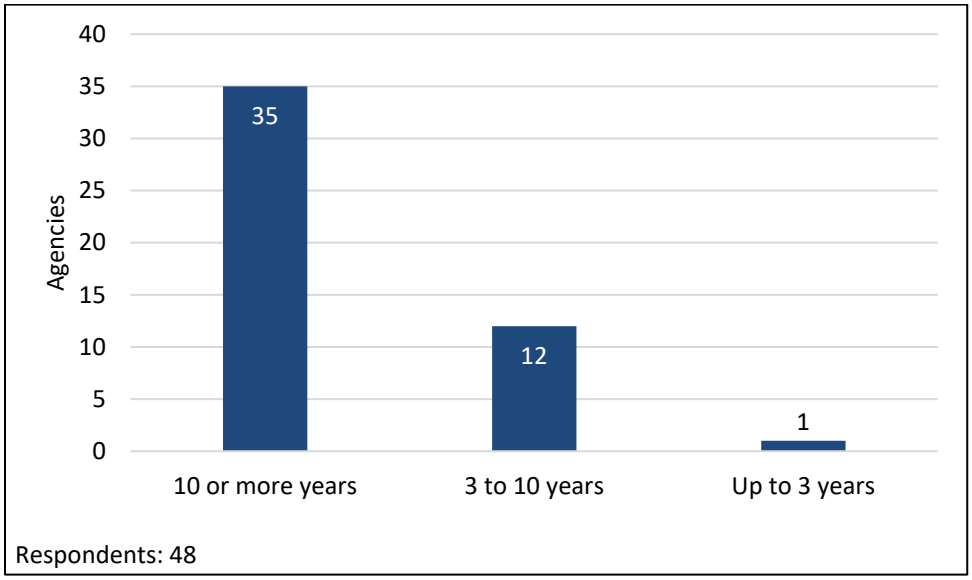


Figure 9. Number of years agencies reported having a pavement preservation program.

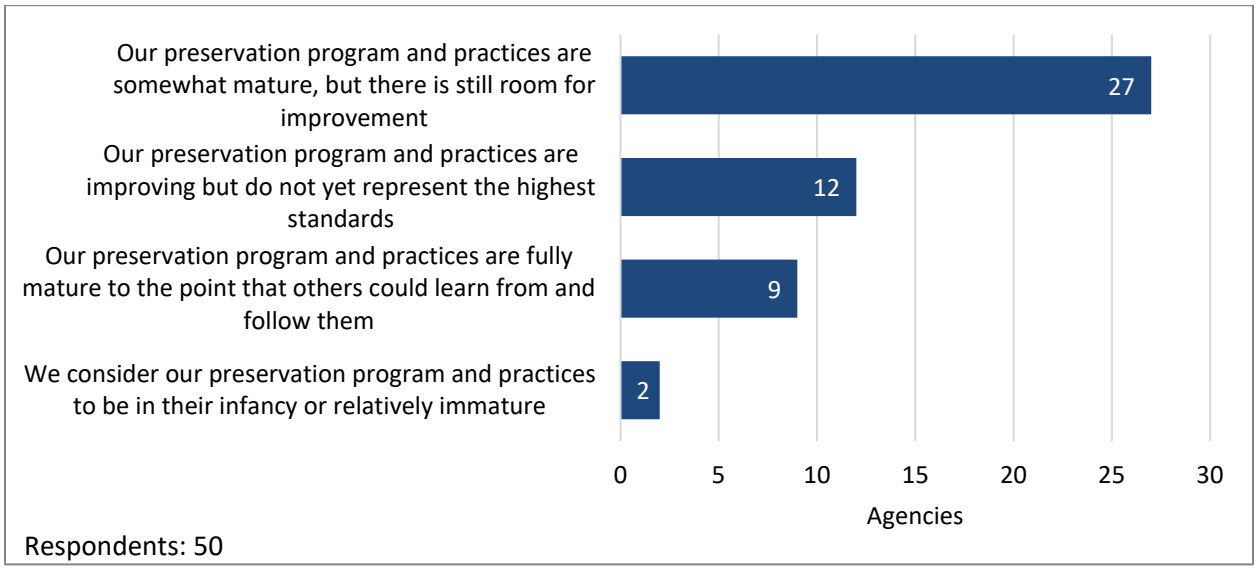


Figure 10. Agency descriptions of preservation program maturity.

Agencies also were asked about program funding source and amount. Funding for many preservation programs initially was carved from related budgetary line items such as maintenance, rehabilitation, or other capital programs. As such, preservation competed with those programs for funding. Survey responses, shown in figure 11, reflect a range of current sources for pavement preservation funding, from dedicated funds, funds from a variety of line-item budgets, to no special funds at all. The responses also reflect that some States use multiple approaches to fund pavement preservation.

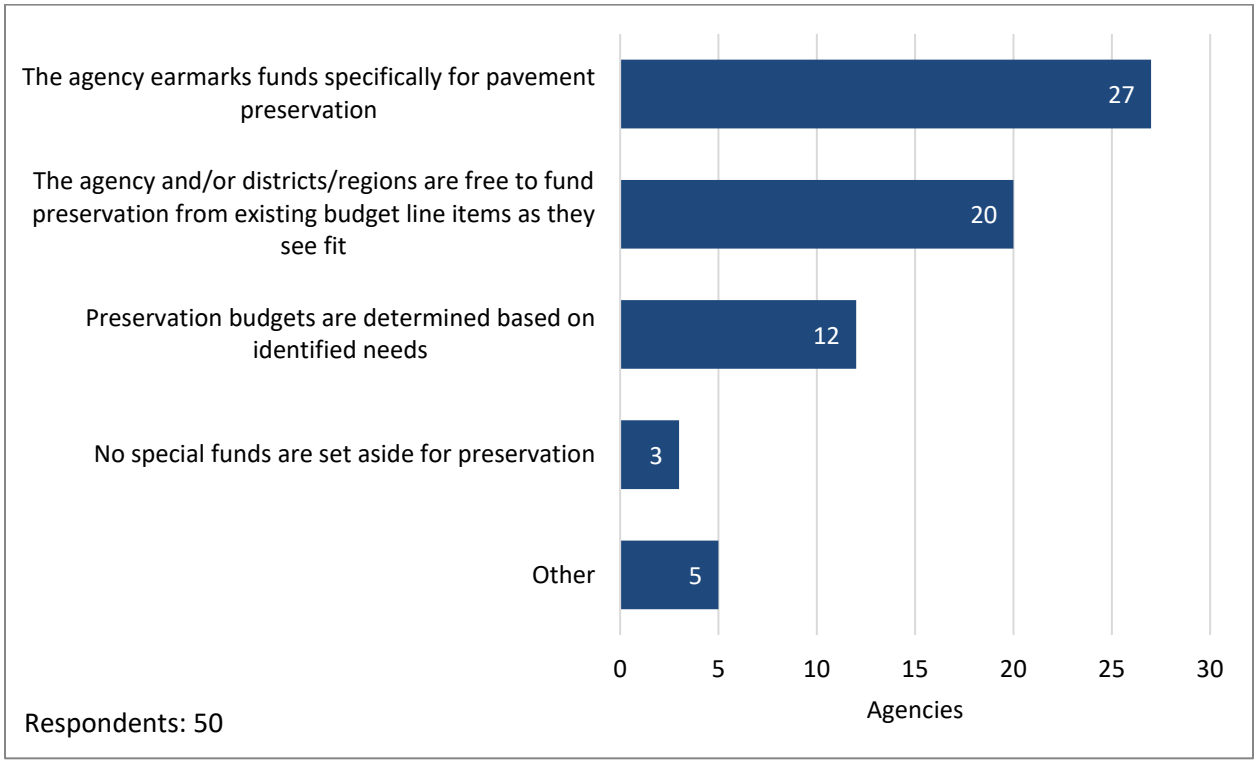


Figure 11. Sources of preservation funding.

State DOTs conduct pavement preservation programs within agency departments including research, materials, maintenance, pavement management, and planning or share decision making among different offices. Based on survey responses, several States reported collaboration in the decision process between the agency's central office and local levels. The "other" responses all indicated some hybrid, usually one in which decisions for major routes were made by a central office and decisions for other routes were made more locally.

Another background question asked respondents who constructs preservation projects. Traditionally, agencies performed most of their own maintenance work and contracted for capital improvement projects. Early preservation activities, such as crack sealing and some surface treatments, may have blurred the distinction between a purely maintenance action completed in house and a contracted project. Figure 13 shows that today, a range of practices are used to deliver preservation projects. Twenty States contracted for the construction of all preservation projects and another 28 constructed preservation treatments using both in-house resources and contractors. Only one agency constructed preservation treatments solely with in-house forces.

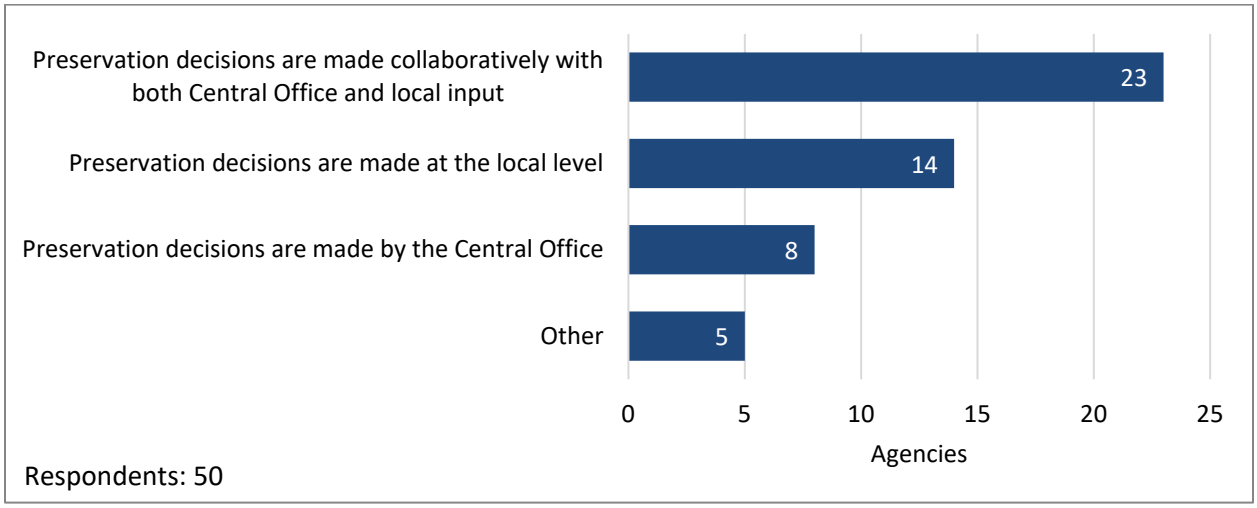


Figure 12. Office responsible for pavement preservation treatment and project selection.

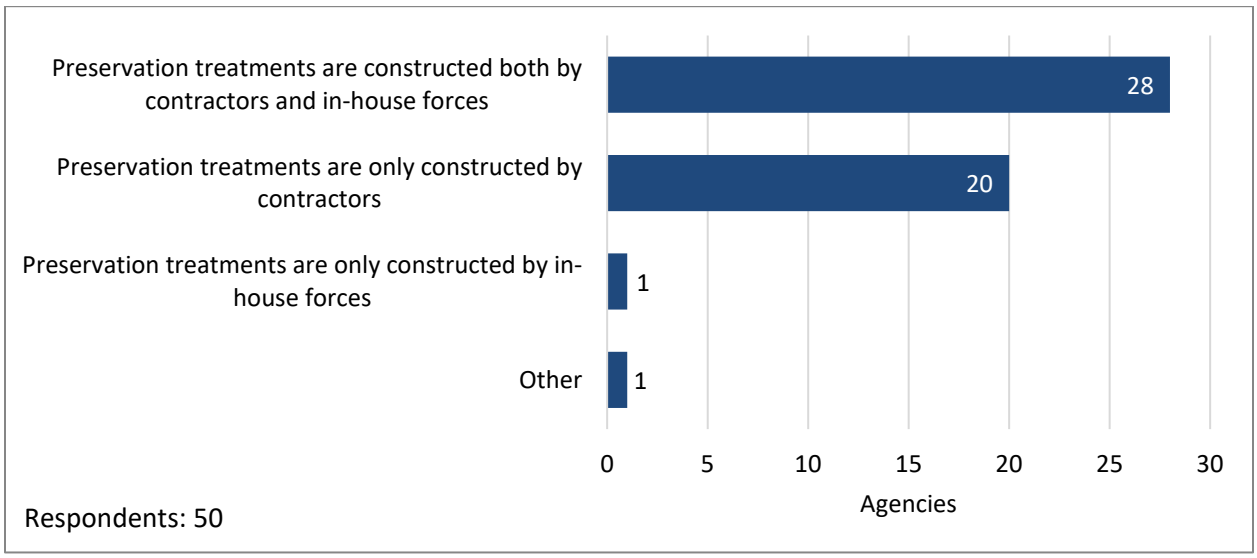


Figure 13. Methods used to construct preservation treatments.

The final set of background questions were related to the benefits of preservation programs. Respondents were asked to identify pavement preservation program benefits that are currently being realized, benefits to document in the future, and benefits that were not monitored. Thirty-two agencies responded with ability to document various benefits of pavement preservation, while two were not monitoring benefits. The results, summarized in figure 14, indicate that most of the identified benefits are improved performance, reduced costs, achieving performance targets, and increasing the miles of treated pavements. Seven of the 32 agencies reporting benefits identified safety improvements (reduction in crashes or fatalities) as an observed benefit.

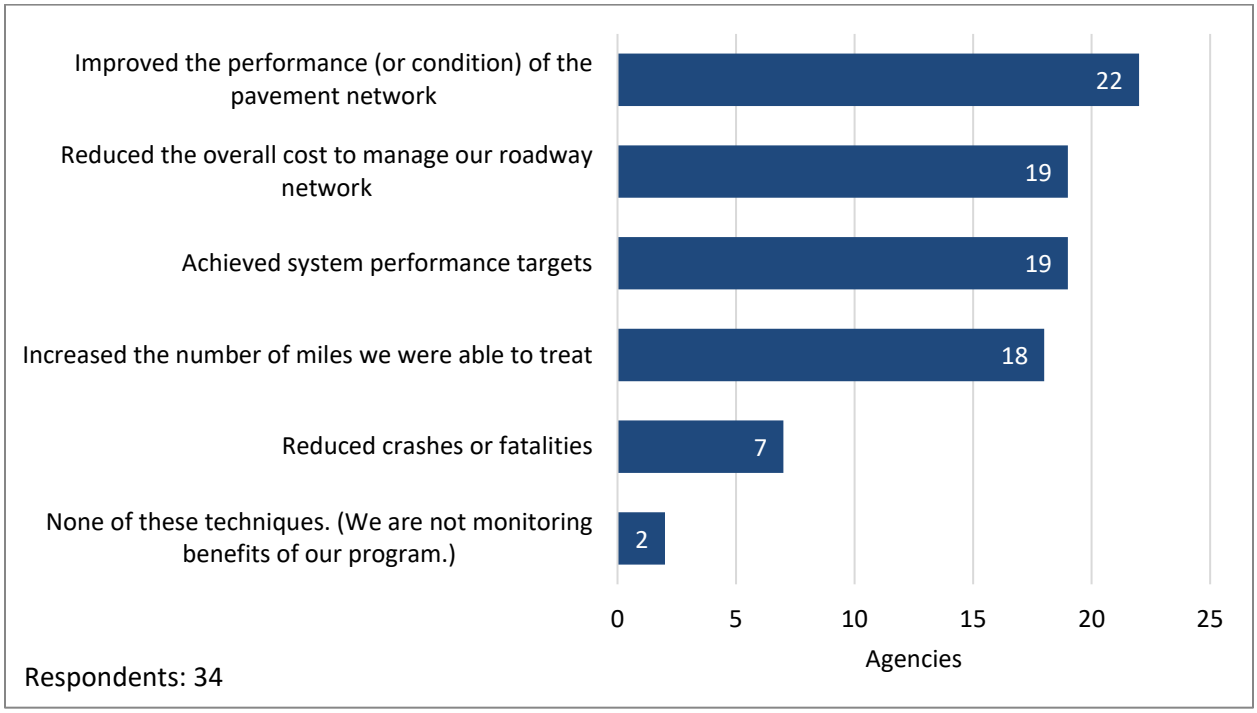


Figure 14. Documented benefits of pavement preservation.

The next question asked respondents to identify which benefits are desired to be documented. As shown in figure 15, there were 34 responses to this question. Nineteen of the responding agencies identified as desired documentable benefits the ability to achieve system performance targets, and seven identified the safety benefits of preservation as important. Since the question allowed multiple answers, figure 15 also shows that 19 identified reduced overall costs, 22 identified improved network performance, and 18 identified increased number of treated miles as benefits to document.

Agencies also were asked to identify where additional guidance in documenting potential benefits would be helpful. The 25 responses are shown in figure 16; safety improvement benefits were cited in 17 responses, followed by reduced overall costs, improved performance, and achieved performance targets, each of which were identified in about half of the responses.

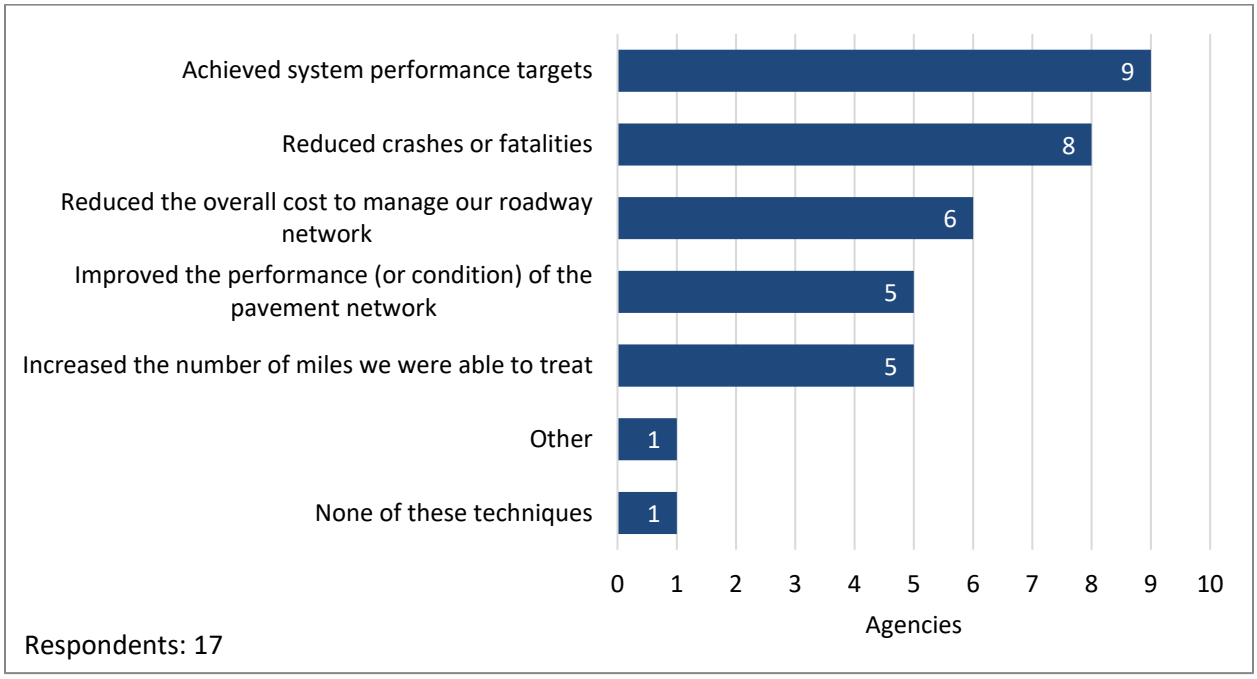


Figure 15. Benefits of pavement preservation that agencies would like to document.

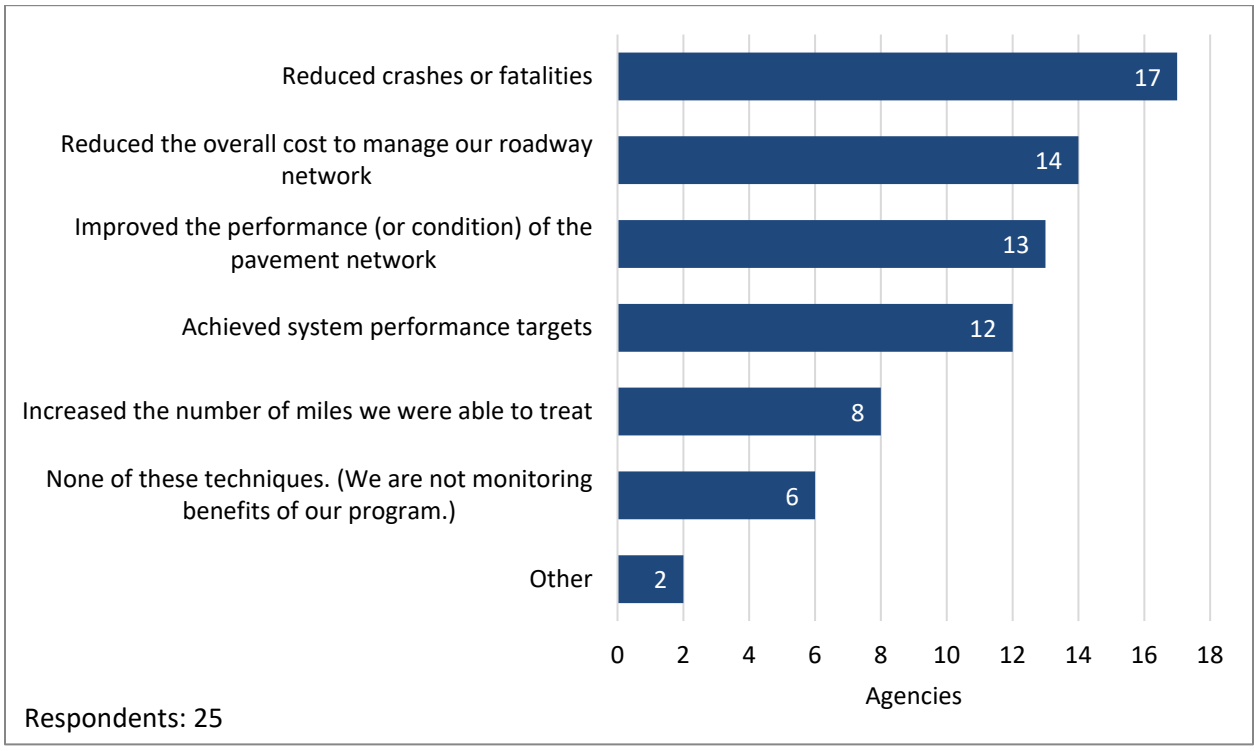


Figure 16. Additional guidance desired to identify these benefits.

A related question asked about reporting preservation program measures. As shown in figure 17, 44 of the 49 responding agencies can report on network mileage receiving preservation treatments and the magnitude of the investment in those treatments, 30 can identify the

improvement in pavement condition from preservation treatment use, and 25 can quantify the service life extension from preservation treatments. The cost saving of preservation programs are not as readily identified, as represented by the responses concerning benefit-cost and life-cycle costs associated with preservation. Only four of the respondents could report on the reduction in wet weather crashes (which could be interpreted as a measure of safety) associated with preservation.

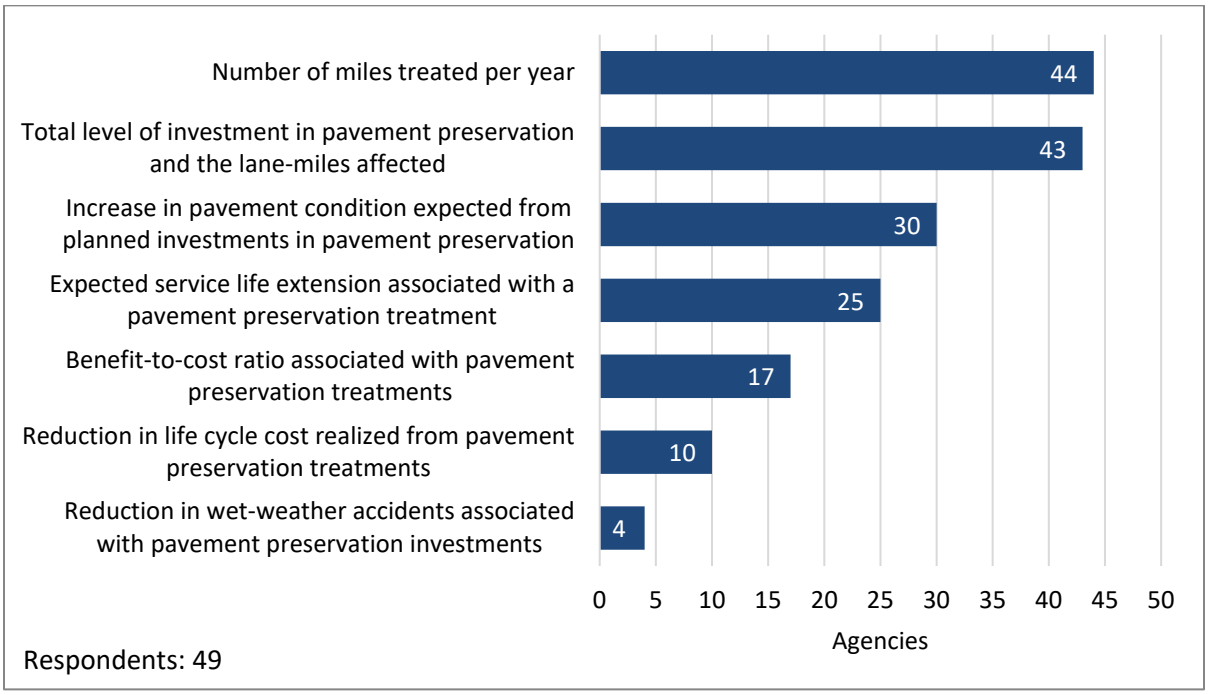


Figure 17. Preservation program measures that can be reported with confidence.

Guidance and Tools

The next set of survey questions asked agencies to provide information on what guidance and tools are available to support preservation programs. Figure 18 presents the questions and responses. The 50 responding States answered this question, and the following responses stand out as represented by a "Strongly Agree" response:

- 34 agencies have a broad range of preservation treatments in the preservation toolbox.
- 30 agencies have access to a history of preservation treatment use in a central database.
- 29 respondents have tools that track where preservation treatments have been used.

Statements with which respondents disagreed also stand out:

- 18 disagreed with the statement that preservation goals are widely known and understood within the agency.
- 17 disagreed with the statement that existing tools allow determination of the cost-effectiveness of preservation treatments.
- 14 disagreed with the statement that the preservation program differentiates between treatments applied in a stopgap manner from those intended to extend pavement life.

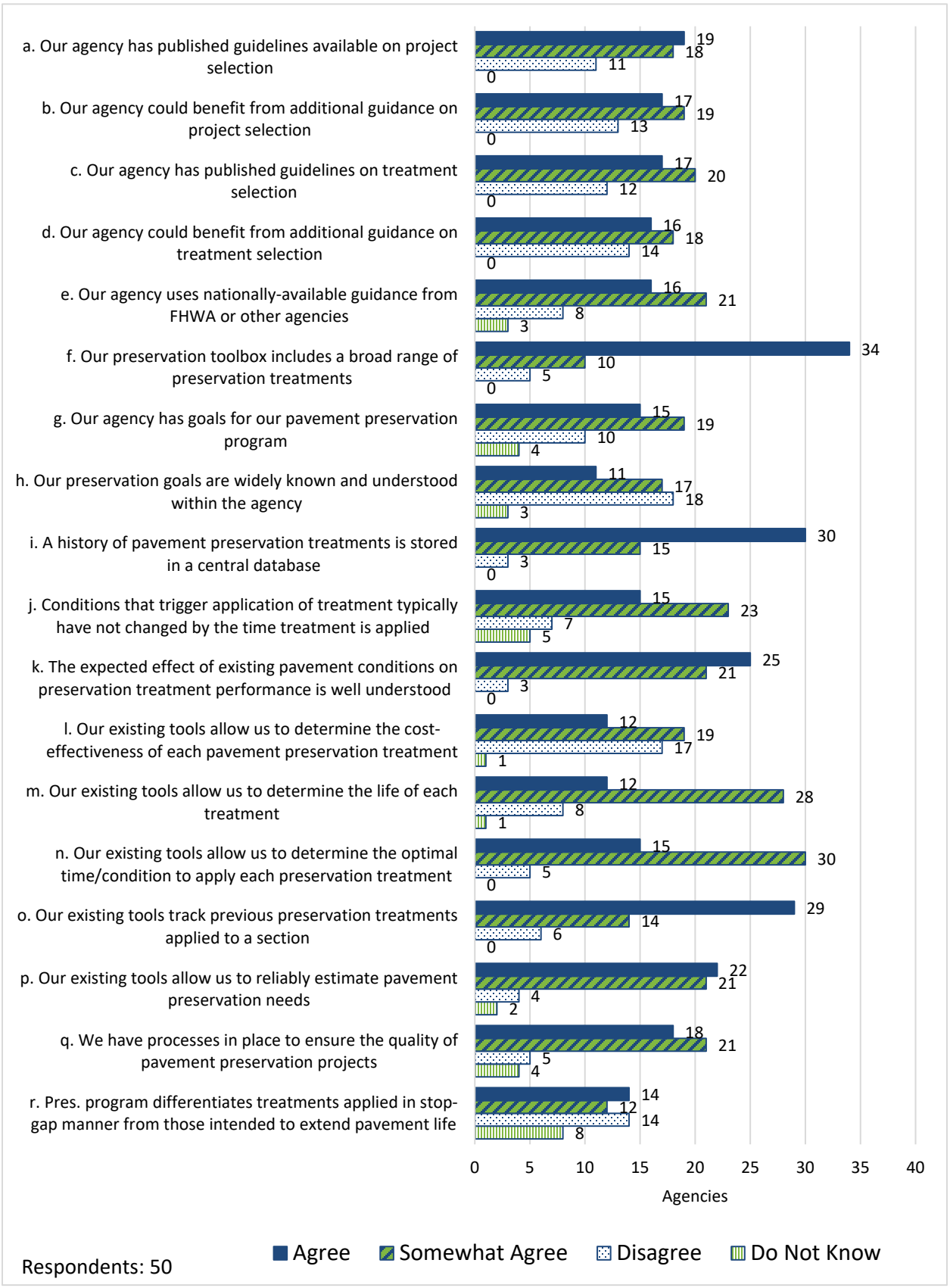


Figure 18. Availability of preservation guidance and tools.

To better understand how pavement preservation decisions are made, the survey asked about the pavement information used to make preservation project selection and treatment decisions. Available categories were individual distresses, composite ratings, ride, friction, deflection, ground penetrating radar (GPR), and other, and possible responses ranged from "regularly use the information to make decisions" to "do not use" and "would like to use." Figure 19 shows the most used sources of information are individual distresses and pavement ride, followed by pavement condition ratings. In the explanations associated with these responses there was interest in being able to make more use of deflection and GPR data, but little interest in making greater use of friction data.

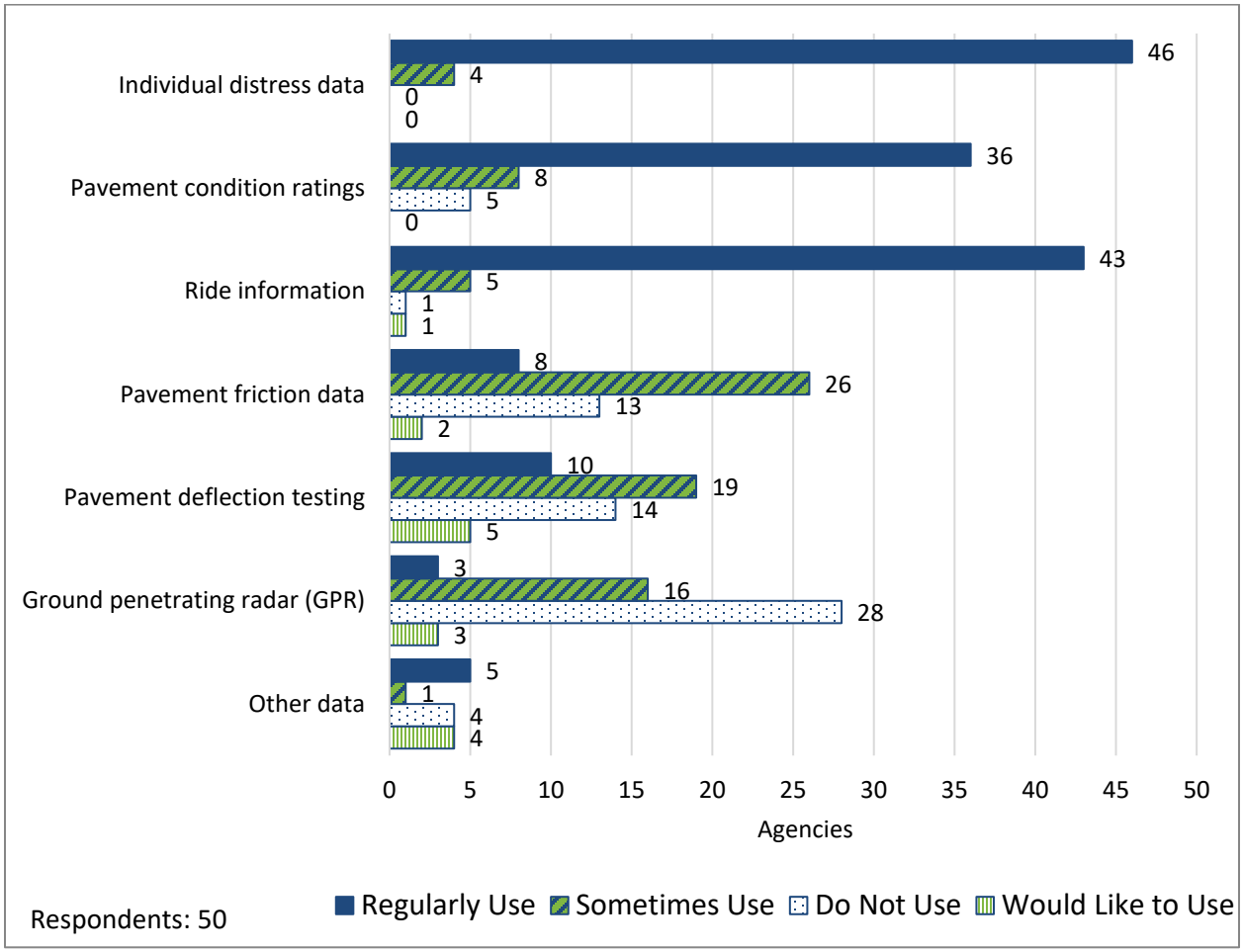


Figure 19. Types of information used to make preservation project and treatment selection decisions.

Program Monitoring

The next set of survey questions and responses explored how agencies monitor and model pavement preservation as part of the overall activities. The frequency of monitoring is represented in figure 20. However, some of the responses suggest that this monitoring is not specifically for pavement preservation, but rather for monitoring the overall network which happens to include those pavements with preservation treatments. Thirty of the 50 responding agencies monitor preservation treatment performance every 1 to 2 years while 19 either do not specifically monitor preservation treatment performance or do so under specific conditions.

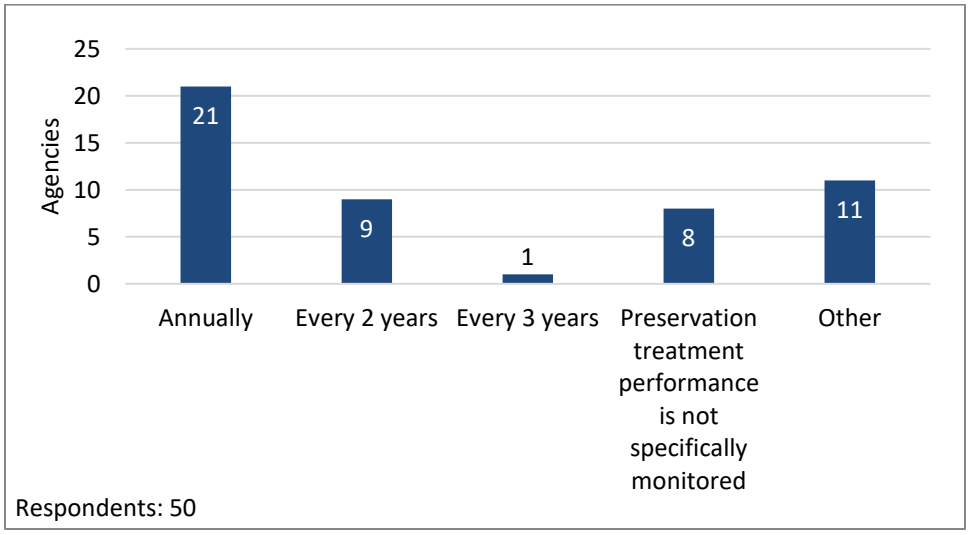


Figure 20. Frequency of performance monitoring of pavement preservation treatments.

Agencies were also asked to identify the source of pavement condition information used in preservation performance monitoring. Figure 21 shows that 44 of the 50 responding States use pavement management condition surveys for this purpose. These are supplemented by more local surveys or specialized inspections. For two of the States the information comes from a contractor-conducted maintenance management survey.

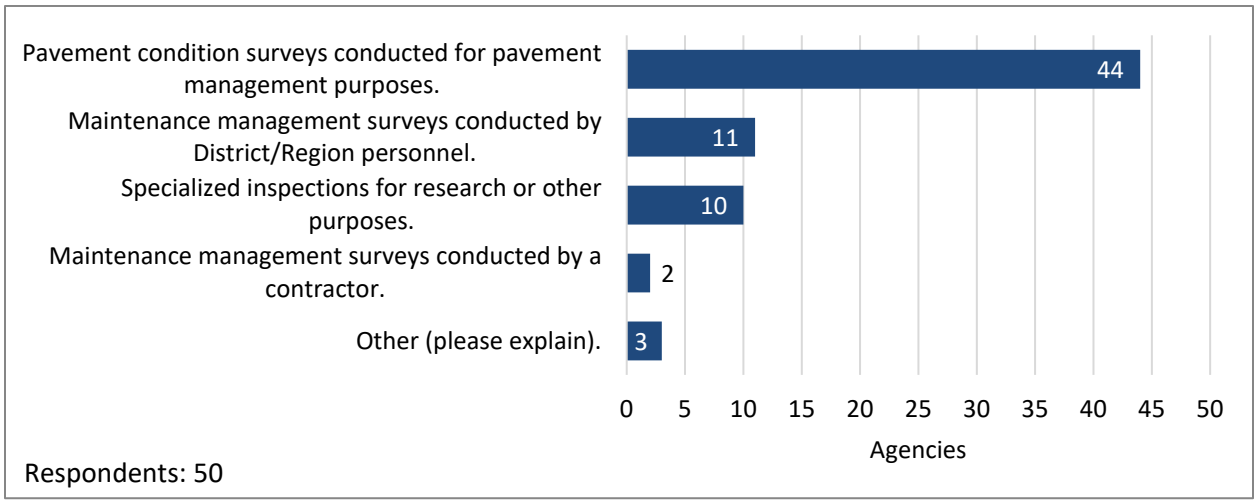


Figure 21. Sources of pavement condition information used to monitor pavement preservation performance.

If preservation program monitoring were occurring, it is likely that such an activity would generate data that could be used to understand how preservation was impacting performance and that would be accomplished through performance models. As indicated in figure 22, of the 50 responses, 14 reported there were no performance models for preservation treatments, while 36 had models for asphalt-surfaced pavement preservation treatments and 20 had them for concrete-surfaced pavement preservation treatments. Five States indicated that monitoring was refined enough to develop performance models able to distinguish between treatments placed in a proactive or preventive application and those placed in a reactive or stopgap application.

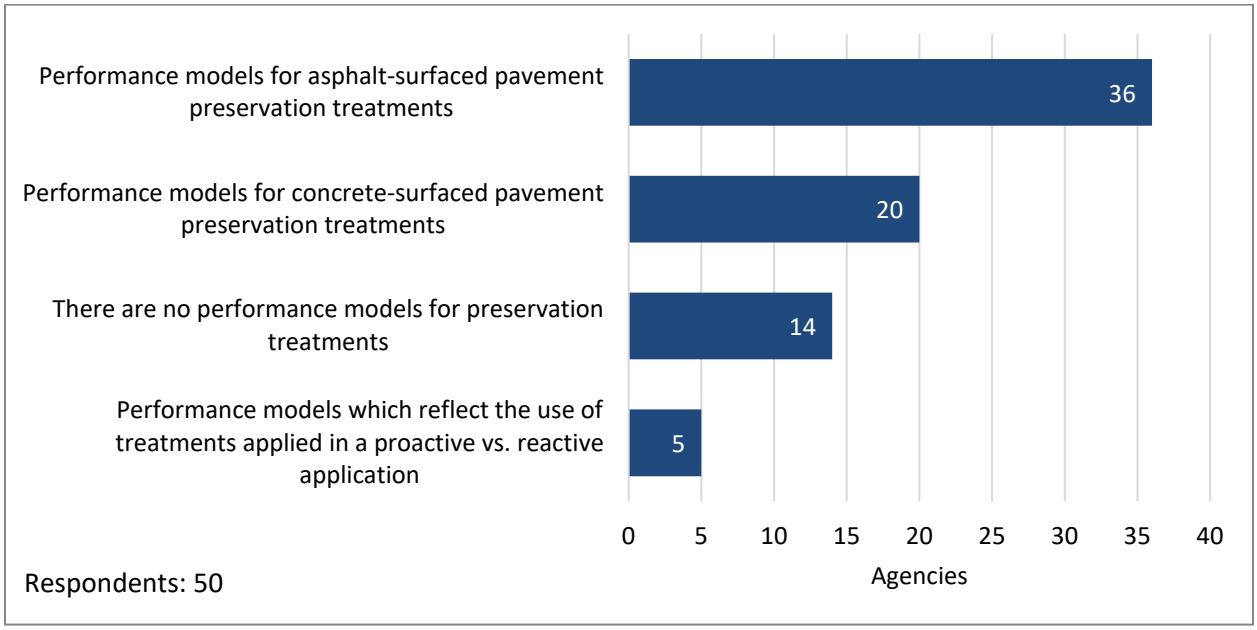


Figure 22. Development of performance models for preservation treatments.

Project and Program Planning

Three survey questions addressed preservation project and program planning. The first question asked how preservation projects are selected and multiple answers were possible. The responses from the 50 responding States are shown in figure 23, and the most common response (from 42 States) was that pavement management recommends good candidates. In a related response, 41 States said information from both pavement management systems and local knowledge is used to select projects. Additional information from the responses includes 24 States indicating use of the pavement management system to identify where preservation will be most effective and 23 program projects in clusters to improve cost-effectiveness. Where districts were involved in programming projects, 20 said actions were based on funding targets and 15 said actions were based on mileage or condition targets. Ten respondents identified a targeted cycle time or frequency as a tool to determine preservation treatment applications.

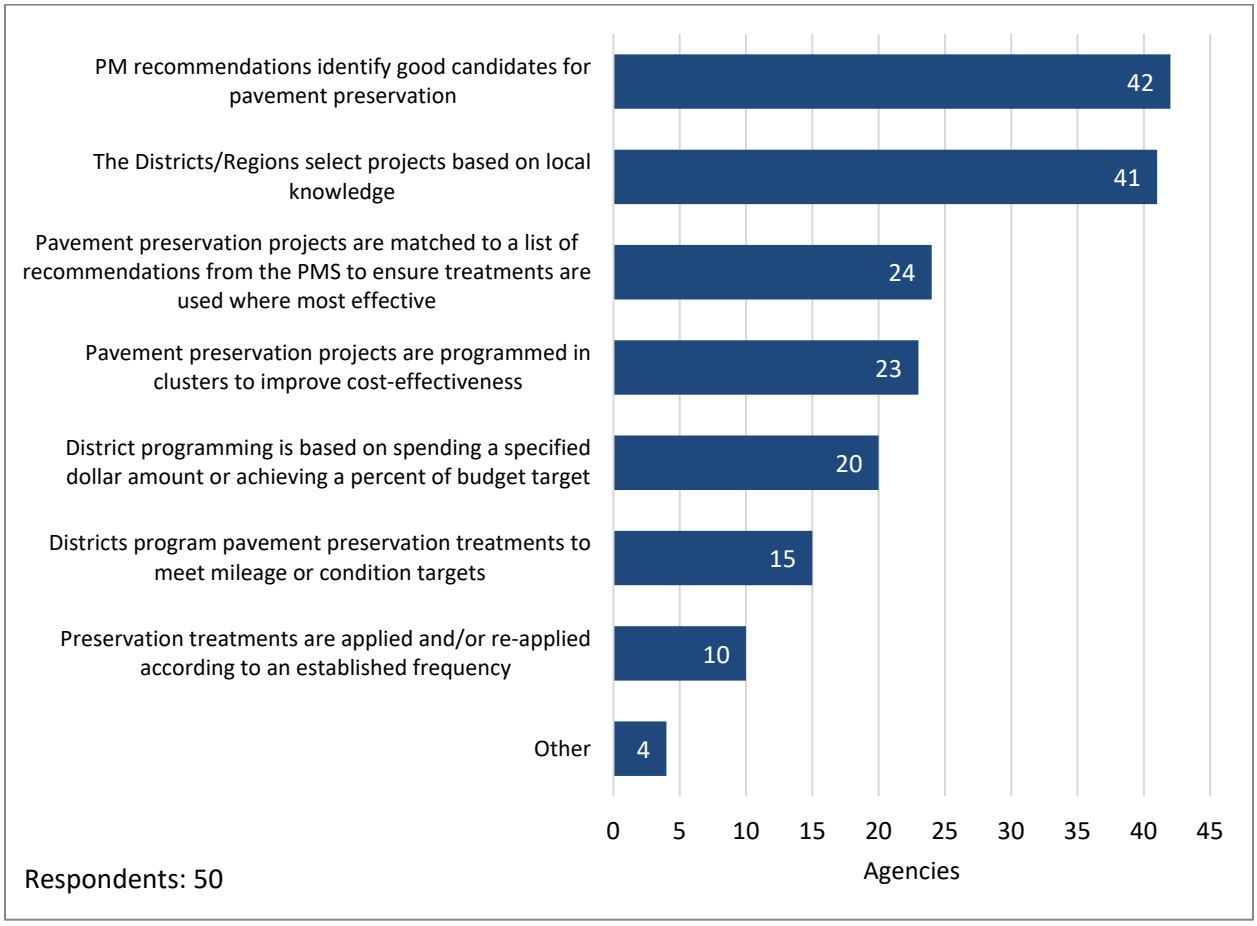


Figure 23. Approaches to project selection.

Project and treatment selections are closely related to preservation budgets. Just as selected projects can determine needed funding, available funding can also determine feasible projects. In figure 24, agency approaches to setting preservation budgets are identified. The most common of the 49 responses was that there is no specific preservation budget (the answer from 13 States). The two most common responses, when considered together, were either that an annual dollar amount for preservation is budgeted or that preservation funding is budgeted as a percentage of the overall budget; together these were 19 of the responses. Other responses included that the budget is based on needs identified by the pavement management system and the budget is based on district or region recommendations.

Figure 25 illustrates a relationship between preservation project identification and construction. Of the 49 responses, only 3 said the interval between the two is less than 1 year and 4 said that it is greater than 5 years; for 33 of the States, it is within 1 to 3 years; and for another 9, it is within 3 to 5 years.

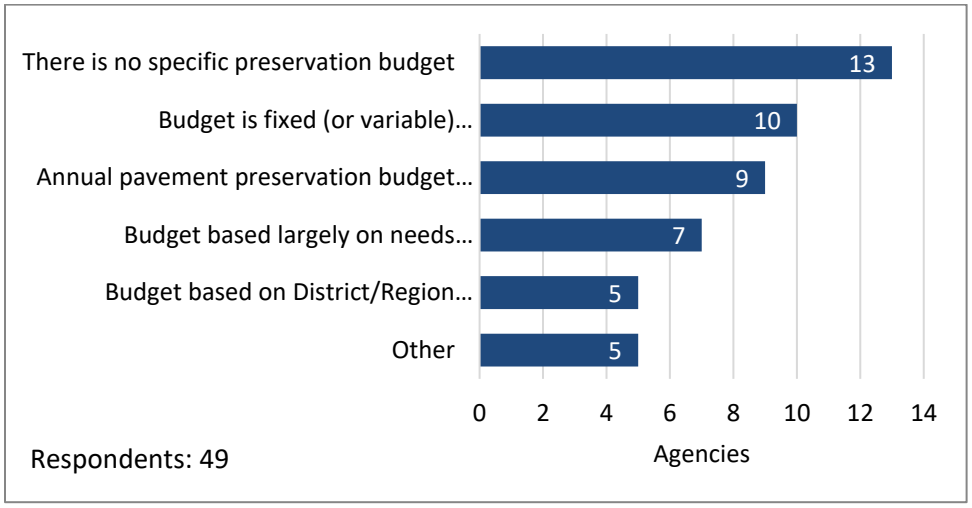


Figure 24. Methods used to establish pavement preservation program budgets.

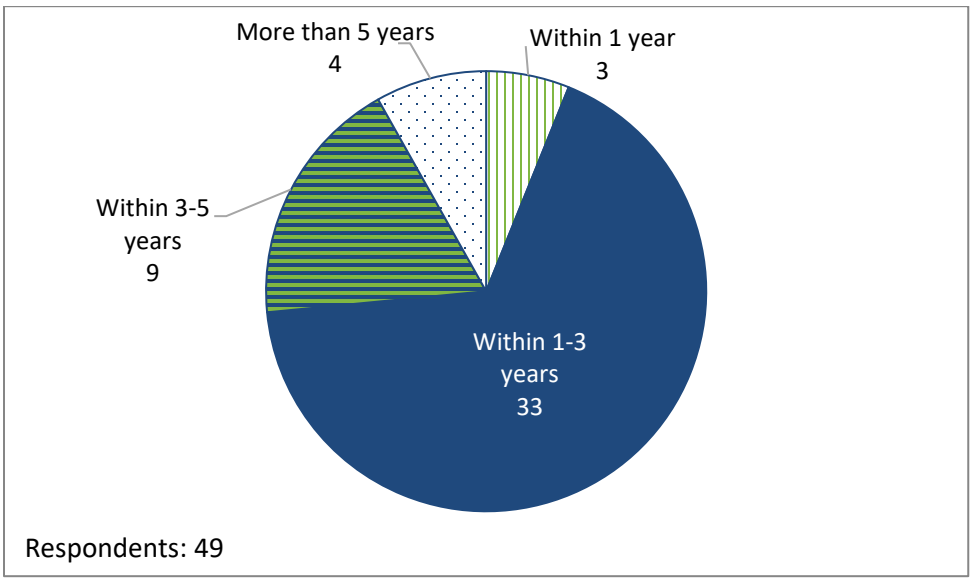


Figure 25. Interval between preservation project identification and construction.

Opportunities

The final two survey questions solicited feedback on preservation program challenges and desired program changes. Potential obstacles to successful preservation practices were listed and agencies were asked to identify those that limited program effectiveness. The responses to that question are shown in figure 26. The challenges range from issues potentially under the control of the contractor (construction quality, contractor availability, treatment failures) to those under the control of the agency (funding, lack of support for preservation, internal resistance, definitions, training, and so on). The public also presents challenges in the form of customer complaints and public perceptions about pavement preservation. There were 48 responding States, and more than one response was possible. The most common responses are summarized as follows:

- Construction quality issues – 32 agencies.
- Inadequate funding – 26 agencies.
- Customer complaints, contractor unavailability, and pressure to address more urgent needs – 19 agencies for each.

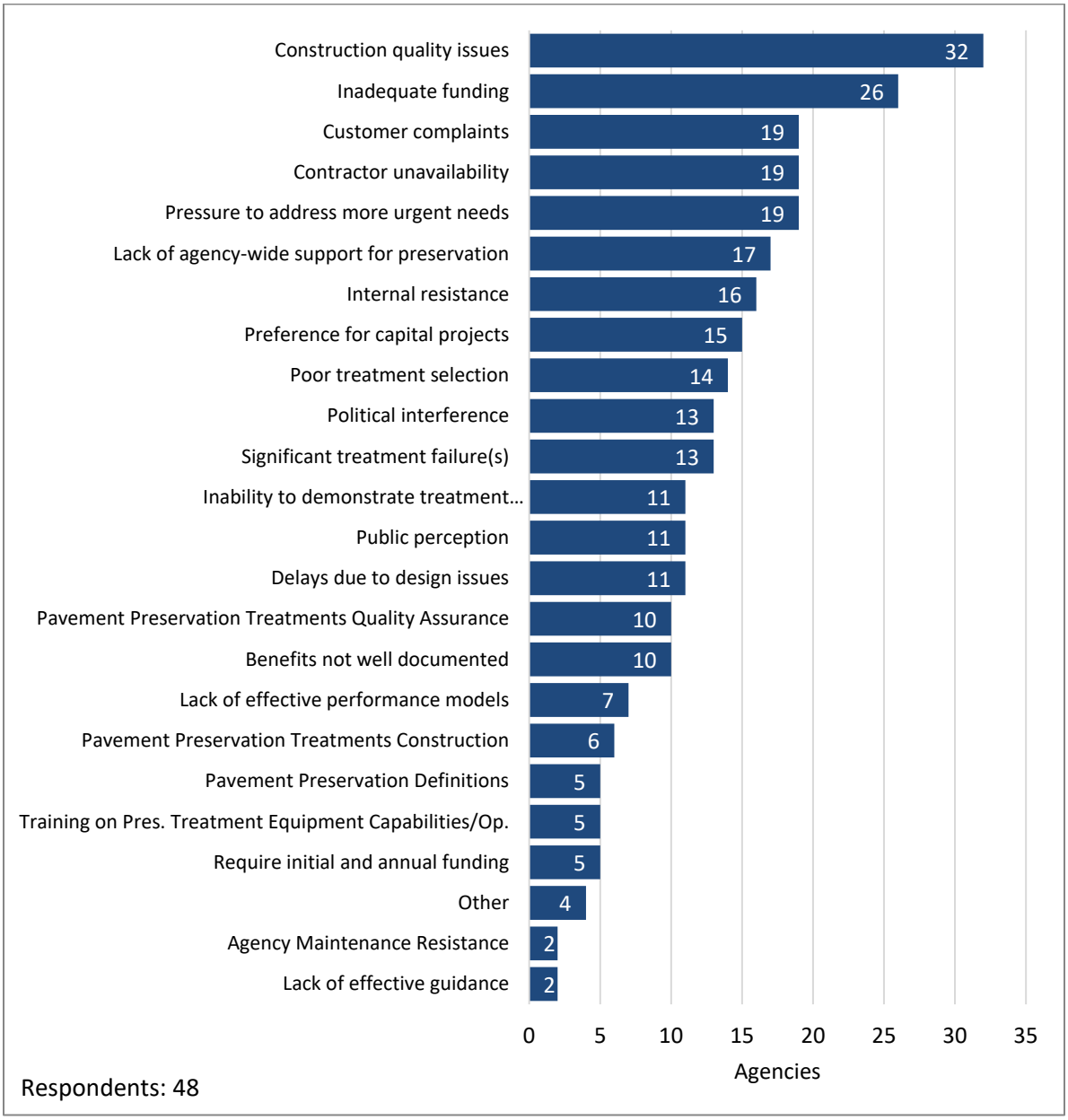


Figure 26. Identified obstacles to the effectiveness of pavement preservation programs.

The final survey question asked agencies to identify program changes being made or that they would make if there were no constraints. In general, agencies included ways to overcome some of the previously identified obstacles and shortcomings, including more training, improved performance models, better identification of needs and establishment of appropriate budgets, improved guidance, and so on.

CHAPTER 4: GAP ANALYSIS

Using the results of the literature review and survey responses (OMB Control Number 2125-0628), this chapter examines key aspects of preservation practices to identify where gaps exist.

Formal Preservation Policy

A preservation policy is a formal statement of an agency's commitment and approach to pavement preservation. A policy might address funding for pavement preservation, while also defining appropriate preservation treatments and strategies and providing further information on project and treatment selection. An example of a formal pavement preservation policy is Mississippi's preservation and treatment policy for Federal-aid projects (Mississippi 2018), consisting of a two-page memo that identifies eligible preservation and preventive maintenance treatments and the conditions under which they may be applied, along with other qualifying factors.

Reviewing the survey responses, 27 agencies reported having a pavement preservation policy of some sort, and 21 agencies did not. However, all 48 agencies responding to the question about preservation practices indicated use of a pavement preservation program, perhaps indicating that there are even more agencies engaged in pavement preservation without a formal policy. Indeed, a number of agencies further explained that in the absence of a formal policy, internal guidelines were used to determine preservation needs. Some agencies identified that preservation actions were decentralized to the extent that districts applied internal policies.

This alone does not resolve the question of whether a formal State DOT policy is essential, but it suggests that it is not. However, a policy may help to grow or support a preservation program or make it more internally competitive against other practices. This can be especially important if an agency is trying to move away from a worst-first approach in which pavements significantly deteriorate before receiving a treatment.

Funding for Pavement Preservation

The survey suggests that State DOTs tie funding for pavement preservation to the presence of a preservation policy. The survey further suggested that in some agencies funding is viewed as a zero-sum equation in which the funding for preservation is subtracted from some other program. Funding for preservation may also be combined with other actions, such as minor rehabilitation, which can create competition between programs. Budgeting tradeoffs between programs are typically required.

In responding to the survey, 27 agencies reported earmarking funds for preservation (either as a fixed amount or as a percentage of overall funds), 20 agencies were free to fund preservation from existing budgets (suggesting no funds were earmarked for preservation), and 12 agencies responded that preservation budgets were determined based on need. One agency noted that each district has targeted performance levels for roadways, and it would not be possible to reach the established levels without preservation being adopted along with other treatments. These responses suggest that a range of practices is in use, and each may be successful for different reasons.

Ideally, how an agency manages its pavements would be based on maximizing measures of pavement performance within budgetary constraints. Such a practice would result in the use of a range of strategies from preservation to rehabilitation to reconstruction, with none favored over

the other, and with funding in any given year going to those strategies yielding the greatest benefits in the most cost-effective manner. The reality is that there are many other factors that determine which pavement programs are supported and to what extent. While dedicated funding for preservation programs has been viewed as a key to success in the past (Davies and Sorenson 2000, Gray 2017), today it may be concluded that programs and practices have continued to evolve, and support (and funding) for preservation as one of several strategies for managing pavements is what is required.

Decision Making

States have developed different organizational structures where decisions are made about pavement preservation—such as selecting projects or treatments—that have an important role in successful preservation programs. The practice of pavement preservation has typically originated from the central office, with staff at that level having initial access to training and promotion of pavement preservation concepts. Conversely, project selection in general is more likely to be a local decision, where there is greater familiarity with how pavements perform and when they need treatment.

Survey responses indicate that 23 out of 50 agencies make pavement preservation decisions collaboratively, with input both from the central office and locally, while 14 out of 50 make the decision at the local level and 8 out of 50 agencies make the decisions at the central office. A desirable objective is to have such decisions made by those who are both knowledgeable about the pavements themselves and have a good understanding about pavement preservation; as such, a combination of local and central office inputs to the decision process is most likely to lead to positive outcomes from the preservation program. The knowledge and understanding from both sources are not mutually exclusive (i.e., having one does not preclude the other) nor is there a preferred manner in which this combination is accomplished. Collaboration between the central office and local offices appears to be a preferred way to ensure that in-depth knowledge about pavement preservation is combined with local knowledge of road conditions. Such collaboration may also lead to more widespread acceptance of pavement preservation, with interaction and feedback occurring between the central office and local interests.

The survey responses suggest that an agency's preference for organizational decision making does not affect the ability to deliver an effective preservation program.

Project Selection

As noted above, selecting projects for pavement preservation is summarized in the survey responses:

- Pavement management system identifies good candidates (42).
- Districts/regions select projects based on local knowledge (41).
- Projects recommended locally are matched to pavement management recommendations (24).
- Projects are programmed in clusters to improve cost-effectiveness (23).
- District programming is based on a spending, budget, mileage, or condition target (45).

With multiple responses allowed, the most common practice is a combination of pavement management system outputs and local knowledge, with objectives related to budgets, mileage, or conditions as additional considerations.

Contracting vs. Agency Construction

In the past it was common for State DOTs to construct preservation treatments with internal equipment and crews. This practice is no longer common because of shortages of staffing, the need for specialized equipment and training, and safety concerns. Based on survey responses, only one agency constructs all preservation treatments with agency crews, 20 agencies construct preservation treatments only with contractors, and 28 use a combination of the two.

In the end, who performs the work is less important than how it is performed. Quality is paramount to realizing the benefits of pavement preservation, but quality is achieved by focusing on good design, appropriate specifications, and timely inspection and acceptance.

Pavement Preservation Performance Monitoring

It is important to know where preservation is placed and under what conditions, and how both the pavement and the treatment have performed since construction. This knowledge is crucial to improving the practice of pavement preservation and applying its benefits. Thirty agencies reported that performance monitoring is done either annually or every 2 years; 8 said that performance is not specifically monitored. In 44 of 50 agencies, pavement condition surveys conducted for pavement management services were used to monitor pavement preservation performance.

In the survey, State DOTs indicated many potential benefits of preservation programs, including the following five:

- Improve performance or condition of the roadway network.
- Reduce overall cost to manage roadway network.
- Positively contribute to system performance targets.
- Increase the number of miles that can be treated.
- Reduce crashes/fatalities.

The following responses (out of 49) were provided when agencies were asked about the preservation program measures that could be reported on with confidence:

- Number of treated miles (44).
- Level of investment (43).
- Increase in pavement condition (30).
- Expected service life extension associated with a pavement preservation treatment (25).
- Benefit-to-cost ratio associated with pavement preservation (17).
- Reduction in Life Cycle Costs from pavement preservation (10).
- Reduction in wet-weather crashes due to pavement preservation (4).

This information is useful is in modeling pavement preservation and documenting its benefits.

Performance Models Incorporating Preservation

As noted above, where preservation applications are tracked and performance is monitored, benefits from preservation can be documented. This information forms a basis for performance modeling, in which an agency's experience with pavement preservation, usually integrated in the pavement management system, can be used to document the relationship between treated pavements and changes in pavement condition. This ability further enables comparisons in performance between treated pavements and non-treated pavements or between pavements receiving one preservation treatment and pavements receiving another.

In the survey, 36 of 50 agencies responded that there were performance models for asphalt-surfaced pavements and 20 of 50 said there were models for concrete-surfaced pavements. Fourteen agencies did not have performance models for preservation treatments.

Availability of Preservation Guidance and Tools

Information on pavement preservation project and treatment selection and the purpose and effect on performance of different preservation treatments, helps agencies to improve and extend preservation programs. Many agencies use tools that support calculations of optimal timing and cost-effectiveness and facilitate tracking treatment placement and performance. Training programs, whether agency-specific or developed for a national audience, have been suggested as an effective method for preservation practitioners to learn about available references and tools and to support preservation programs.

A survey question about the availability of preservation guidance, tools, and other potential preservation program components offered three possible responses—agree, somewhat agree, and disagree—and generated a broad range of responses. The full set of responses is shown previously in figure 18, with selected responses in table 5 indicating agency-perceived gaps or needs. Reviewing individual responses, even agencies with preservation guidance available indicated a need in several instances to improve such guidance. For example, some were using national-level guidelines and stated that local guidelines were needed. Others noted the guidelines needed to be updated or were currently being evaluated and improved.

Table 5. Selected responses indicating agency needs.

Statement	Agree	Somewhat Agree	Disagree
Our agency could benefit from additional guidance on project selection.	17	19	-
Our agency could benefit from additional guidance on treatment selection.	16	18	-
Our preservation goals are widely known and understood within the agency.	-	-	18
Our existing tools allow us to determine the cost-effectiveness of each pavement preservation treatment.	-	-	17
Our existing tools allow us to determine the life of each treatment.	-	-	8
Our preservation program differentiates treatments applied in a stopgap manner from those intended to extend pavement life.	-	-	14

Improving Effectiveness

The survey asked specifically about obstacles State DOTs have faced that have hindered the effectiveness of the pavement preservation program. The responses to this question directly identify gaps from the agencies' perspective. Table 6 repeats identified obstacles in the survey and describes gaps implied by those obstacles.

Table 6. Survey-identified obstacles to pavement preservation program effectiveness and implied gaps.

Obstacle	Responses	Implied Gaps
Construction quality, quality assurance, treatment failures	55	Methods to assure construction quality, including specifications, inspection practice, construction acceptance
Inadequate funding; need for initial and annual funding	31	Connection between preservation needs and available funding
Customer complaints, public perception, political interference	43	Lack of public awareness of preservation impacts on road quality, budgets, safety
Internal challenges, more urgent needs, preference for capital projects, lack of agencywide support	67	Lack of agency awareness
Technical challenges, including poor treatment selection; inability to document effectiveness; and lack of effective performance models, preservation definitions, training, guidance	54	Tools and guidance to improve preservation programs, and awareness of existing tools and guidance, including project selection, program monitoring, modeling
Contractor unavailability	19	Commitment to preservation which would draw more contractors to provide preservation treatments; lack of collaboration between agency and contractors

Summary

Through responses to a national survey (OMB Control Number 2125-0628) and a literature review, attributes of pavement preservation program and current practice among State DOTs are identified. The presented information shows that agency practices vary widely. This chapter focuses on pavement preservation program attributes considered to be elements of good practice. These are summarized in table 7, in which each attribute is associated with one or more indicators that the attribute is in place, what the absence of that indicator means, and an explanation of the significance of the gap, if present.

Table 7. Gap summary.

Preservation Program Attribute	Key Indicator	Gap	Implications of Gap
Preservation policy	Formal pavement preservation policy	Absence of a policy addressing funding and providing guidelines for project and treatment selection	Not essential, but funding and guidelines have contributed to successful programs
Dedicated funding	Budget line item for preservation	Absence of dedicated funding	Importance of and need for dedicated funding may be linked to program maturity. Agencies have used fixed budgets, percent of overall funding, and overall network performance as approaches to meeting needs
Locus of decision making, including project selection	Individual or office responsible for preservation decisions	Not perceived as a gap	-
Performance monitoring	Access to location information including where preservation treatments are applied, which preservation treatment is used at the location, and before and after pavement condition	Inability to differentiate between treated and non-treated roadway segments; inability to track roadway performance for treated versus non-treated pavement sections	Treatment locations and pavement conditions are not known, resulting in reduced ability to determine impacts of preservation on pavement performance
Responsibility for construction	Preservation treatments constructed by contract or with agency forces	Not perceived as a gap	-
Documented impacts	Ability to quantify impacts of preservation	Agencies practicing preservation but lacking the ability to quantify those impacts	If impacts cannot be documented, program funding and treatment use may be adversely affected
Models reflecting preservation impacts	Models for asphalt and concrete pavements	Absence of models	Preservation benefits may not be quantified. Preservation may not be triggered in the PMS.
Availability of guidance and tools	Agency-specific guidance on available treatments, candidate projects, and selection guidance	No guidance or no effective guidance	No guidance, dated guidance not updated, guidance not specific to agency, guidance not widely known, available guidance not followed: all hinder program effectiveness

CHAPTER 5: SUMMARY AND CONCLUSIONS

Summary

This report presents results from a survey of State DOT practices related to pavement preservation (OMB Control Number 2125-0628) and a literature review covering the same topics addressed in the survey. Fifty State DOTs provided responses to questions organized into five broad categories:

- Overview of the responding agencies' pavement preservation programs.
- Availability of preservation guidance and tools.
- Program monitoring practices.
- Project and program planning practices.
- Opportunities for improving practice.

The overall objective of this project is to provide information describing effective State DOT practices that could be used to encourage and improve pavement preservation programs. Toward that end, the responses to the survey and content in the literature provided the following findings:

- Performance monitoring: Preservation treatment locations and pavement conditions prior to treatment application are not always known, reducing the ability to determine impacts of preservation.
- Documented impacts: For those agencies implementing preservation, an inability to document impacts puts program funding and treatment use in jeopardy.
- Pavement management models reflecting effects of preservation: Preservation benefits may not be quantified, and preservation treatments may not be triggered by management systems.
- Availability of guidance and tools: No guidance, dated guidance not updated, guidance not specific to the agency, and available guidance not widely known or not followed can all hinder programs.

The following attributes of preservation programs were observed:

- Preservation policy: May help to clarify practices, but programs can be successful without a formal policy.
- Dedicated funding: Funding for preservation has been provided in many different ways. Ideally, funding would be available to meet an identified preservation need.
- Locus of decision making: Preservation decisions may be made by a central office, locally, or a combination of both.
- Responsibility for construction: Increasingly, preservation treatments are constructed by contractors, but some work may be conducted with agency forces.

Conclusions

Two broad areas were identified where additional efforts are likely to yield benefits. The first involves a more detailed examination of the preservation program gaps and the available tools that could be used to bridge those gaps. The responses to the survey suggested that there are challenges that have not been resolved by every agency. Additionally, State DOTs suggested that additional efforts to identify and share useful tools, guidelines, and practices would likely be beneficial to many agencies. The need for better monitoring of preservation performance, modeling of that performance, and incorporating the results into improved treatment and project selection was described as a critical need by most of the survey respondents.

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). 1999. Survey by the Lead States Team on Pavement Preservation: Pavement Preservation in the United States. AASHTO, Washington, DC.

California Department of Transportation (Caltrans). 2008. *Maintenance Technical Advisory Guide*. Webpage. Accessed April 2022. State of California Department of Transportation, Sacramento, CA.

Caltrans Division of Research, Innovation and System Information (Caltrans DRISI). 2020. *Quantifying the Benefits of Routine and Preventive Maintenance: Survey of Practice*. Preliminary Investigation. PI 0244. California Department of Transportation, Sacramento, CA.

Davies, R. M. and J. Sorenson. 2000. "Pavement Preservation: Preserving our Investment in Highways." *Public Roads*. Vol. 63, No. 4. Federal Highway Administration, Washington, DC.

De León Izeppi, E., A. Morrison, G. W. Flintsch, and K. K. McGhee. 2015. *Best Practices and Performance Assessment for Preventive Maintenance Treatments for Virginia Pavements*. FHWA/VCTIR 16-R3. Virginia Center for Transportation Innovation and Research, Charlottesville, VA.

Dufalla, N., S. M. Karamihas, J. Puccinelli, and K. Senn. 2017. *Performance Evaluation of Arizona's LTPP SPS-3 Project: Strategic Study of Maintenance Procedure Effectiveness for Flexible Pavements*. SPR-396-3. Arizona Department of Transportation, Phoenix, AZ.

Federal Highway Administration (FHWA). 2016. *Guidance on Highway Preservation and Maintenance*. Memorandum. Federal Highway Administration, Washington, DC.

Federal Highway Administration (FHWA). 2019. *Transportation Performance Management*. Webpage (Definition). Accessed February 2022. Federal Highway Administration, Washington, DC.

Geiger, D. R. 2005. *Pavement Preservation Definitions.* Superseded memo distributed within FHWA. Webpage. Accessed June 2020. Federal Highway Administration, Washington, DC.

Gray, J. 2017. "Expert Task Group Defines World-Class Preservation Program." *Pavement Preservation Journal.* Winter 2017. Naylor, LLC, McLean, VA.

Groeger, J., B. Visintine, and D. Brantley. 2018. *EDC-4 Pavement Preservation When/Where Peer Exchange Report*. FHWA-HIF-20-057. Federal Highway Administration, Washington, DC.

Illinois Department of Transportation (IDOT). 2010. *Bureau of Design and Environment Manual*. Illinois Department of Transportation, Springfield, IL.

Lee, J. and T. Shields. 2010. *Treatment Guidelines for Pavement Preservation*. INDOT SPR-3114. Indiana Department of Transportation, West Lafayette, IN.

Luhr, D. 2012. *Rocky Mountain West Pavement Preservation Partnership. DOT Survey of Agency Preservation Practices. Summary of Results*. Washington State Department of Transportation, Olympia, WA.

Maryland Department of Transportation State Highway Administration (MDSHA). 2012. *MDSHA Guide to Pavement Preservation*. Maryland Department of Transportation, Baltimore, MD.

Minnesota Department of Transportation (MnDOT). 2020. *MNDOT Pavement Preservation Manual*. Minnesota Department of Transportation, St Paul, MN.

Mississippi Department of Transportation. 2018. *MDOT Pavement Preservation & Preventive Maintenance Treatment Policy for Federal-Aid Projects*. Mississippi Department of Transportation, Jackson, MS.

New York State Department of Transportation (NYSDOT), 2005. *Comprehensive Pavement Design Manual, Chapter 10 – Preventive Maintenance*. New York Department of Transportation, Albany, NY.

Ohio Department of Transportation (ODOT). 2001. *Pavement Preventive Maintenance Program Guidelines.* Ohio Department of Transportation, Columbus, OH.

Ohio Department of Transportation (ODOT). 2019. *Transportation Asset Management Plan*. Ohio Department of Transportation, Columbus, OH.

Peshkin, D. G. 2006. *Assessment of Research Project SPR 371, Maintenance Cost Effectiveness Study*. FHWA-AZ-06-371. Arizona Department of Transportation. Phoenix, AZ.

Peshkin, D. G., 2011. *Guidelines for the Preservation Of High-Traffic-Volume Roadways*. SHRP2 Report S2-R26-RR-2. Transportation Research Board, Washington, DC.

Peshkin, D. G. and T. E. Hoerner. 2005. *Pavement Preservation: Practices, Research Plans, and Initiatives*. NCHRP Project No. 20-07, Task 184, Final Report. National Cooperative Highway Research Program, Washington, DC.

Peshkin, D. G., T. E. Hoerner, and K. A. Zimmerman. 2004. *Optimal Timing of Pavement Preventive Maintenance Treatment Applications*. NCHRP Report 523. Transportation Research Board, Washington, DC.

Peshkin, D. G., K. L. Smith, A. Wolters, J. Krstulovich, J. Moulthrop, and C. Alvarado. 2011. *Preservation Approaches for High-Traffic-Volume Roadways.* SHRP2 Report S2-R26-RR-1. Transportation Research Board. Washington, DC

Rada, G. R., J. M. Bryce, B. A. Visintine, R. G. Hicks, and D. Cheng. 2018. *Quantifying the Effects of Preservation Treatments on Pavement Performance*. NCHRP Research Report 858. Transportation Research Board, Washington, DC.

Ram, P. K. and D. Peshkin. 2013. *Cost Effectiveness of the Michigan Department of Transportation Preventive Maintenance Program*. MDOT Report No. RC-1579. Michigan Department of Transportation. Lansing, MI.

Smith, K. D., D. S. Harrington, L. M. Pierce, P. V. Ram, and K. L. Smith. 2014. *Concrete Pavement Preservation Guide, Second Edition.* FHWA-HIF-14-014. Federal Highway Administration, Washington, DC.

South Dakota Department of Transportation (SDDOT). 2021. *Pavement Preservation Guidelines.* South Dakota Department of Transportation, Pierre, SD.

Texas Department of Transportation (TxDOT). 2017. *Seal Coat and Surface Treatment Manual*. Webpage. Accessed April 2022. Texas Department of Transportation, Austin, TX.

Tighe, S. and D. Gransberg. 2011. *Sustainable Pavement Maintenance Practices.* Research Results Digest 365. National Academies of Science, Washington, DC.