FEDERAL HIGHWAY ADMINISTRATION (FHWA) PAVEMENT PRESERVATION RESEARCH ROADMAP

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16. Abstract

The Pavement Preservation Research Roadmap, originally developed between 2006 and 2008 as the Transportation System Preservation (TSP) Research, Development, and Implementation Roadmap and including both pavements and bridges, was updated under a contract with the Federal Highway Administration (FHWA). The Roadmap is intended for use by State, local, and Federal agencies and other interested parties in selecting and funding pavement preservation research.

The topic of pavement preservation was divided into six umbrella topic areas: Asset Management, Pavement Management, and Preservation; Treatment Design; Materials; Treatment Application; Performance; and Benefits. A seventh category, Synthesis Needs, contains needs statements for benchmarks of current practices that may fall under any of the six umbrella topic areas. Research and synthesis ideas were generated through a series of conference calls with stakeholders representing State and local agencies, academia, industry, consultants, and the FHWA.

Abbreviated research needs statements were developed for 37 research ideas and 9 syntheses and prioritized using online surveys (OMB Control Number 2125-0628). The final version of the Roadmap is presented as a table with a column for each umbrella topic and the research needs for each topic listed in order of priority.

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ACRONYMS AND ABBREVIATIONS

AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AASHTOWare	Software developed for and distributed by AASHTO
ACPA	American Concrete Pavement Association
ADA	Americans with Disabilities Act
AEMA	Asphalt Emulsion Manufacturers Association
AHD18	Transportation Research Board Technical Committee on Pavement Preservation
ARRA	Asphalt Recycling and Reclaiming Association
BCOA	Bonded concrete overlay on asphalt
CIR	Cold in-place recycling
CCPR	Cold central plant recycling
CRCP	Continuously Reinforced Concrete Pavement
EDC	Every Day Counts
ETF	Emulsion Task Force
ETG	Expert Task Group
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FP2	Foundation for Pavement Preservation
FWD	Falling Weight Deflectometer
GPR	Ground penetrating radar
HIR	Hot in-place recycling
HMA	Hot mixed asphalt
IDIQ	Indefinite delivery, indefinite quantity
IGGA	International Grooving and Grinding Association
IRI	International roughness index
ISSA	International Slurry Seal Association
JPCP	Jointed plain concrete pavement
LCCA	Life cycle cost analysis
LTPP	Long Term Pavement Performance
MAP-21	Moving Ahead for Progress in the 21st Century
MnROAD	Road track research site by Minnesota Department of Transportation
NAPA	National Asphalt Pavement Association
NCAT	National Center for Asphalt Technology
NCHRP	National Cooperative Highway Research Program
NCPP	National Center for Pavement Preservation
NGCS	Next generation concrete surface
NHS	National Highway System

OMB	Office of Management and Budget
PCCP	Portland cement concrete pavement
PEM	Performance Engineering Concrete Pavement Mixtures
PMS	Pavement management system
PPETG	Pavement Preservation Expert Task Group (now PPTFG)
PPRA	Pavement Preservation and Recycling Alliance
QC/QA	Quality control/quality assurance
RAP	Recycled Asphalt Pavement
RCA	Recycled Concrete Aggregate
RNS	Research Needs Statement
RSL	Remaining service life
RWD	Rolling Weight Deflectometer
TAMP	Transportation Asset Management Plan
TSP	Technical service program; also, Transportation System Preservation
TSP2	Transportation System Preservation Technical Service Program
UBWC	Ultra-thin bonded wearing course

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EXECUTIVE SUMMARY

This document updates the Pavement Preservation Research Roadmap, originally developed between 2006 and 2008 as the Transportation System Preservation (TSP) Research, Development, and Implementation Roadmap and including both pavements and bridges. The Roadmap is intended for use by State, local, and Federal agencies and other interested parties in selecting and funding pavement preservation research.

To organize the updated Roadmap, the broad topic of pavement preservation was divided into six umbrella topic areas: Asset Management, Pavement Management, and Preservation; Treatment Design; Materials; Treatment Application; Performance; and Benefits. A seventh category, Synthesis Needs, contains needs statements for benchmarks of current practices that may fall under any of the six umbrella topic areas.

Research ideas were generated through a series of conference calls with stakeholders representing State and local agencies, academia, industry, and consultants, as well as the FHWA. Following completion of the conference calls, abbreviated research needs statements were developed for 37 research ideas and 9 syntheses. The research needs statements and syntheses were prioritized using seven online surveys (OMB Control Number 2125-0628), with one survey for each of the six main umbrella topic areas and one additional survey for the syntheses. The final version of the Roadmap is presented as a table with a column for each umbrella topic and the research needs for each topic listed in order of priority.

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CHAPTER 1: INTRODUCTION

This report outlines the purpose, goals, methods, and results regarding recent efforts to update the Pavement Preservation Research Roadmap.

The report is organized as follows:

- Chapter 1 describes the history of the Roadmap, its purpose and goals, and the stakeholders considered in the remainder of the report.
- Chapter 2 describes the approach used to develop the updated Roadmap, including a description of the umbrella topics, the subtopics selected for the subsequent teleconferences, the use of teleconferences to identify needs, the development of abbreviated research needs statements, and the surveys (OMB Control Number 2125-0628) used to set priorities.
- Chapter 3 presents the results of the teleconferences, including a list of topics under each umbrella category, the identified research needs, and the identified activities that agencies can or should do but that do not constitute actual research. A chart that graphically displays the roadmap is also included.
- Chapter 4 presents the process used to prioritize research needs and the results as well as the list of invited participants and some observations on the process.
- Chapter 5 describes a process for updating the Pavement Preservation Research Roadmap.
- Chapter 6 includes ideas for dissemination of the Pavement Preservation Research Roadmap and conclusions.
- Three appendices are included. Appendix A contains a literature review, Appendix B presents the abbreviated research needs statements, and Appendix C presents the synthesis statements.

History

The first pavement preservation research roadmap was entitled Pavement Preservation Research Problem Statements and was dated June 21-22, 2001. The initial infrastructure preservation research roadmap, called the Transportation System Preservation (TSP) Research, Development, and Implementation Roadmap, was developed between 2006 and 2008 as a research project funded by the Federal Highway Administration (FHWA). That roadmap included both pavement and bridge preservation activities and was developed using three multi-day regional workshops, in each of which about 30 to 40 subject matter experts participated. Two workshops dealt with pavement preservation, and one focused on bridge preservation. Discussions at the workshops focused on white papers written by experts in various aspects of preservation, with six white papers each for pavement and bridge preservation. The completed roadmap included pavement and bridge preservation research needs statements that were ranked in order of importance and in order of urgency.

The purpose of the 2008 roadmap was to reach consensus about the most pressing research needs to move the preservation of roads and bridges into more common practice and to provide decision tools to assist agencies with proper project selection, use of materials and specifications, quality construction using the “new” preservation techniques, and appropriate monitoring of performance. The 2008 roadmap was developed when many States were in the earliest stages of implementing preservation practices. For many agencies, this meant constructing a limited number of roadway trial sections with treatments like chip seals or micro surfacing. The emphasis of pavement preservation research was on materials and specifications. Bridge preservation was slowly building momentum but was limited in many States to joint repairs, preservation coatings, and protective deck treatments.

The pavement portion of the 2008 research roadmap included research needs in the areas of asset management, contracting methods, materials, construction, design, and performance. A total of 38 research needs statements were developed from the two pavement workshops. The statements were distributed among the topic areas as follows:

- Asset management: 8
- Contracting methods: 3
- Materials: 7
- Construction: 7
- Design: 7
- Performance: 6

Since the 2008 roadmap was published, there has been significant progress in the understanding of pavement preservation treatments and their impact on system performance.

A major question both in the 2008 roadmap and today regarding pavement preservation is the impact of roadway condition on the performance of pavement preservation treatments. This topic is the focus of work begun in 2012 at the National Center for Asphalt Technology (NCAT) and that continues today. In addition, new technologies for pavement condition data collection, including high-definition videos and three-dimensional (3D) crack detection, are being used by an increasing number of State agencies. Another relatively new technology, automated pavement condition surveys, was the subject of NCHRP Synthesis 531 (Pierce and Weitzel 2019).

Additional aspects of pavement preservation are being addressed elsewhere. Through the American Association of State Highway and Transportation Officials (AASHTO) Transportation System Preservation Technical Service Program (TSP2), State and local agencies regularly discuss treatment lives and life extensions. A recent publication, NCHRP Report 857 (Chatti et al. 2017), developed a framework for performance-related specifications for pavement preservation treatments. NCHRP Report 858 (Rada et al. 2018) reported on the effects of preservation treatments on pavement performance.

In addition to these recent efforts to research and disseminate new preservation practices, the TSP2 Emulsion Task Force (ETF) has developed materials specifications and construction guides for many emulsion-based preservation treatments, and these documents are in the process of being approved for use by the AASHTO Committee on Materials and Pavements. Note that use of these specifications and guides are not required under Federal law. The ETF evaluates and discusses the current state of the practice and proposes research to aid in the development of specifications and construction guides. The ETF is actively pursuing quality assurance and quality control processes for emulsion-based preservation treatments.

There have also been significant changes to the Federal legislation governing agencies' asset management and performance measurement practices since the 2008 roadmap. The Moving Ahead for Progress in the 21st Century Act (MAP-21), signed on July 6, 2012, instituted both performance measures and Transportation Asset Management Plans (TAMPs) for State agencies (see 23 U.S.C. 150 and 119). Under MAP-21 each agency was required to set performance targets in a variety of areas, including pavement and bridge condition, system reliability, safety, and others (see 23 U.S.C. 150).

The use of preservation to maintain system condition and extend pavement life was a valuable tool to achieve the goals of MAP-21. Those goals were extended in the subsequent Fixing America's Surface Transportation (FAST) Act, signed on December 4, 2015. Following MAP-21 and the FAST Act, there has been an increased emphasis in research on asset management; pavement management systems (PMS); and the planning and programing of pavement preservation activities.

The pie charts in Figures 1 and 2 show that recent publications in pavement preservation have become more balanced among the different preservation-related topic areas and that there has been a dramatic decrease in the emphasis on materials. Agencies and academic institutions are increasingly studying asset management and treatment/system performance, reflecting the importance of these topics in recent Federal legislation.

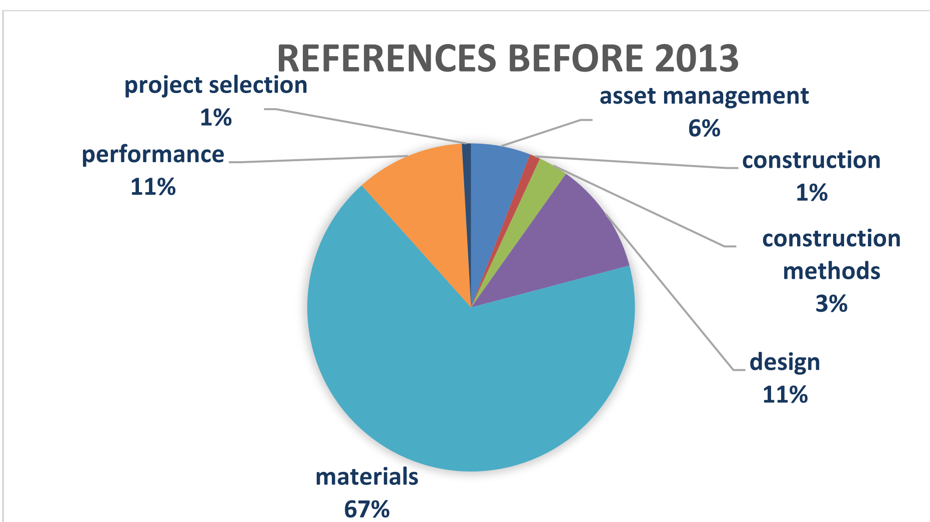

Figure 1. Distribution of publications in areas related to pavement preservation before 2013, showing that 67% of publications were related to materials

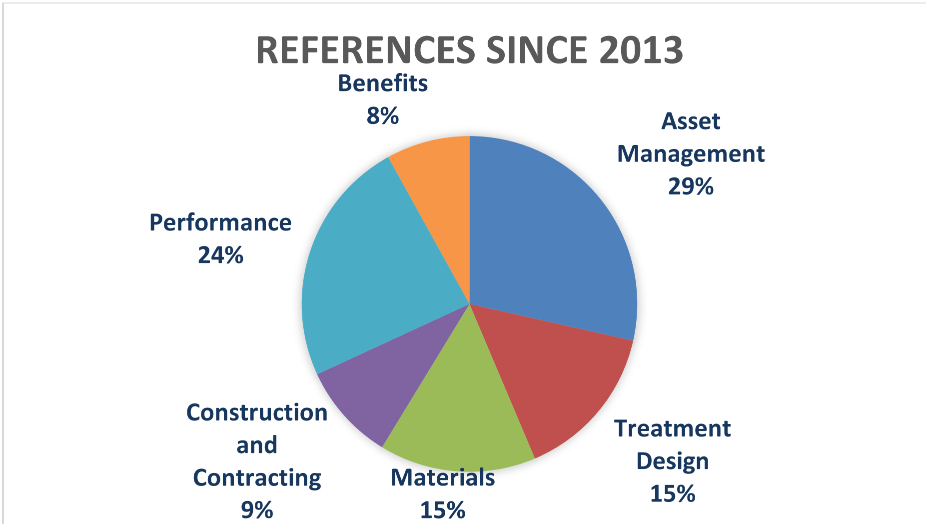

Figure 2. Distribution of publications in areas related to pavement preservation since 2013, showing that the majority of publications were related to asset management (29%) and performance (24%)

Pavement preservation was also a focus area of Every Day Counts-4 (EDC-4), the 2017-2018 round of the FHWA's EDC initiative. This program focused on the when, where, and how of pavement preservation. The first part of the program emphasized project and treatment selection, i.e., applying the right preservation methods to the right road at the right time. The second part emphasized construction methods and best practices aimed at improving the quality of preservation projects. EDC-4 developed checklists, suggested practices, and mobile applications to allow an inspector to review and document key aspects of a treatment. Peer exchanges and focused workshops were among the EDC-4 efforts, which concluded in spring 2019.

The last decade has also seen significant changes within State agencies. A trend beginning two decades ago has accelerated the shift from self-performed maintenance and construction to contracted work. As a result, many agencies have downsized, reducing the size of personnel complements in areas including planning, design, construction, and maintenance. Based on peer exchanges, national conferences and other interactions with agencies and contractors, they have achieved reductions in force by offering retirement incentives, accelerating the loss of experienced personnel. The result of these changes typically has been a loss of experience and expertise in pavement preservation. These changes have resulted in an increased need for training and workforce development in the pavement preservation industry.

Technological and material changes have also impacted the practice of pavement preservation. Among the technological changes is automated distress data collection and interpretation, which allows agencies to collect pavement condition data at highway speeds and, as an additional benefit, provides high-resolution imaging to enhance pavement management systems. Changes to materials have included polymer modified emulsions and the use of fibers in micro surfacing. Asphalt rejuvenators are another key growth area, with both asphalt-based and bio-based materials being used.

Along with these changes and developments, there has been significant work in the development of pavement preservation education, outreach, and certification programs. TSP2 has organized regional Pavement Preservation Partnerships that meet annually. Recently, three industry groups created the Pavement Preservation and Recycling Alliance (PPRA), which hosts a website to further education in preservation techniques, materials, and benefits. Several States, including Virginia and South Carolina, have certification programs for pavement preservation, and TSP2 offers a National pavement preservation certification through the NCPP.

Purpose and Goals

The purpose of any research roadmap is to identify needs and priorities so that research funding can be directed to the most pressing needs within critical topic areas. Research roadmaps have been developed for a variety of topic areas related to civil engineering, including asphalt, concrete, asset management, and others.

An example of a roadmap that remained effective over a long period of time is the Strategic Plan for Long-Term Pavement Performance (LTPP) Data Analysis (November 9, 1999). This strategic plan suggests where LTPP program and other FHWA funding could be directed to achieve broader program goals. The plan was reviewed and updated every year and expanded when new topics were identified. Thus, the Strategic Plan for LTPP Data Analysis was a living document.

The purpose of the updated Pavement Preservation Research Roadmap is to identify needs and priorities in pavement preservation so that research funding can be directed toward topics that meet the needs of practitioners and increase the service lives of road networks, thereby meeting the needs of the motoring public.

The goals of the updated Roadmap are as follows:

- Provide an easy-to-understand framework of research needs that can be used by a range of interests, including but not limited to the FHWA, Transportation Research Board (TRB) committees, AASHTO committees, the TSP2 Pavement Preservation Partnerships, industry, and State and local agencies, to direct their research requests and funding toward the most pressing needs in the area of preservation.
- Reduce duplication of research through disseminating research findings and regularly updating the Roadmap's research needs statements.
- Identify activities that can be done using today's pavement management systems to address needs identified by participants in the Roadmap's development but that do not strictly qualify as research topics (Chapter 3).
- Encourage, but not require, the adoption and expansion of preservation practices among State agencies and especially among local agencies and municipalities, which own more than 50 percent of pavement assets in the United States.

- Increase the focus on delivering quality preservation treatments through improved project selection, timing, design, specifications, and construction practices so that the benefits of preservation are realized.

Stakeholders

There are many stakeholders in the broad area of pavement preservation. At the highest level, the FHWA has authority to oversee the use of Federal funds, a portion of which is, or could be, used for pavement preservation. State transportation agencies own and maintain the road networks within their States. For most States, the State-owned road network includes the Interstate system and most of the National Highway System (NHS). Typically, the State-owned road network accounts for less than 50 percent of the total road mileage in the State but generally more than 50 percent of the vehicle miles traveled (VMT). Some States own and maintain an expanded road network that includes all but municipal streets. Local agencies, which own over 50 percent of the total road mileage in the United States, are important if not always actively involved stakeholders in pavement preservation.

TRB has a technical committee on pavement preservation, AHD18, which consists of representatives from State and local agencies, the FHWA, academia, consulting firms, and industry. Among AHD18's other activities are identification and advocacy of research needs in the pavement preservation area.

State interests in a wide variety of topics and policies are addressed through AASHTO. AASHTO uses and maintains an extensive committee structure to address technical issues; the Committee on Maintenance and the Committee on Materials and Pavements are most directly involved in pavement preservation, with the Committee on Construction and the Committee on Performance Measures (including asset management) involved to a lesser extent. TSP2 is a voluntary AASHTO program with participation by 46 or more States each year and with annual regional partnership meetings to exchange preservation knowledge and improve preservation practices Nationally.

Just as AASHTO's activities involve a variety of committees, the FHWA works through a variety of offices, including the Office of Infrastructure Research and Development, the Office of Infrastructure, the Resource Center, and the Office of Federal Lands Highway. At a deeper level, the Office of Infrastructure includes the Asset Management Team and the Office of Preconstruction, Construction, and Pavements, which has teams on construction management, pavement materials, and pavement design and performance, among others. Each of these offices and teams may have interests and experience in pavement preservation.

Similarly, each State agency has its own diverse organizational structure. Many State agencies have devolved responsibility for managing pavement preservation to their regional offices, often called districts. In addition, State agencies may use a centralized project selection review process or a centralized pavement management system to recommend projects for consideration. Treatment specifications may be developed in the materials and testing, construction, or maintenance and operations areas within a given State agency.

In addition to the stakeholders listed above, academic researchers also have an interest in preservation research. The research produced by these stakeholders often results in the publication of master's theses or PhD dissertations, as well as publications in journals and presentations at National and international conferences. Some academic institutions maintain research centers related to preservation. Among them are the NCPP at Michigan State University, the National Concrete Pavement Technology Center at Iowa State University, the California Pavement Preservation Center at California State University at Chico, the partnership between the National Roads Research Alliance at the Minnesota Department of Transportation (MnDOT) and NCAT at Auburn University, and the Center for Transportation Infrastructure and Safety at Missouri University of Science and Technology. In addition to these centers, several universities have long-standing research programs in pavement preservation. These include the University of Nevada at Reno, Texas A&M University, North Carolina State University, Purdue University, the Pennsylvania State University, the University of Arkansas, the University of Oklahoma, and others.

Much research work in the preservation research area is also conducted by engineering consultants. Consultants perform work for the FHWA and State agencies and conduct NCHRP projects, including producing Synthesis of Practice reports. Industry groups also support pavement preservation research. Among them are the Foundation for Pavement Preservation (FP2), the International Slurry Seal Association (ISSA), the Asphalt Recycling and Reclaiming Association (ARRA), the Asphalt Emulsion Manufacturers Association (AEMA), the International Grooving and Grinding Association (IGGA), the American Concrete Pavement Association (ACPA), and the National Asphalt Pavement Association (NAPA). ARRA, AEMA, and ISSA collectively formed the PPRA.

Individual material suppliers are also stakeholders in pavement preservation. These stakeholders include emulsion manufacturers, aggregate quarries, producers of additives for both asphalt-based and concrete mixtures, and manufacturers of mastics and sealants.

While it was not possible to include all stakeholders in the development of the Pavement Preservation Research Roadmap, representatives with a variety of interests were invited and many participated.

CHAPTER 2: APPROACH

This chapter describes the approach used to develop the updated Pavement Preservation Research Roadmap.

Umbrella Topics

In selecting the umbrella topics for the updated Roadmap, the research team considered the topic areas from the 2008 roadmap. As with the earlier roadmap, critical topics included planning a preservation program, selection and design of treatments, materials, construction, contracting methods, and treatment performance.

Asset Management, Pavement Management, and Pavement Preservation

In light of the requirements of MAP-21 and the FAST Act, the planning functions were grouped under the title Asset Management, Pavement Management, and Pavement Preservation. As required by MAP-21 (23 U.S.C. 119(e)), every State transportation department has now submitted to the FHWA a Transportation Asset Management Plan, which uses the agency's pavement management system to identify pavement conditions and needs. As part of the TAMP, each State was required to include its 23 U.S.C. 150(d) targets for pavement condition (among other items) and include a 10-year financial plan (23 CFR 515.9). Many agencies have found that pavement preservation techniques have enabled them to achieve their targets even with today's highly constrained budgets. In addition to program development and planning, this topic area includes asset management technology and dealing with technological change.

Treatment Design

Treatment selection and design were included under an umbrella topic titled Treatment Design. This topic area includes treatment selection criteria, design methods for preservation treatments, and the design of new pavements to prolong the period when preservation treatments can be used effectively.

Materials

Materials was the dominant area of pavement preservation research before 2013, and that work has resulted in significant progress in understanding and specifying materials for preservation treatments. Work remains to be done, however, including on the use of additives to enhance the performance of preservation treatments. Materials information items stored in many State agencies' pavement management systems describe only broad categories of materials and do not lend themselves to analysis of performance. Identifying the key material information needed for future analyses is a major need within this topic area.

Treatment Application

The research team combined construction and contracting into a single topic area called Treatment Application. A wide variety of contracting methods can be used to deliver pavement preservation treatments, and both warranties and indefinite delivery indefinite quantity (IDIQ) contracts are included under this topic area. This topic area also includes processes and methods to ensure and evaluate construction quality. Concerns regarding insufficient competition for preservation contracts are another subject within this topic area.

Performance

Performance is an umbrella topic area that includes items such as the impact of construction methods on treatment performance and the impact of an asset's pretreatment condition on treatment performance. Identification of the data needed to define performance and identification of performance goals are also included. Significant work related to the performance topic area is ongoing, and when that work is complete some items within the topic area may have already been addressed. Specifically, this includes the test track and off-track experiments at NCAT and MnROAD, which are designed to address treatment performance as a function of pavement condition prior to treatment.

Benefits

A new umbrella topic was added to cover the benefits of pavement preservation. This topic area includes the societal benefits of pavement preservation as well as communicating the value of pavement preservation treatments to stakeholders. An additional item, improving the definitions for cost elements, was included to enhance State-to-State information sharing and but can also benefit national research efforts.

Synthesis Needs

The final group for the updated Roadmap is synthesis needs. This group is a prioritized list of suggested syntheses that resulted from the Roadmap development process. Synthesis ideas were identified during the teleconferences for most of the umbrella topic areas; however, they are commonly separated because they are typically funded from different funding pools. Syntheses of current practice can also assist in the identification of research needs and allow States to compare their practices with those of other agencies. Example topics include current approaches to incorporating preservation into pavement management systems, agency design methods for several preservation treatments, and agency treatment selection and trigger values.

Subtopics for Umbrella Topics

Research needs for the six umbrella topics were to be discussed and collected using web-based teleconferences. (A dedicated teleconference was not held for Synthesis Needs.) Each teleconference was planned to last 1.5 hours. To ensure that those meetings remained focused and covered the broad range of topics under each umbrella area, an initial conference call was held to develop subtopics for each umbrella topic.

One-page descriptions were written for each of the umbrella topics, with the exception of Synthesis Needs. These descriptions were sent to members of the FHWA Pavement Preservation Expert Task Group (PPETG), now the Pavement Preservation Technical Feedback Group (PPTFG), and to the research chairs of the TSP2 Pavement Preservation Partnerships. Both groups were invited to participate in the initial conference call.

Asset Management, Pavement Management, and Pavement Preservation

The following subtopics were suggested:

1. Performance curves to develop performance jumps and life extensions.
2. Performance curves for original pavement and treatments.
3. Types of processes needed to obtain asset management acceptance.
4. Tying performance projection to investment strategy.
5. Use of LTPP data for pavement preservation.
6. Applying NCAT and MnROAD findings to planning.
7. Bridging from one technology to another; standards and methodologies.
8. Comparing various pavement management systems and data collection methods.
9. Life cycle or whole life costing, including pavement preservation.
10. Ensuring data quality; the importance of year-to-year continuity and consistency.

Treatment Design

The following subtopics were suggested:

1. Articulating and quantifying the benefits of a designed treatment versus the use of standard application rates (i.e., no design), a common practice for many agencies.
2. Procedures and specifications for cold in-place recycling (CIR) and hot in-place recycling (HIR).
3. Repairing bonded concrete overlays on asphalt.
4. Synthesizing design techniques from the States.
5. Triggers for the timing of thin treatments.
6. Appropriate pavement preservation strategies in urban environments.

Materials

The following subtopics were suggested:

1. Link between materials and performance.
2. Trade-off in performance if lower quality materials are used or if higher traffic levels occur.

3. Durability of materials under climate and traffic.
4. Aggregate selection, including impacts of using slag.
5. Green technologies like bio-based asphalts.
6. Effects of using substandard materials.
7. Recycled asphalt pavement (RAP) in pavement preservation treatments used in California and by other States.
8. Inclusion of rubberized materials in pavement preservation treatments.
9. Use of other waste materials in surface treatments.
10. Effect of additives on ability to perform future recycling.
11. New pozzolanic materials, silica fume, etc.
12. New additives, addition of fibers, etc.
13. Process for evaluation and approval of proprietary products.

Treatment Application

The following subtopics were suggested:

1. Design of pavements to reduce future maintenance and preservation.
2. Benefits and costs of various contracting methods.
3. Traffic control to reduce motorist delays.
4. Quality control/quality assurance (QC/QA) suggestions.
5. Contractor qualification/certification or other approaches.
6. Warranties for pavement preservation projects.
7. Timing for QA of warranty projects, whether at completion of work or after warranty period.
8. Evaluation of equipment mobilization and other costs relevant to setting appropriate project lengths (for example, as related to HIR).

Performance

The following subtopics were suggested:

1. Need for performance curves for various treatments.
2. Performance life ranges considering data for preservation only, and with standard deviations.
3. Differentiation by climatic zones and the use of LTPP climate data to support classification.
4. Variations within States, or how microclimates affect performance.
5. Variability of traffic impacts among States in terms of axle loads and other factors.
6. Differentiating treatment performance from pavement performance.
7. Triggers for when to apply treatments.
8. Performance measures for roads with preservation treatments.
9. Performance in special usage: abrasion resistance where studded tires are allowed and durability when aggressive snow/ice removal is standard practice.

Benefits

The following subtopics were suggested:

1. Safety benefits of preservation and trade-offs between safety and performance.
2. Benefits of good pavements for housing values.
3. Economic benefits.
4. Motorist operating costs (e.g., International Roughness Index (IRI) versus fuel use) and the societal benefits of preservation.
5. User delays.
6. Connecting agency goals and plans to infrastructure maintenance and preservation.
7. Noise reduction.
8. Reduced vibration.
9. Sustainability measures for pavement preservation.
10. The benefits best suited to each treatment.
11. Communicating benefits to politicians, executives, and the public.

Teleconferences to Identify Needs

After the initial conference call to identify subtopics, separate web-based teleconferences were held for each of the six umbrella topics, with each scheduled to last 1.5 hours.

Stakeholders were invited to participate, including the members of the FHWA PPETG (now the PPTFG) and the TSP2 ETF; some members of TRB committee AHD18; board members for the regional Pavement Preservation Partnerships; representatives from local agencies, FP2, ARRA, AEMA, ISSA, IGGA, FHWA, NCAT, and MnROAD; consultants with a history of work in pavement preservation; and others who expressed an interest.

Participation was active and widely distributed among the group. The dates and topics for the teleconferences are shown in Table 1. Chapter 3 of this report presents the results of the teleconferences in terms of both the research needs and other non-research activities suggested.

Table 1. Teleconference dates and topics

Teleconference #	Topic Area	Date
1	Asset Management, Pavement Management, and Pavement Preservation	September 19, 2018
2	Treatment Design	October 10, 2018
3	Materials	October 24, 2018
4	Treatment Application	November 1, 2018
5	Performance	November 14, 2018
6	Benefits	December 6, 2018

Development of Research Needs Statements

The research team held a meeting at the NCPP on February 5, 2019 to discuss the results of the teleconference meetings and to identify research needs and assignments. The results of this meeting included the following:

1. Preliminary Pavement Preservation Research Roadmap in table form.
2. List of research needs to develop and submit to the teleconference invitees for prioritization.
3. List of activities that can be performed with currently available information but that were identified as needs in the teleconferences.

The group agreed that abbreviated research needs statements (RNS) were needed for prioritization of the research activities. These RNS may need additional work to be ready for submission to the NCHRP, but they currently identify the problem or need and outline the type of outcome expected from the research. Among the additional RNS that may be needed before funding may be considered are a literature review of work in the topic area, the expected benefits of the research, time and budget estimates for the work, and a statement of urgency. Those additions can be made by FHWA, AASHTO committees, State agencies, or TRB committees submitting the needs statements for funding consideration.

Prioritization

A survey was conducted under OMB control number 2125-0628 for each umbrella topic area. Everyone who had been invited to the teleconferences to develop the Roadmap was invited to participate in prioritizing the resulting RNS. About 150 individuals were included in the list. The number of participants who completed each of the surveys ranged from 26 (for the Treatment Design topic) to 39 (for the Treatment Application topic).

A simple online polling software application was used to conduct the surveys, and the RNS for each umbrella topic area were attached to the corresponding survey introductions. The surveys asked each respondent to rank the listed RNS in order of priority, with one being the highest priority. Respondents could not assign the same priority to more than one RNS. The number of RNS in each survey varied between 5 (for the Treatment Design and Benefits topics) and 9 (for the Syntheses Needs topic). Each survey was open for between 7 and 10 days. The final survey closed on May 31, 2019.

Following prioritization, the tabular version of the updated roadmap was modified to put the research ideas in priority order, with the highest priority items at the top. The RNS were renumbered to reflect the prioritization.

Summary

The updating of the research Roadmap was based on stakeholder input collected from a series of web-based teleconferences, each meeting covering one of the six umbrella topics. Following the information gathering, the research team created a tabular representation of the new Roadmap, with suggested research topics under each umbrella topic area. The team drafted abbreviated research needs statements, which were sent to the invitees from the teleconferences to prioritize. This process created prioritized lists of the research needs statements under each umbrella topic area and a prioritized list of nine synthesis topics.

CHAPTER 3: RESEARCH NEEDS STATEMENTS, SYNTHESES, AND ACTIVITIES

Introduction

As described in Chapter 2, the result of the series of teleconferences was a list of research needs that were divided among the research team for development of abbreviated research needs statements. In addition, a list of activities that agencies felt are needed but that do not strictly qualify as research was generated. Numerous syntheses were identified to provide agencies a snapshot of the state of the practice on various topics. These syntheses are frequently used by agencies to benchmark their practices against other agencies and to identify areas where their practices can be improved.

The Roadmap itself is presented as a table of projects under the six umbrella topics. The technical lead for the project has had previous experience in the development and use of the Strategic Plan for LTPP Data Analysis. That effort also resulted in a table that could be evaluated by the Data Analysis Expert Task Group (ETG) and through which items could be identified as completed or partially completed over time. This is a very desirable feature of a roadmap, so an analogous form was developed for the Pavement Preservation Research Roadmap.

The Roadmap

In the Roadmap table, the umbrella topics are ordered to reflect the activities involved in planning, developing, contracting, monitoring, and assessing a pavement project. Within each column, the highest priority RNS is at the top, with lower priority RNS following and the syntheses listed at the bottom. Note that a variable number of rows can appear under each umbrella topic, depending on the number of topics generated during the teleconference.

Asset Management, Pavement Management, and Pavement Preservation

The first heading and first column of the table—Asset Management, Pavement Management, and Pavement Preservation—represent the planning functions. Items within this column also include the data management systems and data collection systems typically used by agencies to manage their road networks. As pavement management becomes integrated into agency practices, data to support the agency's programming and decision making become especially critical.

Treatment Design

Treatment Design is the next activity in preparing a project for letting and construction and is the second column from the left in the Roadmap table. This topic area includes project selection criteria, treatment design methods, design for new pavements to optimize future preservation efforts, and the use of treatments including cold in-place recycling, cold central plant recycling (CCPR), and hot in-place recycling. Identification of approaches to extend the period during which preservation is appropriate is included in this topic area.

Materials

Selection of and specifications for materials and construction best practices are part of the Materials topic area and are addressed in the third column from the left. Identification of those material properties that most significantly affect performance and that could be included in an agency's pavement management system is a critical need in this topic area. Other topics include use of recycled materials, fibers, and other additives to enhance treatment performance.

Treatment Application

The Treatment Application topic area, addressed in the third column from the right, includes items related to construction and contracting. A high-priority need in this area is a set of suggested practices for adequate inspector training for preservation projects. Among the contracting topics are use of IDIQ contracts and early measures for use in warranty projects. Methods to increase competition and improve bid prices by increasing quantities are also included.

Performance

A long-term goal of pavement preservation research in the area of Performance—addressed in the second column from the right—is linking pretreatment road condition to treatment performance. Other topics in this area include identification of performance goals for preservation treatments and data that can be used to differentiate performance results. Since preservation treatments are sometimes applied to roadways that do not meet the criteria for preservation projects (i.e., the roadway is not in fair to good condition), one project under this umbrella topic would develop life extensions for treatments that are applied in preservation mode.

Benefits

While practitioners of preservation understand that their program of projects results in long-term benefits, they have struggled to quantify and communicate those benefits to stakeholders. The Benefits topic area, addressed in the right-most column, includes research for determining the societal benefits of preservation and communicating those benefits through media channels. This topic area also includes improving the definitions of the costs associated with preservation activities so that items can be compared consistently between States or agencies. Another topic deals with approaches to determining the relative numbers of reconstruction, rehabilitation, and preservation projects needed to optimize the use of agency budgets and maintain the network in the best possible condition.

Synthesis Needs

The Roadmap also includes pertinent synthesis topics under most of the umbrella topic areas. A synthesis provides valuable information about the current state of the practice. A new synthesis on a topic previously covered by an earlier synthesis may be appropriate when changes in materials or technology have affected practice. An example would be developing a new synthesis on rubber-modified chip seals, where new technology has resulted in finer rubber particles and fewer construction issues.

Activities

During the teleconferences, State participants described some needs that the research team felt did not strictly qualify as research but that nevertheless represent important needs. The research team calls these needs activities. Agencies may feel that they do not have the personnel or resources to deliver these activities, but the research team believes that there are opportunities for those agencies to work with universities or consultants to address these needs.

Research Needs Statements

Thirty-seven abbreviated research needs statements were developed and are presented in Appendix B. Each statement includes a title, the umbrella topic area, background information describing the need, and the objectives, which articulate the research team's view of the research goals. The purpose of developing the statements was to provide sufficient information about each need and the general approach to addressing the need to allow the research needs to be prioritized. These statements are not a commitment or direction from FHWA of resources toward FHWA's overall research program. The contents of the research needs statements, including any references to and interpretations of Federal or other requirements, discussions of acceptable or predominant practices, and opinions about how research products may be used to meet Federal requirements, solely reflect the views of the research needs statements' authors and are not intended to reflect the views of FHWA.

More detailed research needs statements should, ideally, be developed in order for the FHWA to pursue more advance research studies. Among the additional information needed would be a literature review of recent work, identification of tasks to accomplish the work, suggestions for a budget and the time needed to accomplish the work, a statement of urgency, and anticipated implementation results.

Synthesis Topics

Syntheses typically include a literature review and a survey of agency practices in the topic area. Some, but not all, include international input. Syntheses managed by TRB do not identify best practices or conduct any analysis apart from presenting the results of the survey. Unlike the NCHRP process, anyone can submit a synthesis idea to TRB using its online portal. Submitters include TRB technical committees, AASHTO committees, State agencies, consultants, and industry representatives. Even with the limitations of a TRB synthesis, funding for synthesis projects is highly sought after and competitive. In one recent year, more than 150 proposals were submitted and 15 were funded.

The FHWA also funds synthesis projects. These projects are typically one year in duration and do not need large research budgets.

Although it has not been common in the past, syntheses may also be funded by State research programs, pooled funds, or other groups. For example, the TSP2 Pavement Preservation Partnerships could fund syntheses of interest to its members.

Nine synthesis topics were developed in response to the discussion during the teleconferences. One topic each was developed for three of the umbrella topic areas: Asset Management, Pavement Management, and Pavement Preservation; Treatment Design; and Performance. Three synthesis topics each were developed for two of the umbrella topic areas: Materials and Treatment Application. The following synthesis statements are included in Appendix C:

1. Including Pavement Preservation Treatments in Pavement Management Systems.
2. Agency Selection of Preservation Treatments, Timing, and Triggers.
3. Agency Design Methods for Chip Seals, Micro Surfacing and Slurry Seals.
4. Agency Approaches to Contractor Prequalification for Preservation Contracts.
5. Methods of Increasing Competition for Pavement Preservation Projects.
6. Use of Ground Tire Rubber in Surface Treatments.
7. Alternatives to Portland Cement for Full- and Partial-Depth Patching of Jointed Plain Concrete Pavement (JPCP) and Continuously Reinforced Concrete Pavement (CRCP).
8. Early Opening of Concrete Pavement to Traffic Following Preservation Treatments.
9. Traffic Control Practices for Chip Seal Applications.

Synthesis topics appear in the Roadmap table under the appropriate umbrella topic. They are denoted with the heading "Synthesis of Practice." Prioritization, which is discussed in Chapter 4, was conducted separately for the nine synthesis topics.

Activities

Activities are needs that were identified by State agencies during the teleconferences but that do not qualify as topics for research needs statements. Some of these activities could be conducted using State personnel, or by consultants or academicians contracted by the agency. Alternatively, the activities could be addressed by one of the regional partnerships under TSP2 and the results shared with all agencies within the partnership.

The activities fell into four key areas: Data, Pavement Management, Performance, and Construction.

Data

- Evaluate the benefits versus costs of good-quality data.
- Provide adequate and timely training for data collectors.
- Maintain adequate data collection continuity following staff turnovers.

Pavement Management

- Understand the capabilities of various PMS and relate these to agency needs and high-level policy goals.
- Incorporate pavement preservation treatments into PMS history and evaluate the effects of unusual events (e.g., flooding).
- Use PMS data to show the effects of various funding levels and the effects of inconsistent preservation funding on system performance.

Performance

- Identify pavement evaluation methodologies that tend to favor worst-first project selection.
- Use cost data to calculate the cost-effectiveness of preservation treatments.
- Use traffic and climate information from the LTPP program and treatment performance data from NCAT/MnROAD to project the results of treatments for other climatic regions.
- Distinguish pavement repairs from treatments that extend pavement life.
- Evaluate recent work on triggers, timing, and other practices for preservation treatments. Assess the strengths and limitations of various approaches.

Construction

- Conduct forensic investigations of successful and unsuccessful thin surface treatments.
- Conduct end-of-job debriefings to improve specifications, contracts, and ultimately treatment quality.

Summary

The series of teleconferences resulted in lists of research needs statements, synthesis topics, and activities. For each research need identified, an abbreviated research needs statement was developed. Nine synthesis statements were also drafted. Both the research needs statements and the synthesis statements were sent to stakeholders for prioritization. The prioritization process and results are described in Chapter 4.

CHAPTER 4: PRIORITIZATION

Introduction

Research needs statements may be a benefit of this project. Those statements may be useful to pavement preservation stakeholders in considering limited research budgets.

Research funding may be available through various sources. Some of the work may be identified by AASHTO committees, such as the Committee on Maintenance or the Committee on Materials and Pavements and may be submitted for funding under the NCHRP. Other projects may be included in the FHWA's work plan. Still others may be funded by one or more of the TSP2 Pavement Preservation Partnerships or by pooled funds created by groups of State agencies. Funding opportunities may be available through State-sponsored research programs.

Prioritization Process

The research team wanted the prioritization process to include the same diverse group of stakeholders who were invited to participate in the teleconferences. That group included FHWA personnel, members of the FHWA PPETG (now the PPTFG), research representatives and leaders from the AASHTO TSP2 regional partnerships, industry representatives, some members of TRB technical committee AHD18, and consultants with a history of conducting work in areas related to pavement preservation. In total, 150 people were invited.

Online polling was used to conduct surveys under OMB Control Number 2125-0628.

The research team decided to prioritize each of the six main umbrella topics separately using very short surveys. For each survey, the research needs statements developed for that topic area were distributed, and the allowed response time was restricted to 7 to 10 days. Each respondent was requested to read the problem statements and simply assign a unique numerical priority from 1 to the number of statements, with 1 being the highest priority. Duplicate priorities (i.e., assigning the same numerical priority to two statements) were not allowed. By prioritizing each umbrella topic separately, the amount of time needed for the respondent to read the problem statements was kept to a reasonable level.

The synthesis topics were prioritized separately in a final online survey. Syntheses are considered separately for potential NCHRP funding. NCHRP funding is a competitive program and only a small percentage of research projects are funded annually. Some of the syntheses may be funded by one or more of the TSP2 Pavement Preservation Partnerships or by the FHWA.

Umbrella Topic Prioritization Results

The exact survey scores, shown in Table 3, depend on the number of survey responses in each topic area, with high scores corresponding to respondents' perceived high-priority research needs. The number of responses varied from 26 to 39. As a result, scores cannot be compared between topic areas. In general, the results show a few high-priority topics, several medium-priority projects, and a few low-priority research ideas for each umbrella topic area.

Table 3. Prioritized research needs, with prioritization scores from the online surveys in parentheses

Asset Management, Pavement Management, and Pavement Preservation (32 responses)	Treatment Design (26 responses)	Materials (34 responses)	Treatment Application (39 responses)	Performance (26 responses)	Benefits (33 responses)
Cyclic Approaches to Pavement Preservation (5.66)	Best Practices for Pavement Preservation in Urban Environments (3.69)	Identification of Material Properties in PMS for Future Analysis of Performance (4.63)	Best Practices for Adequate Inspector Training (5.46)	Impact of Pavement Condition on Future Performance of Preservation Treatments (4.69)	Societal Benefits of Pavement Preservation (3.52)
Case Studies in PMS and Pavement Preservation (5.47)	Impact of Overlay Type and Thickness for CIR, CCPR, and HIR Treatments (3.62)	Performance-Based or Performance-Related Specifications (4.03)	Establishing Distress Triggers (4.56)	Data Needed to Capture Performance of Pavement Preservation Treatments (3.62)	Achieving a Preferred Mix of Reconstruction, Rehabilitation, and Preservation (3.52)
Changing Technologies for Data Collection and PMS (4.94)	Design and Construction of New Pavements to Prolong the Period of Preservation (2.81)	Use of 3D Imaging for Macrotexture, Friction, and Embedment Depth (3.44)	Maintenance and Preservation of Mumble/Rumble Strips with Thin Treatments (4.54)	Treatment Performance Life when Used in Preservation Mode (3.62)	Improving Definitions of Costs (3.42)
Improving Remaining Service Life Over Time (4.81)	Next Treatment at End-of-Life for Bonded Concrete Overlays on Asphalt Pavements (2.46)	Performance of Micro Surfacing with Fibers (3.24)	Innovative Traffic Control for Work Zones for Preservation Treatments (4.05)	Impact of Construction Techniques and Quality on Performance (3.42)	Communicating with the Media (2.61)
Development of Advanced Models for Pavement Preservation (4.72)	Development of Web Application for Design and Inspection of Chip Seals (2.42)	Suitability of Recycled Concrete in Thin Layers (3.12)	IDIQ Contracts for Pavement Preservation (3.51)	Identification of Performance Goals for Preservation Treatments (3.35)	Treatments Leading to Noise Reduction (1.94)
Web-Based Statistics Training for PMS Engineers and Users (3.78)		Development of Suggested Practices for Concrete Pavements (2.52)	Early Measurements for Warranty Contracts (3.28)	Common Elements in State Data Quality Plans (2.31)	

Asset Management, Pavement Management, and Pavement Preservation (32 responses)	Treatment Design (26 responses)	Materials (34 responses)	Treatment Application (39 responses)	Performance (26 responses)	Benefits (33 responses)
Methods for Determining Structural Adequacy at the Network Level (3.53)			Bid Price versus Quantity for Preservation Work (2.59)		
Using AASHTOWare Pavement ME Design™ for Structural Adequacy (3.13)					

Synthesis Needs Prioritization Results

The nine synthesis needs statements were prioritized separately from the umbrella topics by 34 survey respondents. The two highest priority statements were "Including Pavement Preservation Treatments in Pavement Management Systems" and "Agency Selection of Preservation Treatments, Timing, and Triggers." At a somewhat lower but still high priority was "Agency Design Methods for Chip Seals, Micro Surfacing, and Slurry Seals." Four syntheses were mid-tier priorities: "Use of Ground Tire Rubber in Surface Treatments," "Agency Approaches to Contractor Prequalification for Preservation Contracts," "Methods of Increasing Competition for Pavement Preservation Projects," and "Alternatives to Portland Cement for Full- and Partial-Depth Patching of JPCP and CRCP." Two synthesis topics received lower priorities: "Early Opening of Concrete Pavement to Traffic Following Preservation Treatments," and "Traffic Control Practices for Chip Seal Applications."

Summary

All invitees to the teleconferences in which research ideas were developed were invited to participate in online surveys to prioritize the research needs statements and synthesis statements. A separate survey was conducted for each of the six main umbrella topics, with a seventh survey to prioritize the nine identified synthesis topics. Between 26 and 39 people responded to each of the surveys.

For each of the main umbrella topics, the research needs statements were ranked as high, medium, or low priority based on the survey results. Three of the research needs statements were ranked significantly higher than other statements within their umbrella topic area. These include the following:

1. Identification of Material Properties in PMS for Future Analysis of Performance.
2. Best Practices for Adequate Inspector Training.
3. Impact of Pavement Condition on Future Performance of Preservation Treatments.

Other high-priority research ideas include "Cyclic Approaches to Pavement Preservation," "Case Studies in PMS and Pavement Preservation," "Best Practices for Pavement Preservation in an Urban Environment," and "Impact of Overlay Type and Thickness on CIR, CCPR, and HIR Treatments." The topic of "Performance-Based or Performance-Related Specifications" is also a high-priority topic and may allow consideration of alternate materials, additives, and construction techniques. There is also high interest in "Data Needed to Capture Performance of Pavement Preservation Treatments" and "Treatment Performance Life when Used in Preservation Mode." Societal Benefits of Pavement Preservation is another high-priority need, as is "Achieving a Good Mix of Reconstruction, Rehabilitation, and Preservation."

CHAPTER 5: UPDATING THE ROADMAP

Introduction

The updated Pavement Preservation Research Roadmap was developed over a period of four months in 2019 and represents the needs and views at that time of a select group of practitioners and experts in pavement preservation. The current needs reflect significant recent work, including the achievements of the FHWA's EDC-4 initiative, with its focus on pavement preservation, and the work of the TSP2 ETF. In addition, the impact of Federal legislation—MAP-21 and the subsequent FAST Act—have shifted the current National focus toward asset management and performance measures.

It is anticipated that future shifts and future programs will result in adjustments to the Roadmap. The publication of the Roadmap itself will spur discussion of pavement preservation research needs and may result in additional ideas for research.

Just as recent research reports from the NCHRP have addressed critical topics in pavement preservation, and State-administered research is also now addressing preservation research needs, future research funded by a variety of sources may continue progress in the broad topic area of pavement preservation. In addition, work at MnROAD and NCAT is focused on determining the effects of existing pavement condition on future performance for a variety of preservation treatments.

As new research related to pavement preservation is completed, it should be critically reviewed. Some of the research may successfully and completely meet one of the research needs. Or, a research project may only partially meet a need stated in the Roadmap. Some research projects may need additional steps before their findings and suggestions can be implemented by State or local agencies.

The approach taken with the Strategic Plan for LTPP Data Analysis provides a model for development and maintenance of a strategic plan that remains viable and relevant over many years. The Data Analysis ETG reviewed and updated the strategic plan on an annual basis, with topics added and input received from other LTPP program ETGs. Members of the ETGs reviewed the final reports and assessed the extent to which the needs in the strategic plan were met. As owner of the LTPP program, the FHWA oversaw the work, managed most of the projects, and was responsible for maintaining the strategic plan. The long-term success of a strategic plan involves annual reviews and updates, multiple reviews of research findings, addition of new topics as needed, the showing of progress over time, and consistent maintenance of the strategic plan itself.

Roadmap Oversight

Key components of maintaining and updating the Roadmap may include keeping up with current and proposed research, reviewing completed research, identifying remaining work needed for implementation, and identifying new research needs.

When research work related to pavement preservation is completed, it can be reviewed to see if the work addresses all the components included in the RNS. If it does not, a revised RNS, covering the portion of work remaining to be done, could be developed and included in the Roadmap.

New research ideas and needs will also be identified in the future, whether in research reports; in committee or task group meetings; as the result of new policies or procedures; or by other stakeholders. As new ideas are identified, an RNS can be developed and added to the Roadmap.

The complete process will research identification, determining if a RNS is no longer needed because work has been done, modifying RNS for which a portion of the need has been met, and adding new RNS in the future This will keep the Roadmap useful for many years into the future.

Identification of Current and Completed Research

A significant amount of research related to pavement preservation is sponsored by the NCHRP, the FHWA, State agencies, pooled funds, and industry. Additional work may be sponsored by AASHTO's TSP2 Pavement Preservation Partnerships depending on the interests and priorities of the members. National and regional centers also sponsor research based on the needs identified by their funding agencies.

An initial idea to help track current research was to develop a calendar that would show research in progress with anticipated completion dates. To evaluate the feasibility of this approach, the research team explored the links to State agency websites provided on a website maintained by the AASHTO Special Committee on Research and Innovation. Specifically, the team identified whether the State agency sites offered web-based access to completed reports and a listing of ongoing research with anticipated dates of completion.

Nine of the State agency sites provided that information: California, Connecticut, Louisiana, Minnesota, Missouri, Nevada, North Carolina, Oregon, and Virginia. Eight of the links on the AASHTO site directed the user only to the State agency's general website, and no specific information was readily available from those agencies regarding the State-funded research program. Some State agency sites, such as those for Louisiana and Oklahoma, provided extensive lists of research reports but asked for a written request to obtain copies. Other sites, such as those for Illinois and Colorado, offered web-based access to completed reports but no listing of current projects with completion dates. The lists of completed reports tended to be chronological lists with no search capability. A few sites, such as that for Georgia, provided a list of ongoing projects but did not provide a list of completed work.

The primary database of completed research reports is TRB's Transport Research International Documentation (TRID). Providing access to more than 1.2 million records of transportation research worldwide, TRID combines the records from TRB's Transportation Research Information Services (TRIS) database and the International Transport Research Documentation (ITRD) database maintained by the Organization for Economic Cooperation and Development's (OECD's) Joint Transport Research Centre. TRID allows searches to be focused using Boolean operators, but even with careful crafting, hundreds of pages of search results can be generated. The searcher would then need to comb through the many abstracts and identify those that relate to pavement preservation research. One of the features of the TRID database, however, is that a search can be limited to a specific period. For the purposes of updating the Roadmap, the initial TRID search might include the preceding five years, but in subsequent annual searches only the preceding one or two years would be needed.

The TRID search would include not only completed research reports but papers based on those reports presented to such organizations as TRB, the American Society of Civil Engineers (ASCE), and research submitted to technical journals. For the purposes of determining whether a completed research project has met a given need in the Roadmap, the final research report, would need to be reviewed. Final documents may be available online now and will be increasingly available online in the future.

The goal of creating and maintaining a calendar would be to create a focused subset of research projects from the TRID database and other sources in a convenient format. These projects can then be monitored periodically to identify when a final report has been issued.

Summary

For the Roadmap to be of value, it should be maintained and updated so that it reflects the progress made through research and the changing needs of the pavement preservation community. The reviewers could also provide comments on new unmet needs suggested by the report, the steps needed to implement the research, and additional research identified in the report.

CHAPTER 6: PUTTING THE ROADMAP TO WORK

Introduction

The first four chapters of this report outlined the process used to develop the Roadmap and to generate and prioritize the research and synthesis needs statements. Chapter 5 provided an approach to maintaining and updating the Roadmap. This closing chapter suggests approaches to implementing the Roadmap.

Stakeholders and Potential Users

A logical discussion of implementation of the Roadmap begins with a discussion of the people and groups that may use the Roadmap and the ways it may be used. Understanding the potential users of the Roadmap helps to inform approaches to implementation.

The primary potential users of the Roadmap are the various stakeholders in pavement preservation activities. A diverse group of stakeholders participated in the teleconferences to identify research needs and in the online surveys to prioritize those needs. That group included FHWA personnel, members of the FHWA PPETG (now the PPTFG), industry representatives, representatives from the TSP2 Pavement Preservation Partnerships, some members of TRB technical committee AHD18, and consultants with experience in areas related to pavement preservation. As part of the FHWA PPETG membership, several members of the AASHTO Committee on Maintenance participated. The representatives from the TSP2 Pavement Preservation Partnerships are from State departments of transportation (DOTs).

State agencies use a portion of their Federal funding to conduct planning and research activities and represent a venue through which the Roadmap might be used. Many State agencies solicit research ideas from their employees and group those ideas according to the agency's organizational structure. Many agencies also request ideas from the universities and colleges within their States. Subject matter experts in the various areas then rank the submitted topics, and a program of State-funded research is identified from the highest ranked topics. As part of this process, a pavement preservation topic related to one of the Roadmap's research needs statements could be aggregated with other ideas in the areas of materials, pavements, asset management, operations, or maintenance. If no topic is identified in pavement preservation, then funding may be used for other identified State research needs.

The TRB committees have several responsibilities, one of which is developing and posting research needs statements. Most technical committees have a research coordinator who solicits ideas from the membership and identifies committee members and friends of the committee to develop those ideas into research needs statements. The research coordinator and the committee membership as a whole can benefit from having a list of potential ideas in the form of the Roadmap's research needs statements

A pooled fund usually develops around a topic area and includes an administrator and a number of participating agencies that contribute to the fund. This topic area might address one of the Roadmap's research needs statements. One of the largest of these is NCAT, which has worked with MnROAD to host construction and testing of pavement sections with experimental preservation treatments in Alabama and Minnesota.

Industry also conducts research in the pavement preservation area to improve its products and services. Many of the results of its research are proprietary in nature. Nevertheless, the views of industry on the relative importance of various components of preservation treatments, which might be informed by the Roadmap, can move the preservation research process forward.

Disseminating the Roadmap

Webinars are a very effective method of getting information into the hands of pavement preservation stakeholders. The content of the webinar could include the following topics:

- Umbrella topics
- Research ideas
- Activities
- Syntheses
- Highest priority topics
- Topics with work in progress
- Updating the Roadmap
- Work that needs to be done to prepare the RNS for submission to funding agencies
- Questions and answers

In addition to webinars, presentations would allow more condensed Roadmap information to be delivered to specific groups. Presentations to the four regional TSP2 Pavement Preservation Partnerships can be offered, although each group can decide on the specific type of presentation delivered to its partnership meeting. Presentations to the regional partnership meetings are frequently video recorded and made available by the NCPP using YouTube or the NCPP website. This allows attendees the opportunity to review a presentation from the conference and, even more importantly, allows those unable to attend to access to the information.

A general presentation about the research Roadmap could be made to the AASHTO Committee on Maintenance, with a more specific presentation made to the Pavement Technical Working Group. Similarly, a general presentation might be appropriate for the plenary session of the AASHTO Committee on Materials and Pavements, with a more detailed presentation to the Technical Subcommittee on Bridge and Pavement Preservation.

Once the Roadmap is posted online, it is anticipated that it may be used by TRB committee AHD18 to identify one or more research ideas for the committee to develop. The committee may use teleconference meetings on an annual basis before the annual TRB meeting to allow adequate discussion of the selected topics.

The FHWA has typically hosted one or more sessions at TRB's annual meeting. A presentation on the updated Pavement Preservation Research Roadmap could be delivered at one of these sessions. The presentation would also reflect the FHWA's emphasis on collaboration, the ongoing role of the PPTFG (formerly the PPETG) and the importance of research. Specialized presentations focused on topics of interest to local agencies could also be made through the FHWA's Local Technical Assistance Program (LTAP). Since local agencies own and maintain more than half of the public road network in the United States, it is vital that the benefits of preservation research reach local road owners.

Three industry groups represent many of the suppliers and contractors in the pavement preservation area: ARRA, AEMA and ISSA. Representatives from all three groups were invited to participate in the process to develop the updated Roadmap. A presentation at their annual joint conference would get the word out about the Roadmap to industry stakeholders. Roadmap presentations could also be offered to the ACPA and the NAPA, both of which have their own research roadmaps in their respective areas.

Another idea that would present the Roadmap to key stakeholders and practitioners would be to create a Roadmap poster that includes not only a full-color graphic of the Roadmap but also the website address, key contact personnel, and some interesting and colorful graphics. The goal would be a poster that a pavement preservation engineer could hang on an office wall and periodically glance at to review the ideas addressed by the Roadmap. The regional TSP2 Pavement Preservation Partnership meetings or the TRB annual meeting would be ideal venues at which to distribute these posters to agency personnel.

An annual report should include identification of the research needs that are believed to be met or partially met, support for follow-up research, changes to the Roadmap during the preceding year, and evidence of implementation of key research results from the Roadmap. It may take more than a year before the Roadmap shows evidence of development through new research ideas or before evidence of implementation is more than anecdotal, but the annual report could focus on the need for progress in pavement preservation.

Summary

The pavement preservation community can benefit from having access to a collection of research ideas that have been prioritized. The preservation community as a whole can own, use, and maintain the Roadmap.

Presentations at various conferences can introduce audiences to the Roadmap and explain its priorities. Such presentations could be made at many venues, including the TRB annual meeting and the regional TSP2 Pavement Preservation Partnership meetings, among others. Outreach to local agencies through the FHWA's LTAP is also encouraged.

Because webinars allow for longer presentations, more detail about the Roadmap could be provided in this format than could be provided during a conference presentation. Webinars are also frequently recorded, providing additional viewing opportunities for those unable to attend the initial webinar.

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APPENDIX A: LITERATURE REVIEW

The literature review is arranged by the six umbrella topic areas described in Chapter 2 with a single combined reference list of source material at the end of the review.

In conducting the literature search, it became apparent that many of the reports and papers could apply to multiple topic areas. For example, the umbrella topic area of Asset Management, Pavement Management, and Pavement Preservation includes work on performance curves, trigger values, and performance jumps because these topics are critical to life cycle cost analysis (LCCA) and to planning. However, they are also key topics for the Performance umbrella topic area. The key topics within each section are highlighted in bold to facilitate finding topics of interest.

Asset Management, Pavement Management, and Pavement Preservation

Note: Unless accompanied by a citation to statute or regulations, the practices, guides, and specifications discussed below are not required under Federal law or regulations.

Asset management plans and an increased use of pavement management systems (PMS) in developing programs and investment strategies became requirements for State agencies pursuant to 23 U.S.C 119 and 23 CFR part 515. These requirements have spurred significant activity within the Federal Highway Administration (FHWA), in research sponsored by the American Association of State Highway and Transportation Officials (AASHTO) through the Transportation Research Board (TRB), within State agencies, and among academicians.

This topic area focuses on the planning aspects of a pavement preservation program, but planning should be based on good-quality data, development of deterioration curves, time thresholds for treatments, understanding of the impact of treatments on roadways, and modelling and prediction of the extension of a pavement’s life due to application of the treatment.

For the purposes of this literature review, the broad topic of asset management, pavement management, and pavement preservation has been subdivided into general asset management and pavement management systems; life cycle cost analysis and life cycle assessment; maintenance, operations, and preservation; and pavement condition, data collection, and data quality.

General Asset Management and Pavement Management Systems

Development of long-range plans for maintenance, rehabilitation, capacity enhancements, and reconstruction for the Illinois State Toll Highway Authority was reported by Gillen et al. (2017) and used performance predictions based on AASHTOWare Pavement ME Design™ software.

Use of PMS to identify candidate roads for treatment is common, but work is sometimes delayed due to funding limitations and other competing priorities. The consequences of delayed maintenance were the focus of National Cooperative Highway Research Program (NCHRP) Report 859 by Chung et al. (2017). This report covers seven assets common to State agencies, including pavements. The consequences are expressed in terms of asset condition and costs to the agency and the assets' users. Technical barriers and data integration issues were identified by Abdelaty et al. (2018) as areas preventing agencies from using more data-driven pavement treatment performance evaluation in decision making. Key to data-driven decision making is a validated PMS, and Henning et al. (2018) developed a validation process for 18 years of performance data in New Zealand's PMS.

Agency goals lead to policies that are then used to set priorities for asset management and PMS. Fricker et al. (2014) reported on the use of asset management by the Indiana Department of Transportation (INDOT) to control costs and sustain highway levels of service. Limsawasd et al. (2016) used minimization of fuel consumption to optimize highway rehabilitation decisions. Rydholm and Luhr (2014) used budget-constrained models to analyze pavement preservation strategies for the Washington State Department of Transportation (WSDOT). Bruun and Laumet (2016) also used a budget-constrained model that considers maintenance needs and performance goals as part of network maintenance analysis. Li et al. (2018a) considered five pavement maintenance indices and a comprehensive ranking of road sections to make network-level maintenance decisions. Prioritization based on safety, using accident rates, was used in setting performance thresholds by Anastasopoulos et al. (2016).

Data from the Long-Term Pavement Performance (LTPP) database, the Colorado Department of Transportation (CDOT), the Louisiana Department of Transportation and Development (LADOTD), and WSDOT were used by Baladi et al. (2017) to study the effects of maintenance and rehabilitation strategies on treatment effectiveness. Work by Bektas et al. (2014) evaluated pavement performance modeling to evaluate the existing pavement condition index (PCI) equations for the Iowa Department of Transportation (Iowa DOT).

One of the main components necessary for predicting future condition is deterioration curves. A pavement condition prediction model was developed by Katicha et al. (2016) using pavement age and modified structural index to improve prediction. Khalegian et al. (2014) used 16 years of condition data to validate pavement deterioration curves for Interstate pavements in Oklahoma. Ibraheem (2014) began the process of developing deterioration curves for Baghdad, Iraq, including condition indices and an inventory of sections. Setting appropriate condition jumps for preservation treatments is another aspect of modeling future performance and has been studied by Chen et al. (2018a) for the North Carolina Department of Transportation (NCDOT).

Pavement performance curves are used to determine the life expectancy of road sections. Saleh (2014) determined remaining service life at the network level using models based on the Fourth Highway Development and Management Model (HDM-4). Han and Lee (2016) forecast life expectancies using multi-maintenance criteria for Korean national highways. The longer life expectancy of a stone mastic surface was demonstrated in work by Svenson (2014), who analyzed nine pavement types used in Sweden considering traffic loads, pavement type, bearing capacity, and other characteristics of the roadways. Local road work in the town of Avon, Indiana, was shown to benefit from timely preservation by Strange (2014).

Decision making methods are another key component of asset management and using PMS. Both Meidini and Ghanem (2015) and Abaza (2017) have used Markov decision-based processes. Cross-asset optimization modeling was undertaken by Wang and Chou (2015) using a linear programming model to determine optimal budget allocation. Zuniga-Garcia et al. (2018) used Monte Carlo simulation and more than 14,000 maintenance and rehabilitation projects to conduct an economic analysis of pavement preservation techniques and found that chip seals are the most cost-effective treatment and have low cost variability. Mullin et al. (2014) studied the varied distresses caused by the variety of pavement sections and climatic regions in Alaska in their evaluation of pavement preservation treatments in that State. A case study in Indiana conducted by Bardaka et al. (2014) verified the service lives of asset treatments using econometric techniques. Humphries and Lee (2015) studied maintenance and preservation activities at general aviation airports in Texas and found that most airport managers rely on either the Texas Department of Transportation (TxDOT) or consultants to manage their airport pavements. Peshkin et al. (2014) evaluated the impact of pavement preservation surface treatments on National Park Service roadways and used the study to estimate performance jumps and life extensions for single-course chip seals.

Sustainability is a growing area of interest within pavement preservation. Kazmierowski and Navarra (2014) developed sustainability metrics for two pavement rating systems, both designed to promote green initiatives in pavement construction, rehabilitation, reconstruction, and preservation. Umer et al. (2017) also developed a sustainability evaluation methodology that includes both economic and environmental components. Work by Bryce et al. (2014) used reduction of road roughness, which reduces fuel consumption, as part of an assessment of an agency's contribution to reducing global warming. Okie et al. (2019) reported on models that include both the heat island effect and rolling resistance, with three different models to capture roughness progression. Additional references regarding sustainability can be found under the Benefits section below.

Life Cycle Cost Analysis and Life Cycle Assessment

Work by Mirzadeh et al. (2014) identified the need to use different price indices for general construction materials and for oil products to obtain a reasonable LCCA. Lu et al. (2018) and Yu et al. (2013) combined engineering sustainability metrics via life cycle assessment (LCA) and economic evaluation with LCCA.

State and provincial agencies frequently use LCCA in their treatment selection process. Tamayo (2018) conducted LCCA for pavement preservation treatments in Arkansas. Work by Akbarian et al. (2017) combined LCCA with user costs resulting from pavement-vehicle interaction and work zone delays in Minnesota. Luhr and Rydholm (2015) conducted economic evaluation of pavement management decisions, focusing on year-to-year operating plans. Jannat and Tighe (2016) used a comprehensive list of variables including traffic, climate, and material properties to develop more realistic LCCA for treatment selection. Researchers in China, led by Zhu et al. (2016), used LCA to evaluate recycled pavement, asphalt rubber, and warm-mix asphalt and found that the zeolite technology in warm-mix asphalt consumes more energy than does hot-mix asphalt.

Risk-based LCCA in preventive pavement management, studied by Wu et al. (2014, 2017), considers variables that include discount rate, traffic growth rate, and preservation costs. Using distribution functions for the various components allows risk-based optimization of various scenarios for preventive pavement maintenance.

Maintenance, Operations, and Preservation

Asset management and PMS data are used in a variety of evaluations. Gaspar (2016) calculated the actual efficiency of road pavement rehabilitation based on a 25-year monitoring period and 14 combinations of pavement structure type and subgrade. Choi et al. (2016) used regression and clustering analysis to determine future maintenance costs for low-volume highway rehabilitation projects for use in LCCA. The impact of repeated maintenance work in managing a road network was evaluated by Han et al. (2017) to identify the optimal time for reconstruction using LCCA. Ahmed et al. (20156) calculated pavement damage and associated user damage apportionment to calculate the marginal pavement damage cost. Both agency costs and user costs were used in the two-level approach to pavement management developed by Moreira et al. (2017).

The application of asset management data to maintenance scheduling is of high importance to transportation agencies. For asset management and PMS to be used effectively, the road network should be segmented into homogeneous sections. Kim (2016) evaluated existing methods of segmentation focusing on maintenance operations. Zhang et al. (2017) formulated a joint optimization scheme for maintenance, rehabilitation, and reconstruction using a two-part process. The first part used a combined budget and the second part used an individual budget for each category. Lee and Madanat (2014) also developed a joint optimization scheme for pavement design, resurfacing, and maintenance with historically dependent models.

Maintenance and rehabilitation budget planning was used to optimize network reliability in work by Wang et al. (2015). Their novel models were validated with 8,454 0.5-mile management sections from the Texas pavement network. Ding et al. (2013) identified optimal strategies of pavement preventive maintenance over a 20-year period using LCCA. Monte Carlo simulation was used by Batouli et al. (2015) to consider uncertainties in network-level cost analysis, including future preservation funding. Denysiuk et al. (2017) created a framework to allow optimization of maintenance scheduling using two-stage multi-objective optimization. Artificial neural networks were used by Woldemariam et al. (2016) to estimate annual maintenance expenditures for pavement assets. The procedure can also be used to identify those factors that most significantly influence estimations. Chu and Huang (2018) used mathematical programming to consider traffic, pavement age, and maintenance activities and identify maintenance strategies for worst-first, best-first, and threshold-based strategies.

Examples of network-based asset management in the literature have become common in the last five years. Saliminejad and Perrone (2015) used a problem reduction technique to allow multi-year programming for a large-scale network. Mathew and Isaac (2014) used a genetic algorithm to determine the optimal maintenance strategy for a rural road network. This work, in Kerala state, India, led to a pavement maintenance and management system.

Urban networks experience more and different distresses than rural networks due to utilities and traffic that impede repair. Shah et al. (2013) used a variety of techniques, including HDM-4 road management software, an artificial neural network, and multi-criteria decision making along with a geographic information system (GIS), to develop a framework for urban pavement management. HDM-4 was also used, with adaptation, by Shah et al. (2016) to develop a tool for strategic analysis of urban road networks. Results showed the need for adequate capital and recurring maintenance funding. The impact of environmental assessment and budgetary restrictions on an urban network was provided by Torres-Machi et al. (2018), including a finding that a 2% increase in funding would allow selection of more sustainable recycling treatments. Additional work by Torres-Machi et al. (2016) integrated technical, economic, environmental, social, and political considerations into LCCA for an urban network. An analytical hierarchy process was used by Prakasan et al. (2015) to develop a priority ranking model for maintenance of urban roads. Noureldin et al. (2014) conducted a case study on the Indiana urban road network that considered the impact of changing treatment trigger values and annual rehabilitation funding on the long-term condition of the network.

TxDOT has implemented a PMS to manage its network of over 197,000 lane miles. Hong et al. (2017) used the new PMS to plan, optimize, analyze, and evaluate pavement maintenance and rehabilitation projects. Washington State developed cost-effective strategies for its pavement assets, including conversion of 3,000 lane miles from asphalt to chip seals and planning major reconstruction of aged concrete pavements. The analysis that led to these strategies was conducted and reported by Li et al. (2017). Jannat and Tighe (2018) utilized LCCA with multiple treatment strategies, materials, and traffic levels to identify cost-effective pavement maintenance and rehabilitation plans. They also provided a case study on Ontario highways demonstrating an application of the probabilistic approach to predicting maintenance needs (Jannat and Tighe 2017). Andre and Gerke (2014) reported on the adoption of network-level preventive maintenance in Saskatchewan, Canada, to preserve the existing good condition of the high-speed, high-volume network.

Pavement Condition, Data Collection, and Data Quality

Bianchini (2014) used principal component analysis to evaluate the relative importance of different types of distresses on the condition assessment of flexible pavements. This analysis was used for pavement maintenance planning at the network level and demonstrates the complexity and importance of pavement condition data to PMS and asset management. Dennis et al. (2017) reported on innovative approaches to pavement condition data collection, including smartphone accelerometer indices, crowdsourced condition data, automated vehicle systems, in situ structural health monitoring, and automated distress classification. Radopoulou and Brilakis (2016) discussed the fact that worldwide almost 99 percent of pavement data are collected manually, and the cost and applicability of new technology should be considered. The recently published NCHRP Synthesis 531 by Pierce and Weitzel (2019), Automated Pavement Condition Surveys, reports on technology that many agencies are using or preparing to use.

The efforts by Ontario's Ministry of Transportation to transition from manual to automated distress data collection were the focus of a report by Chan et al. (2016). The authors compared manual and automated systems and reported improved accuracy and repeatability with the automated system. Jing et al. (2015) used real-time distress screening with automated distress data collection. They developed crack integral profiles and used the pixel values of the profiles to "draw" the cracks. Work by Tsai et al. (2015) used automated crack detection algorithms and 3D laser technology to estimate the amount of crack sealing needed for an airport project. Australian efforts, including that by Copcic et al. (2014), identified 31 different cracking parameters of interest.

Xu et al. (2016) developed a classification algorithm that uses the fusion of texture and shape, via a neural network, to interpret pavement distress images. Lea et al. (2014) addressed automated condition survey data, with sensor data, for distress monitoring of jointed concrete pavements for pavement management.

Data quality is an important issue because States and local governments use asset management data to direct funds, maintain preservation programs, justify funding levels to legislatures and the general public, and show progress toward performance measures. Woldesenbet and Jeong (2014) developed a highway data quality report card that uses 10 data quality dimensions to assess pavement management data. They proposed that using the report card can assist agencies in justifying the continuous and costly data collection efforts.

The impact of pavement condition variability on network-level maintenance decisions was examined by Jia et al. (2016). The authors found that a moderate level of distress had the most significant impact on the pavement distress index. Work by Simpson et al. (2018) compared agency-collected and research team-collected distress data on Interstate highways. The work resulted in a pavement sampling data quality management plan for Interstate highways. Siabil (2016) integrated heuristics and statistics to improve the quality of network-level pavement condition data. This work considered time-series trends in pavement condition and variability within supposedly homogeneous sections.

The South Carolina Department of Transportation (SCDOT) is using GIS-integrated technology to allow decision makers to identify the proximity of candidates within the network. Reed et al. (2018) reported that the tool is helpful in selecting roadways for the pavement preservation program. Tsai and Wang (2018) investigated remote sensing coupled with GIS to identify and locate distresses on concrete pavements. The Missouri Department of Transportation (MoDOT) sponsored a series of projects related to pavement preservation. The work in this series by Anderson et al. (2015) was focused on pavement evaluation tools and data collection methods.

Treatment Design

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The Treatment Design topic area includes the broad topics of treatment selection and treatment timing. These topics are included in the FHWA's Every Day Counts-4 (EDC-4) program, which examines the when, where, and how of pavement preservation. Specifically, EDC-4 addresses the where and when of project selection and treatment selection and timing (Kuennen 2017).

Several reports have covered the broad topic of treatment selection or have included numerous treatments. Ali and Mohammadafzali (2014) reported on asphalt surface treatment practices in the southeastern United States in a report prepared for the Southeastern Association of State Highway and Transportation Officials (SASHTO). Work by Vitillo et al. (2015) covered the range of treatments that could be used by the New Jersey Department of Transportation (NJDOT). Treatment selection for a variety of traffic, climate, and structural integrity levels was developed by Sakhaeifar et al. (2015) for the Oklahoma Department of Transportation (ODOT). Work by Humphries and Lee (2015) focused on treatment selection for general aviation airports in Texas. LCCA was used by Jannat and Tighe (2018) to consider optimal treatment selection for various materials and traffic levels in Ontario, Canada. Treatment selection criteria, including environmental assessment and budget restrictions, were applied to data from an urban area of Chile by Torres-Machi et al. (2018).

Treatment triggers, or specific condition values at which treatment is recommended, are also included in the umbrella topic of Treatment Design. Work by Noureldin et al. (2014) focused on the impact of trigger values on budgetary needs in Indiana. This work was part of a broad asset management evaluation for both bridges and pavements by Fricker et al. (2014). The authors of this study showed the impact of the trigger values on the percentage of pavements in good condition and the needed budget.

When used in treatment selection, LCCA uses information about treatment costs and future maintenance costs. Choi et al. (2016) created a model to predict future maintenance costs for low-volume highways to assist in project scoping decisions. Maintenance scheduling was also the focus of recent work by Ding et al. (2013) and Denysiuk et al. (2017). Both in-place recycling and conventional pavement construction were considered by Santos et al. (2017) in their life cycle assessments.

Treatment selection criteria as well as recommended timing of treatments to achieve successful preservation were addressed by Smith et al. (2017) in work conducted for New England State agencies. Strange (2014) reported on the benefits achieved by the town of Avon, Indiana, by analyzing pavement conditions and using them to determine treatment timing. Work in the area of treatment timing has not been limited to the United States. Work in Jiangsu, China (Li et al. 2014, Li and Ni 2015), showed the importance of treatment timing for cost-effectiveness and LCCA.

Development of tools and recommended practices to assist in the selection of appropriate treatments has been the focus of significant research, both academically and within agencies. Rada et al. (2014) described four emerging technologies for use in treatment selection. Work by Cancian et al. (2015) focused on tree-based decision making and included a discussion on the impact of delaying treatment. Neural network pattern recognition was used by Elbagalatti et al. (2018) in their decision-making tool for use in pavement management systems.

Work related to agency tools includes the incorporation of subsurface condition evaluation into pavement preservation treatment selection for INDOT by Ahn and Lee (2016a). A selection tool was developed by de Leon Izeppi et al. (2015) as part of their work for the Virginia Department of Transportation (VDOT) on best practices and performance assessment. Pavement treatment trigger tables and decision trees for candidate selection were developed as part of a multi-phase effort for MoDOT by Richardson and Lusher (2015a). Abdelaty et al. (2015) developed a pavement treatment selection tool for local agencies in Iowa that considers pavement condition in selecting feasible treatments and analyzing them to determine the return on investment. A treatment selection algorithm was updated by Tapper et al. (2016) that provides candidate treatments and cost estimates for roadway preservation in New Zealand. Recommended design practices and a selection tool were developed by Arabali et al. (2016, 2017) for flexible pavements in general aviation facilities.

Apart from the broad treatment selection practices and tools described above, work is also being done in treatment selection for individual treatments. Wang et al. (2017a) focused on crack sealing treatment selection using crack characteristics. Tsai and Wang (2016) developed a crack sealing planning tool that uses three-dimensional (3D) laser data and automated crack detection to identify potential projects for crack treatments.

Chip seals, one of the most common preservation treatments, have been the focus of multiple research studies. Mahoney et al. (2014) considered optimal timing and design as well as construction factors based on a series of surveys and meetings on bituminous surface treatments in Washington State. Kim et al. (2014) evaluated the performance of chip seals in the development of performance-related specifications. Chip seal designs and specifications were developed based on sections showing the range of performance from very good to poor in work by Buss et al. (2016).

Sebaaly et al. (2016) evaluated the effectiveness of micro surfacing cape seals and slurry seal cape seals for northern Nevada using both performance life and cost-effectiveness. Micro surfacing and chip seal sections were evaluated by Hencken et al. (2014) relative to noise for selection in the preservation of pavements with very low levels of distress. A recent FHWA TechBrief addressed project selection criteria for cold in-place (CIP) recycling and cold central plant recycling (CCPR) (Cross and West 2018).

Thin overlays with hot-mix asphalt layers are a relatively recent addition to the pavement preservation toolbox. Work by Wilson et al. (2015) addressed project selection, treatment design, and construction considerations for Texas. Use of thin asphalt over a granular base was assessed for use in Western Australia by Rice et al. (2018) to provide a cost-effective alternative to full-depth asphalt pavements. Work in Korea by Han (2017) focused on determination of optimal overlay thicknesses based on data from 150 test sections.

Reflection cracking mitigation methods for overlays on flexible pavements were evaluated by Golestani et. al (2018), and priorities were set based on cost, performance, and recyclability. Use of a reflective cracking relief interlayer for asphalt pavements was considered for three test sections for the Nevada Department of Transportation (NDOT) by Habbouche et al. (2017). One test section included an experimental stress relief course, another used the current NDOT fine-graded Type 3 mixture, and the last test section was a control with no stress relief layer.

Only a limited amount of work is documented for rigid pavement treatment design. Treatments including slab stabilization, partial- and full-depth repairs, retrofitted edge drains, load transfer restoration, diamond grinding, joint resealing, and concrete overlays are included in the FHWA's *Concrete Pavement Preservation Guide* by Smith et al. (2014). Experiences with these treatments in the U.S. were reported by Smith and Ram (2017) at a conference in Australia. Recommended practices for the use of concrete overlays, including treatment selection criteria, are included in work by Harrington and Fick (2014). Techniques to restore concrete texture depth and skid resistance include diamond grinding, transverse grinding, bush hammering, shot blasting, and micro milling. These techniques were applied to test sections in England and monitored for skid performance by Fingerle et al. (2014). Continuously reinforced concrete pavement with the replacement of asphalt repairs by concrete repairs are described by Brink (2017).

Materials

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A significant amount of research has been conducted in the Materials area, including laboratory studies, field investigations, and development of specifications. For the purposes of this literature review, the Materials topic is subdivided into three main areas: component materials, pavement preservation treatments, and performance-based or performance-related specifications.

The Transportation System Preservation Technical Services Program (TSP2) oversees the Emulsion Task Force (ETF). The task force has done significant work in developing materials specifications and treatment specifications for pavement preservation treatments using emulsions. These specifications are submitted to the AASHTO Committee on Materials and Pavements for balloting and use by State agencies.

Component Materials

Improved characterization of and specifications for asphalt emulsions have been a significant need. Adams et al. (2018) developed performance-graded specifications for asphalt emulsions for use in chip seals that are based on the multiple-stress creep and recovery test and the dynamic shear rheometer frequency sweep test. These tests were selected to address performance in terms of bleeding and low-temperature aggregate loss. Work by Hanz et al. (2014), also on the selection of emulsions for surface treatments, recommended the use of dynamic shear rheometer and bitumen bond strength tests to evaluate high-, medium-, and low-temperature emulsion performance.

Aging of asphalt binder results in changes in the performance of an asphalt mixture over time. Anderson et al. (2016) used aging-related properties from rheological tests on recovered asphalt to identify the proper time for preventive maintenance. Work in the United Kingdom by Bowden et al. (2018) focused on using infrared spectroscopy to identify pavement aging and allow strategic rather than reactive treatment.

Rejuvenators and investigation of the mechanisms by which rejuvenators reduce aging effects have also been studied by multiple investigators. Oldham et al. (2015) proposed chemo-mechanical metrics for measuring the restoration of properties and the benefits of bio-based rejuvenators. Sabahfar and Hossain (2016) measured the effects of rejuvenators on hot in-place recycled pavements in Kansas using Hamburg wheel tracking, dynamic modulus, flow number, the Texas Overlay Tester, thermal stress restrained tests, and moisture susceptibility tests.

Use of asphalt rubber binders has proven effective in improving the rutting resistance and fatigue resistance of flexible pavements. Work done by Williams and Puga for the Midwest Transportation Center at Iowa State University (2019) developed a mix formulation that reduced production temperatures and provides a wider range of lay-down temperatures. Souliman and Eifert (2016) conducted laboratory testing on conventional and asphalt rubber gap-graded mixtures and found that the asphalt rubber mixtures had a significantly lower cost per 1,000 cycles of fatigue life compared to conventional hot-mix asphalt.

Friction testing of surface layers is a component of the safety monitoring of many highway agencies. Smith and Fu (2015) correlated laboratory and field friction measurements for pavement test sections in Utah. Blumenfeld and Bohm (2018) used a variety of tests, including SKM, grip tester, SRT, and sand path tests, to evaluate mastic asphalt mixtures in comparison to lower cost but non-polish-resistant aggregates.

Pavement Preservation Treatments

Crack sealing is an effective pavement preservation technique that prevents moisture infiltration into pavements. Sawalha et al. (2017) developed a modified crack sealant adhesion tester for hot-poured asphalt sealants and validated the results with sealant field performance data. Adhesion of crack sealant to pavement crack walls was also the subject of work by Cao et al. (2015), who analyzed sealant bonding properties using Image-Pro® Plus software. Lee et al. (2015) developed crack sealing and filling best practices for INDOT, including both sealant selection and installation methods. Performance-based specifications for hot-poured asphalt crack sealant were validated by Al-Qadi et al. (2016), and the work includes recommended practices for planning, sealant selection, and construction.

Chip seals consist of an emulsion binder with an aggregate topping and can be laid in single, double, or triple layers. Compatibility of the aggregates and the emulsion is essential for good performance, and this topic was studied by Alvarado and Howard (2014). The authors emphasized optimal cure time to prevent excessive chip loss and the correlation between mass loss and moisture loss. A field and laboratory investigation into the variables affecting chip seal performance was conducted by Karasahin et al. (2015). The authors utilized two different binders and two types of aggregate and found that limestone was more resistant to raveling than basalt.

A chip seal with a highly reflective aggregate was used to reduce temperature variations in an asphalt pavement susceptible to rutting in work by Mallick et al. (2015). The authors described the system as having an insulating layer and a highly reflective surface layer.

Updyke and Ruh (2016) reported on the abundance of reclaimed asphalt pavement (RAP), which has led the California Department of Transportation (Caltrans) and others to incorporate RAP into preservation treatments, including chip seals, micro surfacing, and slurry seals. The cost-effectiveness of chips seals with and without millings (that used RAP) was studied by Tarefder and Ahmad (2018) for the New Mexico Department of Transportation (NMDOT). The authors found that treatments with RAP had a higher cost-effectiveness index than those without RAP.

In some areas of the U.S., high-quality aggregates for chip seals and other surface treatments are not readily available. Toole et al. (2018) considered the use of marginal and non-standard materials and provide information on their use for low-volume roadways. Otta seals, an alternative to bituminous surface treatments, were investigated by Ceylan et al. (2018). Otta seals have been used on low-volume roadways in Minnesota and Iowa.

Asphalt rubber chip seals have been used in the western U.S. and are beginning to be used in the northeast. Laboratory performance testing based on surface wear tests was reported by Zhu (2013), who developed a pavement surface abrasion tester.

Micro surfacing is used to restore skid resistance, correct minor rutting, reduce raveling, and protect the underlying pavement from oxidation. Ilias et al. (2018) developed micro surfacing specifications to address raveling resistance and recommended the use of the wet track abrasion test but not the asphalt bond strength to characterize micro surfacing performance.

Thin asphalt overlays are an increasingly popular preservation treatment. You et al. (2015) conducted laboratory research on two mixtures using tests including dynamic modulus, dynamic creep, static creep-recovery, semi-circular bending, and Hamburg wheel tracking. Hajj et al. (2016) conducted a laboratory evaluation of thin asphalt overlays and found that the overlays are expected to provide additional service with a modest increase in construction cost. The Texas Transportation Institute developed a successful thin-lift mix for TxDOT using small aggregate and a polymer-modified emulsion (Kuennen 2014). Arellano et al. (2015) developed practices for the use of thin asphalt surface mixtures for pavement preservation by TxDOT. The recommended practices emphasize the importance of good rolling patterns because no density controls are enforced due to the thin lift. Prozzi and Archilla (2018) developed a simple fatigue test for thin overlays to help ensure the quality needed for aggregates used in the thin overlays.

In-place recycling techniques include both cold in-place recycling and hot in-place recycling, and both techniques are generally considered to be rehabilitation rather than preservation treatments. Sebaaly et al. (2018) developed mix design and structural design procedures for cold in-place recycling for the Nevada Department of Transportation. The authors also provided information about when an asphalt overlay should be applied over the recycled layer or when a maintenance activity should be performed. Use of cold in-place recycling using foamed asphalt on the Vadodara Halol Toll Road Project (India) was reported by Bhavsar et al. (2016) at the 11th Transportation Planning and Implementation Methodologies for Developing Countries conference. Design of cold in-place recycling was also the focus of Mueller et al. (2014), who used the Superpave indirect tensile tester to evaluate resistance to thermal cracking. Hot in-place recycling was used in a Jiangxi, China, case study reported by Zou et al. (2015).

Wang et al. (2017b) evaluated four types of joint sealant materials for concrete pavements in civil airports. Performance characteristics included surface drying time, cone penetration, elastic recovery rate, tensile modulus, and others. Guo et al. (2017) developed a blend of polymer modifiers and superfine portland cement to use in repairing cracks in concrete pavements. High early strength concrete for use in repair of existing concrete pavements was evaluated for 12 projects in Wisconsin by Cramer et al. (2017). The authors concluded that the durability issues that had occurred were most likely due to issues arising during construction or mix design. Work by Hampton and Hodgkinson (2015) focused on slab replacements using rapid-set concrete, which allows work to be completed in a single shift.

Ghahari et al. (2017) investigated salt scaling of roller-compacted concrete pavements when deicer salts are applied. They tested the use of a natural pozzolan called Trass and an air-entraining agent to determine whether scaling would be reduced but found that it was not. The causes of scaling and freeze-thaw deterioration in concrete pavements was also studied by Oh et al. (2018), who found that scaling resistance varies with saline solution, surface finishing treatment, and freeze-thaw environment.

Performance-Based or Performance-Related Specifications

Performance-based or performance-related specifications would shift the focus of specifications from "how" (i.e., method specifications) to the identification of the performance indicators used to determine whether a project is acceptable. One of the challenges is to link the initial quality of the pavement before treatment to the long-term performance of the pavement once treated. Liu (2013) developed a methodology focused on thin-lift hot-mix asphalt and using International Roughness Index to characterize pavements before and after treatment. Liu and Gharaibeh (2015) used a simulation-based approach for developing performance-related specifications, again focusing on thin-lift hot-mix asphalt. The authors used LTPP sections in Texas, Idaho, Florida, and New Jersey to demonstrate the methodology.

Chatti et al. (2017) provided an approach for preparing performance-related specifications for a range of flexible and rigid preservation treatments. The recommended practices include a methodology for determining pay adjustment factors and example specifications for flexible and rigid pavements. The example for flexible pavements is a micro surfacing performance-related specification developed by Haider et al. (2017a). The example for rigid pavements is a diamond grinding specification developed by Haider et al. (2017b).

Mogawer et al. (2014a) developed a performance-based specification for high-performance thin overlays that include RAP. The mixture, utilizing highly modified asphalt binder, was tested for reflective cracking, thermal cracking, fatigue cracking, and rutting. The need to test the RAP material was emphasized. Mogawer et al. (2014b) validated and modified the earlier specification, noting again that the RAP material has a significant impact on the performance of the mixtures.

A recent Concrete Pavement MAP Brief by Cackler et al. (2017) described performance-engineered mixtures (PEM) for concrete pavements, an approach that considers six properties that control mixture performance: aggregate stability, fluid transport properties, weather, shrinkage, strength, and workability. A table that is part of the PEM approach includes ASTM and other tests to include for those properties most relevant to a particular region.

Treatment Application

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This section deals with the construction of preservation treatments and, to a limited extent, with contracting methods used for preservation work.

Crack treatments include both crack filling of non-working cracks and crack sealing for cracks that experience movement. Morris (2016) provides an introduction to crack treatments, both sealing and filling. The Center for Transportation Research in Austin, Texas, completed a project that involved a survey of crack treatment methods as well as monitoring of five test sites that included a variety of routing configurations and sealant materials (Lee et al. 2015). Recommended practices for crack sealing and filling, including site selection, material selection, installation methods, and inspection, were developed by Truschke et al. (2014) for the Colorado Department of Transportation (CDOT). Decker (2014) prepared a best practices approach for crack treatments for asphalt pavements based on both National and international practices. Caltrans, which has a history of developing equipment to meet the agency's needs, has developed a Sealzall machine for high-production crack sealing that uses a fully automated process involving only a single operator (Bennett and Velinsky 2014).

Many agencies have observed the development of transverse bumps in asphalt overlays placed over crack sealant. This issue was studied by Shuler (2017a, 2017b), who determined that vibratory breakdown rolling, pavement gradient, sealant geometry, tack coat application rate and tack coat adhesivity, and the amount of asphalt immediately in front of the breakdown roller are contributing factors. Recommended practices were developed for CDOT and presented Nationally.

The TSP2 ETF has undertaken a variety of efforts to provide material specifications and construction recommended practices for a variety of pavement preservation techniques. ETF-suggested construction practices are being developed based on the results of NCHRP projects.

Shuler et al. (2018) provided construction specifications for chip seals and micro surfacing as part of NCHRP Project 14-37. One of several State manuals for chip seal design and construction was developed by Testa and Hossain (2014) for the Kansas Department of Transportation (KDOT). The last two chapters of the Kansas manual deal with treatment application and areas of concern during construction.

A number of projects have dealt with the various measures of chip seal performance. These include the aggregate application rate, the emulsion application rate, and the embedment depth of the chips. Rawls et al. (2016) developed a field test to measure the emulsion application rate for quality control field testing. Work on chip seal construction variability led to the development of quality control and quality acceptance criteria for NCDOT (Kim et al. 2018). Embedment depth has also been the focus of work by Haider et al. (2018) for the Michigan Department of Transportation (Michigan DOT).

While patching typically falls into the category of reactive maintenance, some patching is typical in many preservation operations. Dong et al. (2014) demonstrated the value of semi-permanent patching over rapid throw and roll techniques and encouraged the use of the higher cost treatment for the Tennessee Department of Transportation (TDOT).

Micro milling prior to application of a thin overlay was studied by Lai (2014) and Tsai (2015). Lai (2014) considered the setting of an appropriate ridge-to-valley texture depth for a project on I-95 in Georgia. The work by both Lai (2014) and Tsai (2015) aimed to remove only the upper 3/4 in. to 7/8 in. of deteriorated thin open-graded friction course without damaging the underlying layer.

Cold in-place recycling and hot in-place recycling are usually considered to be rehabilitation rather than preservation techniques. Van Frank (2015) developed field protocols for cold in-place recycling, including recommendations for mix design, density control, and roller patterns. Zou et al. (2015) described a case study in Jiangxi, China, of hot in-place recycling and included construction and quality control methodology.

A series of case studies on concrete repair best practices was conducted by Darter (2017a) based on input from both contractors and agencies, and a series of related tech briefs was developed. Cross-stitching is described by Darter (2017b) as a methodology to hold longitudinal cracks or joints tight over time and is demonstrated using a MoDOT case study. In a diamond grinding case study, Darter (2017c) describes the benefits of this technique in terms of improved ride quality, good frictional characteristics, and noise reduction. In a WSDOT case study on dowel bar retrofits, Darter (2017d) reports that the treatment had improved load transfer from 30 percent to more than 80 percent. Darter (2017e) uses case study information from Minnesota, Missouri, Utah, Washington, Georgia, and California to describe how spalling along joints and cracks can be addressed using partial-depth repair. Darter (2017f) describes the use of full-depth concrete repair for jointed plain concrete pavement in California and for jointed reinforced concrete pavement in Missouri.

In other work on concrete repair best practices, Hampton and Hodgkinson (2015) focused on slab replacements using innovative concrete replacement solutions that allow a complete slab replacement within one work shift. Brink (2017) describes maintenance and repair for a continuously reinforced concrete pavement in South Africa for which the transportation agency required maintenance of two lanes of traffic at all times.

Three research studies have dealt directly with contracting methods as they pertain to pavement preservation. The Mississippi Department of Transportation (Mississippi DOT) had been using deduct values from its pavement condition surveys to set the thresholds for warranty pavement treatment contracts. Work by Qi et al. (2015) recommended that, based on National warranty practice, using distress-defined thresholds would be more consistent and easier for the Mississippi DOT to implement. Performance-based contracts transfer risk and responsibility from the agency to the private sector but are dependent on selecting meaningful and measurable metrics, setting appropriate thresholds, and setting penalties and incentives. Abu Samra et al. (2017) describe the impact of small changes in thresholds on both life cycle costs and contract costs. Lu and Meng (2018) discuss use of build-operate-transfer contracting and setting appropriate tolls to cover highway construction and maintenance costs.

Performance

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A recently released NCHRP report by Rada et al. (2018) describes a process that agencies can use to identify performance measures for their road networks, select adequate data to develop performance curves and performance jumps as a result of preservation treatments, and use these to calculate the impact of preservation activities on both roadway and network performance. The report includes an approach for setting performance measures for pavement preservation and case studies demonstrating some key steps.

The remainder of this section divides the literature falling under the Performance topic into two groups: performance prediction and modeling and performance of preservation treatments.

Performance Prediction and Modeling

Monte Carlo simulation was used by Ioannides et al. (2018) to predict the performance of roadway sections based on data from Ohio Route 50. The authors emphasized the difficulty in predicting performance over a long period of time when distress trends are developed for much shorter periods of time. Duckwork et al. (2018) assessed models to predict pavement performance for the Iowa DOT and found that linear predictive models provided reasonable estimates for pavement condition index (PCI). Enhanced pavement deterioration curves were developed by Katicha et al. (2016) using a modified structural index to determine the critical condition index, and the enhanced curves were able to improve the predictions made by the future critical condition index by 21.6 percent.

Richardson and Lusher (2015b) assisted MoDOT by writing procedures for the development of pavement family and treatment performance models. This work is Volume III of a series outlining various aspects of a pavement preservation program. Jethwa and Topp (2014) describe a process for using historic data to develop condition deterioration models using as few as two years of data. The models consider local factors, including materials and traffic loading. Periods of accelerated deterioration, like that caused by flooding, can result in interim road deterioration models, as described by Martin and Choummanivong (2015). The models allow calculation of the costs incurred as a result of the flooding event. Performance models for urban pavements, whose maintenance is complicated by utilities and variable traffic demands, were developed by Osorio et al. (2015) using five categories of streets and three climates.

The impact of pre-existing condition on the performance of pavement treatments is important to agency decision making. Eisma et al. (2015) considered various site conditions, including construction practices, traffic, climate, and pavement conditions, in their analysis of service life extension using data from the LTPP program. The FHWA published a TechBrief on the effects of maintenance and rehabilitation strategies on treatment effectiveness that also used LTPP data (Michigan State University Department of Civil & Environmental Engineering and NTH Consultants, Ltd. 2016). Haider et al. (2015) used analysis of variance and multiple linear regressions to analyze the impact of pavement condition on the performance of slurry seals, chip seals, crack sealing, and thin overlays. Work by Kadar et al. (2015) explored the expansion of condition data to include time series data by utilizing HTML text strings, thereby expanding the scope of condition analyses beyond the use of simple averages and standard deviations.

Much of the literature related to performance modeling is included under the Asset Management, Pavement Management, and Pavement Preservation umbrella topic above, which the reader should refer to for additional resources on the topic. Three examples are included here for completeness. Hong and Prozzi (2015) developed pavement deterioration models that include both observed and unobserved heterogeneity, and the models can be integrated into an optimized decision-making process that minimizes total life cycle cost. Work by Abaza (2017) and by Lethanh and Adey (2013) used Markov-based models to model the performance of rehabilitated pavement and pavement deterioration, respectively.

The sustainability of pavements and the impact of various treatment types over the pavements' lives were evaluated by Santos et al. (2018) using multiple bi-objective optimization analyses considering agency costs, user costs, and greenhouse gas emissions. Sustainability, combined with an economic analysis of options, is generally carried out using LCCA in combination with LCA. LCCA is an analytical technique that evaluates long-term alternatives using economic principles. Work by Kim et al. (2015) describes enhancements made for Caltrans to FHWA's RealCost LCCA software, which integrates service life, maintenance frequency, and agency cost for each maintenance activity. Lu and Xin (2018) developed pavement performance models that consider both environmental factors and rehabilitation activities, like milling and overlays, to predict multiple performance indicators. Medury and Madanat (2014) demonstrated an approach to optimizing life cycle costs and emissions in pavement management. Lu et al. (2018) found that materials, construction-related traffic congestion and pavement surface roughness are three major contributors to energy consumption.

Estimation of service life is a critical element of agency planning activities, whether for preservation, rehabilitation, or reconstruction. Bardaka et al. (2014) used mixed linear modeling techniques to evaluate the service life of seven common rehabilitation techniques in Indiana. Remaining service life is used by many agencies to track the adequacy of their programs for maintaining infrastructure condition. Dissipated energy was used by Gao et al. (2018) to predict the remaining service life of asphalt pavements based on indirect tensile tests on samples of different ages. The remaining service life interval defines the time to the next needed treatment, and a framework for its application to pavement management was developed by Rada et al. (2016).

Performance measures indicate the extent to which a pavement or a network of pavements achieves particular goals. Rada et al. (2018) developed pavement performance measures under NCHRP Project 14-33 (with results published in NCHRP Report 858) that consider the contributions of preservation treatments. This project was designed to identify performance measures that reflect the positive benefits of preservation treatments. Existing performance measures, such as International Roughness Index (IRI), may show the benefit of thin overlays but not the benefit of chip seals or crack sealing. INDOT has an active safety program and had Li et al. (2018b) develop benchmark life cycle friction performance curves for chip seals, micro surfacing, ultra-thin bonded wearing courses, and diamond grinding.

Progression of roughness was modeled for asphalt pavements by Meegoda and Gao (2014) in a Weibull model that included traffic load, structural number, annual precipitation, and freezing index. Satradhar et al. (2015) used artificial neural network modeling to evaluate the impact of distresses, including alligator cracking, potholes, segregation, edge cracking, corrugation, and patching, on ride quality in terms of IRI. A relationship between roughness and present serviceability rating (PSR) was sought by Bharti et al. (2014) using statistical modeling and artificial neural networks. The best relationships were found with exponential and logarithmic models. Harvey (2017) developed improved models relating smoothness and distress for Caltrans to use in its pavement management system, PaveM. Buttlar and Paulino (2015) developed a pavement cracking model that links pavement roughness with vehicle maintenance and driver comfort. The authors also included the estimated emission costs associated with pavement roughness.

Performance of Preservation Treatments

While pothole repair is a reactive activity, work by Sadeghi et al. (2016) has developed a model to predict pothole formation and identify routes that are susceptible to this distress. Traffic loads, weather condition, and pavement condition are all key indicators.

Tremblay and Sanborn (2014) provided an assessment of AASHTO M 364/ASTM D6690-12 Type II and Type IV joint sealers for the Vermont Agency of Transportation. Based on three years of monitoring, the Type IV sealers allowed less water passage through the length of the filled crack. Wang et al. (2017a) developed crack sealing performance models for both crack sealing and crack filling. Crack type, density, and width are all included in the models. The injection method for sealing longitudinal reflective cracks was found by Mezhoud et al. (2018) to provide benefits that included improved pavement layer stiffness and the ability to be applied without highway closure.

Various approaches to mitigating reflection cracking were found in the literature. Chun et al. (2016) found that applying hot-mix asphalt layers with thicknesses of 0.5 in., 1.5 in., or 2.5 in. performed better in retarding reflection cracking than did 1 in. of open-graded crack relief or 0.5 in. of an asphalt rubber membrane interlayer. Florida has used asphalt rubber membrane interlayers with variable success, and Nam et al. (2014) have investigated reflection cracking mitigation techniques. Reflection cracking also occurs when asphalt concrete pavement with cracking is overlaid with additional asphalt concrete. An analysis of various reflective cracking mitigation options by Golestani et al. (2018) included life cycle cost, performance, and the recyclability of the materials.

The effectiveness of joint sealant for jointed concrete pavement was studied by Texas Transportation Institute (Kuennen 2016). The evaluation included both the amount of infiltration through the joint and the impact on subbase erosion.

The World Road Association sponsored a study of the expected service life of wearing courses that was conducted by Briessinck et al. (2016) using an international survey. LTPP data from Specific Pavement Study 3 were used in a study by Gong et al. (2016) to analyze the effectiveness of preventive maintenance for flexible pavements. Thin overlays were found to be effective against fatigue cracking and roughness, and chip seals were found to be effective against fatigue cracking. The same LTPP data were used by Musunuru et al. (2016), who concluded that thin overlay treatments improved pavement performance in terms of IRI and rut depth. Serigos et al. (2017) used survival analysis techniques to study the performance of preventive maintenance treatments in Texas using more than 20 years of data. A skid prediction model for surface treatments was the result of work by Chowdhury et al. (2017) based on 70 test sections of asphalt mixtures and surface-treated roads in Texas. The model includes aggregate characteristics, aggregate angularity, mixture gradation, and traffic level.

The opening or widening of longitudinal construction joints in flexible pavements creates maintenance issues for many agencies. The area around these joints typically has a lower density and higher permeability than the main portions of the roadway. Montgomery and Haddock (2017) studied the effectiveness of fog seals as a preventive treatment for longitudinal joints and found that fog seals had the effect of reducing the voids along the joints, enhancing performance.

The National Center for Asphalt Technology (NCAT) has developed an effective way to evaluate the performance of various pavement sections and surface treatments under controlled loadings. One example of test track findings was prepared by West et al. (2018).

Chip seals, or seal coats, are commonly used treatments for low- and medium-volume roadways for many State agencies. Guirguis and Buss (2017) evaluated the performance of emulsion and hot asphalt chip seal pavements and found that aggregate properties and pre-treatment pavement condition have a significant effect on performance. Guirguis et al. (2018) reported a service life of five to six years for chip seals in Oregon. Based on an extensive study of 18 roadways in

Minnesota, including both field evaluation and laboratory testing, Rettner and Tompkins (2017) concluded that stripping under chip seals is not associated with high air voids. Ahn and Lee (2016b) evaluated the low-temperature performance of seal coats and concluded that softer binder performed better than emulsion with stiffer binder in terms of aggregate loss at low temperatures. Neaylon and Harrow (2017) studied the performance of second-coat seals and reseals in New Zealand and found that long-life seals can be applied in a wide range of temperature extremes, rainfall categories, and amounts of sunlight.

Sebaaly et al. (2016) studied the use of cape seals with a micro surfacing or slurry seal topping in northern Nevada and found that the lifespan of a cape seal with micro surfacing (7 years) makes the treatment more cost-effective than a cape seal with slurry seal (3.5 years). The use of micro surfacing and portland cement slurry for rut filling was evaluated by Pittenger et al. (2014), who found that both products performed similarly. Simoes et al. (2017) compared the life cycle cost analyses of various combinations of treatments as well as emission factors and found that repeated application of micro surfacing performed best in terms of economic and environmental benefits.

Sprinkel et al. (2015) describe VDOT's experience with high-friction surface treatments and conclude that these treatments are effective at creating high friction resistance but perform well only as long as the underlying pavement remains intact. Kansas experienced poor bond strength and rapidly decreasing skid resistance in its high-friction surface locations, according to the report by Meggers (2015).

Thin asphalt overlays are an increasingly popular pavement preservation technique. You et al. (2015) examined the thin asphalt overlay practices in Nebraska and compared the modeled performance of two mixtures. A laboratory evaluation of thin asphalt overlays was conducted by Hajj (2016), who found that a modest cost increase in the overlay treatment could extend the pavement overlay's life. Musty and Hossain (2014) studied the performance of ultra-thin bituminous overlays for KDOT and found a sharp drop in effectiveness against fatigue and transverse cracking after a couple of years in service. A mechanistic-empirical evaluation of the combined treatment of diamond grinding and a thin overlay was conducted by Chatti et al. (2016), who found a correlation between IRI and dynamic load index, which can be used in developing performance-related specifications.

Anderson et al. (2017) evaluated 69 test sites with a range of treatments, including crack sealing, full and wheel path chip sealing, mill and fill, and blade patching. All treatments and treatment combinations stabilized pavement condition for between two and four years.

Preservation treatments are also used for rigid pavements. Saboori et al. (2018) developed a performance prediction model regarding cracking for replaced concrete slabs in California. The probability of a slab cracking is based on its age, thickness, and traffic loads. The performance of silicone sealants in sawn joints was studied by Cui and Vorobieff (2015), who found that inadequate cleaning effort and quality control led to early failures. Bakhsh and Zollinger (2016) also studied the effectiveness of joint sealant, and their model showed that properly installed sealed joints had significantly lower flow rates. Early detection of joint distress in portland cement concrete pavements was the goal of Harris et al. (2015). The authors used a variety of tools, including ultrasonic wave speed and ground penetrating radar with signal processing technology called complexity-invariance distance.

The impact of diamond grinding on the performance of rigid pavements was studied by Haider et al. (2016) using LTPP data. The authors found that a reduction in IRI following diamond grinding corresponded to reduction in dynamic axle loads. The changes in surface texture and friction characteristics following diamond grinding of both concrete and asphalt pavements were reported by Li et al. (2016), who found that longitudinal diamond grinding can provide satisfactory frictional properties for both pavement types.

Composite pavements usually consist of asphalt placed on top of underlying concrete pavement. Chan et al. (2014) used survival analyses of composite pavements to evaluate three performance indicators: IRI, reflection cracking, and pavement condition index. All overlay and treatment types in this study used rehabilitation or reconstruction approaches. Composite pavements have unique distresses, but the NCDOT PMS classifies them as flexible pavements. A project by Chen et al. (2018b) developed performance curves for composite pavements and recommended threshold values to trigger treatment. Khurshid et al. (2014) conducted a multi-dimensional benefit-cost evaluation of asphalt overlays over concrete pavements using four measures of effectiveness: roughness, treatment service life, pavement condition over the service life, and the area bounded by the performance curve.

Cold in-place recycling was shown to provide an effective surface treatment for between 6 and 15 years in recent work by Sanjeevan et al. (2014). A 12-year performance review of a cold in-place recycling project with a 6.7 mm stone mastic surface was provided by Moore et al. (2017). Santos et al. (2017) analyzed in-place recycling and conventional pavement construction and found benefits for both road agencies and road users from in-place recycling. Cold central plant recycling was studied by Diaz-Sanchez et al. (2017) regarding its structural coefficients from AASHTO's empirical pavement design methodology. Work by Diefenderfer et al. (2010) evaluated the performance of three NCAT test sections and found similar performance for two different overlay thicknesses and no observable cracking at 20 million equivalent axle loads.

Benefits

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Personnel in agencies charged with managing preservation programs are frequently challenged to identify benefits associated with their preservation program. This challenge extends to several stakeholder groups: agency leadership, legislators and other Government officials, and citizens. Leaders in agencies need to balance the needs of a variety of assets, including pavements, bridges, signage, markings, walls, equipment, and facilities. In times of financial shortfalls, these leaders need to select where to cut funding. Legislators frequently are tasked with apportioning funding to highway agencies and have varying levels of input into how that funding is used within the agency.

A variety of benefits may be demonstrated to stakeholder groups. There may be an economic benefit, which includes the potential benefits of having a preservation program and the potentially negative consequences of delayed road treatments. A second and increasingly important category of benefit is in the area of sustainability. Sustainability benefits include reduced greenhouse gas emissions and reduced fuel consumption. Sustainability is an increasingly important benefit of preservation treatments. A third type of potential benefit may be safety, which is most frequently measured using pavement friction measurements. The literature on these three types of benefits is summarized in this section.

Economic Benefits

Work by Chung et al. (2017) published in NCHRP Report 859 focused on the consequences of delayed maintenance of highway assets, including pavements, bridges, culverts, guardrails, lighting, pavement markings, and highway signs. The researchers identified both the potential savings and the performance enhancements associated with applying treatments at the optimal times and the benefits of incorporating these assets into a comprehensive asset management plan.

Since 1992, the Michigan DOT has had a preservation program (Capital Preventive Maintenance Program) that uses benefit-cost calculations and LCCA to quantify economic benefits. Ram and Peshkin (2014) found that the program resulted in agency cost savings of approximately 25 percent per lane mile versus a rehabilitation-only strategy.

Zuniga-Garcia et al. (2018) studied the cost-effectiveness of three treatments used in Texas: chip seals, micro surfacing, and thin overlays. While the effective life of all three treatments was found to be similar, chip seals were found to be the most cost effective and to have the lowest life cycle cost variability.

Sustainability Benefits

Kazmierowski and Navarra (2014) identified two sustainability rating systems to promote sustainable practices in the design, construction, rehabilitation, reconstruction, and preservation of roads. An FHWA TechBrief prepared by Ozer et al. (2016), *Strategies for Improving the Sustainability of Asphalt Pavements*, reports information about the use of sustainable practices throughout the life cycle of an asphalt-surfaced roadway. Snyder et al. (2016) prepared a similar FHWA TechBrief entitled *Strategies for Improving the Sustainability of Concrete Pavements*.

Work by Santos et al. (2018) utilized multiple bi-objective optimization analyses to consider both economic benefits and greenhouse gas reductions. The authors created a decision support system that used multi-criteria decision analysis to select the best compromise solution. Mosier et al. (2014) developed a carbon footprint cost index that can allow airport managers to select higher cost treatments based on enhanced sustainability. Salem and Ghorai (2015) considered the environmental impacts of commonly used maintenance and rehabilitation treatments by calculating the amounts of greenhouse gases emitted, energy consumed, and resources used and then used this information in an LCCA. They found that treatments like fog seal, crack seal, concrete joint sealing, diamond grinding, and partial-depth repairs have minimum impacts with maximum benefits. Wang and Gangaram (2014) used HDM-4 and the U.S. Environmental Protection Agency's Motor Vehicle Emission Simulator to analyze fuel consumption and emissions for different preservation treatments. The authors found that the environmental impact during road use is more significant than that during the construction stage.

Life cycle assessment was used by Bryce et al. (2018) to evaluate the energy consumption of a pavement network over a defined timeframe. The results could be used by transportation agencies to measure the impact of their treatment decisions on reducing energy consumption at the network level. Umer et al. (2017) developed an integrated LCCA and LCA framework to allow pavement treatment alternatives to be evaluated for sustainability based on both economic and environmental trade-off analyses over the life cycle of the alternatives. Uhlman (2018) conducted an eco-efficiency evaluation comparing a cape seal and a hot-mix overlay and found that the cape seal provided both the lowest life cycle cost and the least environmental impact. Simoes et al. (2017) conducted a similar study on micro surfacing and found that micro surfacing, repeated multiple times, was economically advantageous.

Another type of sustainability benefit may be associated with reduced user costs. A model was developed by Limsawasd et al. (2016) that considers the impact of a proposed treatment on pavement performance and the impact of that performance on user costs in terms of delay time during construction and post-construction user costs. Earlier research by Winston and Duncan (2015) showed that pavement condition directly affects vehicle operating costs and that including these costs in asset management analysis can improve the depiction of the economic impacts of preservation. Zhang (2015) used a simulation-based estimation to model the fuel consumption and emissions of asphalt paving construction. Robbins and Tran (2016) prepared a synthesis report on the value of pavement smoothness to the highway user and the impact of pavement roughness on vehicle operating costs. The operating costs included fuel and oil consumption, tire wear, maintenance and repair costs, and vehicle depreciation.

Safety Benefits

Haddadi et al. (2016) prepared a network-level decision-making tool that includes pavement maintenance and user safety. Development of the tool involved determining the optimal roughness levels at which maintenance and rehabilitation should be constructed for various climates as well as the network-level impacts of roughness and distress on vehicle operating costs and user safety.

Lyon et al. (2018) conducted a large-scale study of both flexible and rigid pavements to quantify the safety effects of pavement friction improvement. The authors found that there were positive benefits regarding wet-weather accidents but that drivers increased their speed under dry road conditions, reducing or eliminating the safety benefits of improved friction.

In work by Li et al. (2018b), Indiana established state benchmarks for the life cycle friction performance of chip seals, micro surfacing, ultra-thin bonded wearing courses, and diamond grinding. Li et al. (2018c) included the effects of aggregate properties and traffic in Indiana's state benchmarking process. Chowdhury et al. (2017) similarly used aggregate texture before and after polishing, gradation, angularity, traffic levels, and historic skid numbers to develop a pavement skid prediction model for surface treatments in Texas.

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APPENDIX B: ABBREVIATED RESEARCH NEEDS STATEMENTS

This appendix contains research needs statements developed through a collaborative process with a variety of pavement preservation stakeholders. In some cases, the stakeholders used words such as "recommendations," "guidelines," or "guidance." In the RNS, these terms do not imply Federal guidance from FHWA or recommendations to the FHWA. These statements are not a commitment or direction from FHWA of resources toward FHWA's overall research program. The contents of the research needs statements, including any references to and interpretations of Federal or other requirements, discussions of acceptable or predominant practices, and opinions about how research products may be used to meet Federal requirements, solely reflect the views of the research needs statements' authors and are not intended to reflect the views of FHWA.

RNS 01 – Web-Based Statistics Training for PMS Engineers and Users

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

NCHRP Report 858 provides methods to quantify the effects of preservation treatments on pavement performance. The report details approaches to determining the performance jump following application of a treatment and the rate of change of deterioration of the treated pavement, ideally compared to a control pavement. The work is a significant advance for pavement management and pavement preservation but will be a challenge for many pavement managers to implement. Many department of transportation (DOT) pavement management system (PMS) engineers are a decade or more past their undergraduate statistics course.

To illustrate the issue, at least three types of regression analysis were mentioned in the NCHRP report: stepwise linear regression, Deming regression, and robust regression with iterative application of weights. PMS engineers should have a background in statistical analysis relating to pavement data sets.

Such training may have application beyond pavement preservation. It may benefit both preservation and rehabilitation design for PMS engineers to understand performance curves and network prediction models.

Objective

The objective of this research is to develop web-based and self-paced statistics training, using real pavement management data. All the methods summarized in NCHRP 858 should be demonstrated in the training, along with exercises for practitioners using supplied data and using their own agency's data. This training may begin with determining the number of sections needed to develop performance models and then assisting students in selecting the most important factors so that they have a manageable analysis. Information about selection of control sections should be included. The various types of regression analysis should be explained, with their strengths and limitations, along with why one type is used for some cases and another type is used for others.

Methods should also be included for combining data from different sources and testing to see how similar those data sets are. It may be possible for adjoining States, each with limited datasets, to combine data for certain distresses and treatments and develop a small regional model.

Many agencies have advanced pavement management systems. Linking the training and statistical techniques to the approaches used in PMS will result in more knowledgeable users of the systems, and less of a "black box" approach as well as improved performance evaluations and confident benefit projections.

RNS 02 – Cyclic Approaches to Pavement Preservation

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Pavement management systems (PMS) typically monitor distresses and other performance characteristics to assess network condition. These performance parameters may be defined by evaluating the extent and severity of different types of cracking, rutting, faulting, roughness etc. The change in these parameters (performance characteristics) may be evaluated over time to develop future preservation and replacement strategies.

Although evaluating the development and change over time of monitored distresses (and other performance characteristics) has been the basis of most PMS systems, the efficacy of this approach has been recently challenged. Since a distress has to occur in the pavement section before it is recognized by the PMS, it is considered a lagging metric or indicator. That is, damage to the pavement has to occur prior to any ability to prevent or mitigate its occurrence.

Time-based PMS solutions provide the opportunity to apply a strategy before distress occurs, presumably preventing or delaying its occurrence. With this approach, it may be possible to extend pavement life and better manage the network. On the other hand, time based solutions may only be appropriate for specific distresses or locations as some distresses may still manifest themselves independent of the application of the prevention. In this situation, it could negate the value of the preservation treatment and may not be an effective use of network funding.

Objective

The objective is to evaluate the effectiveness of time-based treatment application approaches using actual performance data. It may produce best practices for time-based treatments.

The following minimum tasks should be performed:

1. Conduct a survey of agency practices for both PMS and maintenance preservation strategies. Survey results should provide the ability to characterize each of the agency approaches, data, and experiences.
2. Based on actual performance data, develop a best practices time based treatment application procedure. The process should identify when to apply which type of strategy, for what distresses it is appropriate, and for which climates and traffic levels it is appropriate.
3. Prepare a final report summarizing the results of tasks 1 and 2 and the detailing the efforts of the study and the conclusions and recommendations.

RNS 03 – Changing Technologies for Data Collection and PMS

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Pavement management system (PMS) data collection efforts should be stable over time. A measurement obtained in one year should be the same value if collected in a future year for the exact same distress condition. This is a difficult goal as equipment breaks and is repaired, is replaced with newer equipment, and is used by different operators over time.

To compound the problem, technologies are evolving at a rapid pace. Historically, the most dramatic change was in road profiling, which began with road response devices such as Mays meters, and then evolved into inertial profilers. Profilers subsequently evolved into laser-based technologies as opposed to optically based technologies. The laser technologies then evolved into line lasers as opposed to spot lasers. During all these profile equipment measurement changes, agencies need to have time stability in the road roughness measurements. Each of these technologies typically results it slightly different measurement value which can impact long-term network time stability of measurement.

Although historically, road roughness measurement technology has changed the most, the industry is being dramatically transformed with the introduction of automated distress data collection equipment. Not only is the testing being collected with a single unit, which can automatically reduce the data, the use of 3D technology allows data quality levels and uses that have never existed before, such as cross slope measurement, texture measurement, etc.

Objective

The objective of this research is to define the current state-of-the-practice in network level data collection practices including equipment acceptance testing, and annual survey calibration. It will identify recommended practices that can be used when changing equipment or vendor to relate new data to historic data or to determine that such a relationship does not exist.

The minimum following tasks should be accomplished:

1. Conduct a survey of State agency PMS data collection practices, equipment types and use, annual calibration/certification procedures for data collection, staffing levels, new equipment acceptance practices, and whether in-house or contracted services are used. The survey should also define the procedures used for maintaining time stable results, or how long-term trends are developed using different equipment and technologies. The survey should include identification of the results of calibration/certification sites so the variability can be

described. Practices should be identified, and case studies should be provided to demonstrate those practices.

2. Evaluate the current technology marketplace for automated data collection equipment including near term improvement that are expected. This task should contrast the differences between operational features of the equipment; as well as manufacturer levels of agreement; and manual methods. This task should investigate the data collection costs of the various options as well as production rates for both data collection and for data analysis.
3. Prepare a report that describes the state-of-the-practice of agency network level data collection. The report should summarize the findings of tasks one and two and provide recommended best practices.
4. Identify approaches that can be used in changing either technology or vendor to develop relationships between new data and historic data. Prepare recommended practices for effective technology changes and methodologies.

RNS 04 – Improving Remaining Service Life Over Time

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Given knowledge of critical parameters such as materials, design, traffic, climate, etc., it is possible to calculate the rate at which a pavement is deteriorating, and hence, future condition. By defining a minimum condition below which the pavement is unacceptable, it is thus possible to calculate remaining service life (RSL). The overall objective is to maximize the RSL of an entire pavement network. This can best be done by slowing the deterioration of the network components by applying various preservation treatments at the right time and using good quality materials and workmanship. As preservation treatments are applied to good and fair condition portions of the network, their deterioration rates are slowed, and a limited amount of rehabilitation and reconstruction may also be undertaken. However, depending on available resources, it could take several years to retire backlogs (roads with zero RSL) and increase network RSLs to stable levels. RSL is one of several approaches that can be used to reflect network condition, and the research team may consider a variety of approaches.

Objective

The objective of this research is to develop a strategy for improving network conditions over time. The research team should consider various approaches and may find that one approach is best for agencies with well-developed pavement management systems (PMS), and another approach is better for smaller networks with less sophisticated PMS. Methods for tracking network progress from initiation of preservation to a steady state condition should be provided. The information should assist agencies in balancing needed reconstruction with needed structural improvement through rehabilitation and with preservation. The impact of the backlog, which may increase during the initial implementation of preservation, needs to be clearly addressed. While many State agencies have highly developed PMS that can calculate network conditions for a variety of funding scenarios, some State and local agencies may not. They may benefit from a simple tool to project network condition or remaining service life as they transition to a preservation focus.

RNS 05 – Development of Advanced Models for Pavement Preservation

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

In the early days of pavement management system development and implementation, there were not sufficient data, or data with sufficient quality, to consider modeling more than one treatment in place, or to consider the impacts of that treatment on the existing pavement. Today, many State agencies have had pavement management systems (PMS) in place for more than 20 years. With the development and rapid transition to automated pavement distress collection and interpretation, data quality and consistency have dramatically improved.

Each State department of transportation must develop and implement a risk-based asset management plan, which must include a 10-year financial plan (23 U.S.C. 119(e) and 23 CFR Part 515.9). To develop meaningful long-term plans, evaluation of multiple treatments over the life of a pavement may be needed. It is plausible and may be likely that the benefit of successive preservation treatments diminishes over time. Improved performance models may allow more accurate life cycle cost assessments.

An ability to model the effects of multiple treatments over the life of a pavement may be a valuable component of advanced models. In addition, advanced models may consider the effects of pavement preservation treatments on the material properties and distresses in the underlying pavement. Chip seals, micro surfacing, and slurry seals all seal the existing pavement against moisture penetration. Slurry seals with rejuvenators increase the maltene fraction in the existing surface, reducing oxidation and drying of the materials. Micro surfacing may reduce rutting profiles. Models that include these benefits may advance our performance prediction capabilities.

Objective

The objectives of this project are:

1) identify data needed in pavement management systems to allow development of multiple-treatment performance curves

2) develop new models that consider the effect of multiple treatment types over the life of the pavement

3) determine the impact of treatments on the properties of existing pavement layers.

It is proposed that this project focus on the data needed to advance the current state of modeling in pavement management systems, to include multiple treatments and impacts of treatments on material properties and distresses and on the development of some advanced models.

The research team may identify agencies with long-standing pavement management systems and that use high-quality pavement condition evaluations. Are the data from these agencies currently sufficient to develop multiple-treatment performance curves? If not, what data, and in what quantity may be needed to develop advanced models? If an agency wants to move toward advanced models, what data are needed? What changes to improve current agency data collection and interpretation practices may be needed? Are changes needed in the condition data interpretation to allow improved models to be developed? Recommendations on data type, quantity, and quality should be products of this research.

If several agencies have sufficient high-quality data, advanced models of the two types outlined should be developed:

1. Multiple treatments on the same roadway over the life of the pavement and

2. Impacts of treatments on the characteristics of the underlying pavements.

Are the advanced models better able to predict long-term performance? Information for other agencies in moving toward these models should be expected. Benefits and costs associated with the new models should also be addressed.

RNS 06 –Using AASHTOWare Pavement ME Design™ for Structural Adequacy

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Pavement preservation treatments are not intended to add structure to an existing pavement but are intended to extend the service life of the pavement. In determining the suitability of a pavement for a preservation treatment, it may be important to assess the structural adequacy of the road, not only for current traffic loadings, but also for loadings over the service life of the treatment.

AASHTOWare Pavement ME Design™ is software for the mechanistic empirical design of pavement structure. It enables use of localized weather, soil conditions, traffic loadings, and material properties and calculates the structural performance over time in terms of fatigue cracking, rutting, top down cracking, and International Roughness Index (IRI), which indicates ride quality. AASHTOWare Pavement ME Design™ enables the analyst to identify the type of distress and the time at which the failure threshold is reached for the pavement section being evaluated.

While thin pavement treatments are not intended to add structure, they may have beneficial effects on the existing pavement. Chip seals, micro surfacing and slurry seals all seal minor cracks and prevent moisture from entering the pavement surface. Slurry seals with rejuvenators increase the maltene content of the surface asphalt, diminishing the effects of oxidation. Micro surfacing may be placed to reduce or eliminate rutting in the upper course(s). These and other effects of surface treatments should be considered in using AASHTOWare Pavement ME Design™ to assess the structural adequacy of a treated roadway.

Objective

The objective of this research is to develop a systematic approach to use Mechanistic-Empirical pavement design to evaluate the structural adequacy of roadways to be treated with preservation treatments. The goal of this research is to test the feasibility of using AASHTOWare Pavement ME Design™, or other similar software, along with pavement management system data to evaluate the structural adequacy of roadways selected for pavement preservation treatments. The project should consider a wide range of traffic loadings and roadway types, from high truck traffic Interstate highways to low-volume local roads. The product should recognize the significant differences that exist in State road systems: with some small systems consisting of only Interstates and U.S. routes, and other State systems containing almost all roads in the State. If use of AASHTOWare Pavement ME Design™ is found to be feasible for some road classes and not for others, that should be reported.

If AASHTOWare Pavement ME Design™ is found to be useful for evaluating structural adequacy, then information may be needed to assist the pavement analysts in considering the benefits of preservation on the existing pavement.

Pavement preservation programs often consist of many road projects that are bundled into different contracts. Using AASHTOWare Pavement ME Design™ to evaluate all roads in the program may not be feasible. Information on how to select roads for structural adequacy evaluation would be helpful.

Agencies often apply preservation treatments to hold a pavement together until additional funding becomes available for a rehabilitation project. Use of AASHTOWare Pavement ME Design™ to evaluate the short service life of these pavements should also be helpful to agencies in managing their networks.

It should also be useful to pavement planners if the research could produce for a given pavement condition, a list of feasible preservation treatments and expected life extensions for each.

RNS 07 – Methods for Determining Structural Adequacy at the Network Level

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Pavement subgrade materials are assessed according to their strengths (stress level that causes rupture) and stiffness (ability to resist deformation). Tests commonly used to measure these properties include California Bearing Ratio (CBR), resistance value (R-value), and resilient modulus.

CBR is a strength test that measures comparative strength of the subject material versus crushed stone. The R-value is a stiffness test that measures a material's resistance to deformation. It was developed to address rutting (or shoving) in pavement wheel paths. Resilient modulus also measures stiffness and the modulus of elasticity (ratio of stress to strain).

After construction and a period of use, pavement adequacy can be measured using techniques and equipment such as falling weight deflectometer (FWD), rolling weight deflectometer (RWD), backcalculation, and ground penetrating radar (GPR). Deflectometers measure structural capacity. Backcalculation evaluates surface deflections generated by deflection devices. GPR can measure pavement condition and thickness.

One of the principles of preservation is that preservation treatments do not add structural capacity to the pavement. Preservation treatments should be used on pavements which have adequate structural capacity over the life of the treatment. The determination of structural adequacy is an important component of treatment selection and design.

Objective

The objective of this research is to develop a matrix that identifies approaches to determine the structural adequacy of pavements on a network basis and evaluate their strengths and weaknesses. Information about impacts of the methods on traffic, costs, data analysis needs, and equipment availability should be included.

The research may develop methods for determining pavement structural properties and adequacy with enough accuracy that the properties may be used as a basis for predicting highway performance. This should include identifying pavement characteristics where a relationship may be established with one or more desired performance factors, and then developing methods by which the selected pavement characteristics may be measured at a desired level of accuracy at reasonable cost and minimal impact on traffic.

The various approaches currently used may not necessarily produce data that are internally consistent, and may have productivity, safety, and economic shortcomings. For example, use of conventional FWD machines may be slow, disrupts traffic, and may be hazardous to traffic and operators. In contrast, the RWD and GPR may be operated at regular highway speeds without special traffic control. In addition, the RWD can gather continuous deflection data and hence, can produce a more accurate pavement assessment. Highly skilled and experienced workers are needed for interpretation of GPR trace using the RWD equipment, which can be costly.

Although deflection has not generally been used as an indicator at the network level, it could be used as a pavement management system (PMS) tool for strategy selection, in which case, changes to traditional PMS models may be necessary to incorporate such data.

This project should evaluate available options for determining structural adequacy, including the projection of future traffic loadings. Several case studies should be included for any approaches that are feasible for network level analysis.

RNS 08 – Case Studies in PMS and Pavement Preservation

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Most States have a pavement management system (PMS) that is used to inventory pavement conditions, project future conditions, and evaluate options for pavement improvement projects. Pavement management incorporates life cycle costs into a systematic approach to the process of planning the maintenance and repair of a network of roadways to optimize pavement conditions over the entire network with due consideration of available budgets.

Pavement preservation treatments can be shown to be cost-effective options for maintaining/improving pavement condition, improving ride quality, ensuring adequate safety characteristics, reducing road noise and extending pavement service life at reasonable cost. To ensure a consistent process of planning pavement projects across a broad range of activities from pavement preservation treatments through full reconstruction, it should be advantageous to use the PMS process help develop pavement preservation programs.

Several States are noted to have used pavement managements systems for many years and have well-developed approaches to using pavement preservation treatments when or where they may be effective and cost efficient.

Objective

The objective of this research is to develop a set of practices regarding use of pavement preservation and pavement management systems. Identify States that have both long-standing pavement management systems and a history of using pavement preservation treatments as part of their overall pavement programs. Evaluate how and to what extent those States have incorporated pavement preservation options as a consideration in their pavement management practices.

During the initial stages of incorporating pavement preservation treatments in pavement management, what issues did they need to resolve and how were they resolved. Information that may be included in the practices document include:

- how to design effective preservation treatments;
- how to determine best treatments for certain pavement types and conditions;
- how to determine best timing for treatments;

- how to evaluate their potential for near-term and long-term performance;

- how to evaluate costs of the treatments and treatment duration to support life-cycle cost analysis;

- what data to collect on performance and how to collect/analyze it;

- development of case histories on how to incorporate pavement preservation treatments in pavement management systems. These case histories would focus on how the practice evolved. The case histories would describe how the output of the PMS is currently used to develop pavement preservation projects as well as any possible enhancements that would improve the ability of the system to project an effective program of pavement preservation treatments. If possible, the case histories would provide both smaller road systems and larger road systems.

- identify practices for using PMS in carrying out a pavement preservation program.

RNS 09 – Next Treatment at End-of-Life for Bonded Concrete Overlays on Asphalt Pavements

Umbrella Topic

Treatment Design

Background

Bonded concrete overlays on asphalt concrete (BCOA) pavements have comprised about 25 percent of the concrete market growth in recent years. This strategy consists of placing a concrete overlay, typically 3 to 7 inches in thickness, with panel lengths ranging from 4 to 12 feet. The portland cement concrete (PCC) overlays are placed onto existing asphalt concrete (AC) pavements in typically fair to good condition, and which often exhibit rutting and shoving induced by heavy loads such as slow-moving traffic at intersections. This strategy is also used to provide a longer lasting final surface when frequent replacement of the AC surface has been necessary.

The success of the BCOA strategy relies on the bonding of the AC pavement to the PCC overlay so that they act as a composite pavement allowing the concrete to remain in compression for a greater period. Typically, a minimum of 3 to 4 inches of existing AC in good condition and proper bonding at the interface is needed. AC pavements which exhibit stripping or other material deterioration issues may not be good candidates for this strategy. The BCOA can be placed as an overlay or as an inlay to maintain grade.

Typical distresses that develop in BCOA are transverse cracking in larger slab sizes (i.e., 10 to 12 feet), diagonal cracking in panels sizes in the vicinity of 6 feet, and corner breaks in smaller panel sizes such as 4.5 feet or less. The distress types are somewhat associated with the panel size and the proximity of joints to wheel paths. Longitudinal and reflective cracking is also possible.

Since a properly designed and constructed BCOA is a very durable surface, most distress is a structural issue which occurs as a result of construction defects, loss of bonding at the interface, or deterioration of the underlying AC pavement. As a result, conventional concrete preservation activities are typically used to restore the BCOA. When it no longer becomes economical to do, BCOAs are typically milled off and replaced with a new BCOA or new pavement structural section if the underlying AC is failing.

Little information exists in the industry to recognize when the effective life has been achieved and the optimum timing to repair, replace, or eliminate the BCOA.

Objective

The objective of this project is to develop and publish a useful process for establishing the end of life of a BCOA strategy and procedures and testing protocols for developing replacement strategies.

The following minimum tasks should be accomplished:

1. Conduct a survey of State agencies to determine BCOA use and preservation strategy applications. The survey should identify age, condition, and thickness of existing AC pavement at the time of BCOA application, typical BCOA distresses observed, PCC slab parameters including panel size, thickness and mix design, strategies used to repair the distresses, and observed time periods of when distresses were first observed and when BCOA repair or replacement occurred. In addition, identify replacement strategies used. The survey should also address how reflective cracking is typically prevented and how panels failing as a result of reflective cracking are repaired.
2. Evaluate, where possible, the design procedures used for the original BCOA strategy and the subsequent replacement strategy. This information, if possible, should compare predicted service life to actual BCOA service life and for subsequent replacement strategies. Identify practices and illustrate them with case studies. Report the service life extensions for BCOA relative to panel size, thickness, climate, and traffic levels.
3. Prepare a report summarizing the findings of tasks 1 and 2 above. (Note that NCHRP Project 01-61 is currently underway and may provide some of this information.)

RNS 10 – Development of Web Application for Design and Inspection of Chip Seals

Umbrella Topic

Treatment Design

Background

Chip seals are typically used on rural, low-volume asphalt roadways, which tend to be owned by local road agencies. NCHRP Synthesis 342 (2005) reported that in the U.S. and Canada, 63 percent of road agencies responding to a survey indicated that either they used no formal chip design method or relied on experience when designing their chip seals. Nineteen percent of agencies used their own formal method, while the remaining agencies used the McLeod or Kearby methods.

Chip seal success depends on several factors including surface texture, traffic conditions (average daily traffic (ADT)), speeds, percent commercial vehicles), chip seal type, aggregate selection, binder application rate, ambient weather conditions, and quality of construction and inspection. Traditional reliance on experience and judgment is simply inadequate, especially considering that agency and construction personnel often lack the experience and judgment needed to consistently produce high quality chip seals on the right roads at the right time. Using a competent chip seal design combined with proper construction will allow more miles to be constructed, use less resources, and yield better results in terms of treatment longevity and motorist satisfaction. (Note: Depending upon an agency's current chip seal process, proper design and construction may result in fewer miles constructed and more resources, but last longer.)

Objective

The objective of this research is to create a web-based or mobile app-based program for design of chip seals. Much of the experience and judgment needed to design successful chip seals could be incorporated into a computer program and made available as an application on the Web or on hand-held devices. The Minnesota Department of Transportation developed such a prototype program for use on a personal computer. Other available prototypes should be identified and evaluated.

A comprehensive program should navigate through a logical sequence of steps such as roadway condition and suitability (or otherwise) for a chip seal, available materials and characteristics (aggregates, emulsions, binders, etc.), traffic characteristics, types of chip seals available, traffic control needed (whether to use a pilot escort), construction equipment needed, and climatic factors. (The FHWA has published checklists of construction practices and techniques available at https://www.fhwa.dot.gov/pavement/preservation/ppcl00.cfm.)

Basing the logic of the program on recognized practices would be useful for inexperienced practitioners and could improve outcomes for more experienced practitioners.

RNS 11 – Design and Construction of New Pavements to Prolong the Period of Preservation

Umbrella Topic

Treatment Design

Background

As pavements age and carry traffic, they deteriorate due to climatic effects and loadings. At the various stages of deterioration, pavement treatments are available to restore longevity and functionality. As distress levels increase, the treatments become more extensive and expensive, culminating in total reconstruction. Pavement preservation treatments restore functional condition without increasing structural capacity and are significantly less costly than are pavement rehabilitation or reconstruction.

This project should identify methods to extend the time during which a pavement needs only functional preservation treatments. Such methods should include construction of thicker pavements, use of more durable materials, or capping the pavement with a protective layer.

Objective

The objective of this research is to develop a methodology for the design and construction of new pavements that may extend the period of time when pavement preservation treatments could be used. This project may identify methods that can be applied to new roadways, both in design and in construction. The research team should identify possible approaches and any agencies that might be using them. Performance data from agencies using various approaches should be collected. The incremental cost associated with each approach should be considered along with the benefit in extending the period of preservation. For example, pavement design with AASHTOWare Pavement ME Design™ may allow the designer to evaluate the performance of a pavement section regarding fatigue cracking, roughness, and rutting. The impact of increasing the thickness of the asphalt section by 0.5 inches extends the time over which the pavement is structurally adequate, and therefore eligible for preservation, barring other distresses. That 0.5 inches of asphalt has a cost. Similarly, as increasing amounts of recycled asphalt and shingles have been added to pavement layers, the idea of capping these layers with a sacrificial surfacing has been proposed. Numerous possible capping layers are available, ranging from chip seals to ultra-thin bonded wearing courses, with varying ranges of costs and performance lives.

The research team should develop information for agencies to extend the preservation period for new roadways. Case studies from agencies which have applied these approaches may be helpful.

RNS 12 – Best Practices for Pavement Preservation in Urban Environments

Umbrella Topic

Treatment Design

Background

In every preservation project, it is important to select the treatment that suits the needs of that pavement. Because of traffic levels and user costs in urban environments, it is important that these pavements be preserved to delay the need for rehabilitation or reconstruction. With that said, preservation of pavements in urban environments poses some significant challenges. The urban environment has higher traffic volumes, increased levels of signalization, curb and gutter and sidewalks, more American with Disabilities Act (ADA) ramps to be maintained, and a higher density of utilities. In some locations, accommodation is needed for bicycles and for public transportation facilities. The engineer for an urban environment should consider traffic impacts of construction as well as noise, impacts on businesses, dust, and pedestrians.

The public (users and non-users) may be more willing to accept inconvenience and disruption associated with a preservation project if they are informed about what to expect before and during construction. Information may be disseminated through notices, publications, public service announcements (PSAs), and meetings with Q & A opportunities.

The owner agency for any urban street may be a State department of transportation, a local agency, or a municipal government. The goal of this project is to provide, in a single volume, information on treatments, signal loops, traffic control, ADA adjustments, utility protection, contracting options, and other elements of preservation in an urban environment. Some content may be available in other references, but should be included and appropriately referenced, in this single volume.

Objective

The objective of this research is to develop best practices for use of pavement preservation in urban environments. This project may identify best practices in preserving pavements in urban environments. It may consider traffic management approaches to enable placement of the best treatment for a particular roadway. It may also outline practices for preparing utilities in advance of preservation treatments. Information about practices for maintaining traffic signal detection loops for treatments, including micro surfacing, slurry seals, and thin asphalt overlays should be provided. Paint striping is an important element of project completion. Products and processes for paint striping that are well suited to urban environments and preservation treatments should be included. Best practices for traffic control with preservation treatments should be identified. These could include typical lane closures, night-time only work, and weekend closures. Benefits and limitations, and suitability for specific preservation treatments should be included. Contracting methods used for urban projects, especially those that bundle multiple projects together to achieve economies of scale should be described. Additional items that may be important in urban environments may also be addressed, such as noise and dust control during construction, maintenance of pedestrian traffic, safety issues for both workers and the public, and public information before, during and at the conclusion of a project are a few examples.

Identification of products or processes that are used to speed construction of preservation in urban environments should assist engineers in State agencies and municipalities.

Several case studies should be developed to demonstrate best practices of urban preservation. At least one case study should involve an urban Interstate, and one may include a “complete street” project.

RNS 13 – Impact of Overlay Type and Thickness for CIR, CCPR, and HIR Treatments

Umbrella Topic

Treatment Design

Background

While cold in-place recycling (CIR), cold central plant recycling (CCPR), and hot in-place recycling (HIR) processes have been available for almost 30 years, many agencies may be looking at these treatments for the first time, or for the first time in many years. Agencies may be seeking information about the type and quantity of data they should collect during construction of the project to ensure good performance. They may also be interested in collecting specific data (what type, how much, how often, and by what method) following completion of the project that may allow performance to be evaluated (including projection of future performance) of the CIR, CCPR, and HIR methodologies.

CIR, CCPR, and HIR all involve treating an existing pavement, and then overlaying that replaced material with a wearing surface. This project also seeks to understand the impact of overlay type and thickness on performance of CIR, CCPR, and HIR treatments. Overlay options could include not only hot-mix asphalt but also cape seals, micro surfacing, or other thin treatments. The performance data should be focused on pavements recycled in the last 10 years, assuming that there have been improvements in project selection, mix design, and construction practices since the early days of these techniques.

A rational approach to setting upper levels of traffic and heavy trucks may also be needed. Agencies frequently use an upper bound based on risk concerns rather than performance data. A rational method to select traffic loadings should enable use with pavements carrying higher traffic volumes with no increased risk for the owner agency.

Objective

The objective of this research is to develop a methodology to selection of wearing course and overlay thickness and type for CIR, CCPR, and HIR. This project will update early research, from 25 to 30 years ago, with information on performance of CIR, CCPR, and HIR with various types and thicknesses of overlays providing the wearing course. Use and performance of wearing courses consisting of cape seals or micro surfacing or other thin treatments, should also be included. Performance data should be limited to pavements treated in the last 10 to 15 years.

Information should be provided that will enable agencies to collect the right data at the right time for a long enough period to assess the performance of these treatments in their States. Information on new and promising data collection methodologies that may be useful in identifying performance of these treatments should be helpful. Specific performance tests and measures that should identify performance soon after or during construction and also assist in projection of future performance should also be identified.

Setting the upper limits of traffic, and truck traffic is important in selecting appropriate projects and should be based on a rational design method. A suitable design method should be provided along with instructions for its use.

RNS 14 – Suitability of Recycled Concrete in Thin Layers

Umbrella Topic

Materials

Background

Approximately 140 million tons of recycled concrete aggregate (RCA) are produced annually in the United States through the removal and crushing of concrete pavements and structures. This represents a sustainable option for replacing quality aggregates that are becoming more difficult to obtain and mine.

RCA has been used in roadways in the U.S. since the 1970s with the principal applications consisting of base and fill construction. RCA has also been widely used in the construction of new concrete pavements with at least 43 States having used the material for this purpose. Over many years of use, States have developed testing procedures and specifications to accommodate the incorporation of RCA as a substitute for virgin aggregate in new concrete pavements. These pavements have performed very well over decades of service.

RCA possesses somewhat different properties than virgin aggregates and this should be considered in new applications. For use in concrete pavements, it has been found that the RCA aggregate is more angular and absorptive than conventional aggregates and pavements incorporating this material typically have a lower compressive strength and elastic modulus. It was also found that magnesium and sodium sulfate durability testing may not produce reliable results. Stockpiles of recently crushed RCA may produce alkaline leachate until additional carbonation can occur.

RCA, which exhibits higher percentages of mortar paste on the surface, demonstrates higher absorption, lower particle strength, and lower abrasion resistance than virgin aggregate. Therefore, the manufacture of the RCA should be suitable for the intended applications.

Although RCA has been successfully used in the production of hot-mix asphalt pavements, little to no experience with its use in surface treatments such as chips seals, micro surfacing, etc. has occurred. Since it represents a sustainable alternative to virgin aggregate, there may be a need to develop testing and specifications for its use in these applications.

Objective

The objective of this research is to determine the suitability of RCA as a substitute for virgin aggregate in preservation surface treatments such as chip seals, slurry seals, micro surfacing, and thin lift overlays.

The following minimum tasks should be accomplished:

1. Survey agency practice to determine current use and applications of RCA in surface treatments and thin lift overlays. The survey should identify materials specifications and testing to ensure quality. It should also identify performance of known applications.
2. Based on the findings of Task 1, develop any new or additional voluntary testing methods and specifications for incorporation of RCA in preservation surface treatment and thin lift overlays.
3. If sufficient agency data is not available, conduct a laboratory testing program, including performance testing, to evaluate use of RCA for surface treatments and thin lift overlays.
4. Prepare a final report summarizing and documenting the efforts of this study and its conclusions. The report should provide procedures for testing and examples of specifications for use by agencies.

RNS 15 – Identification of Material Properties in PMS for Future Analysis of Performance

Umbrella Topic

Materials

Background

The original concept of pavement management (Hass and Hudson) advocated the inclusion of design, materials, specifications, maintenance, traffic, environment, distress, and construction quality in a closed-loop feedback pavement management system (PMS). The purpose for this was to account for and manage the many factors that affect pavement performance.

Today, many PMS monitor and manage distress, roughness, traffic, and friction along with structural section information to prioritize and select strategies. Some systems account for maintenance activities on the network, but few if any consider the quality of materials used or the specifications available at the time of construction. As such, the deterioration models that evolve as well as decision tree approaches, are often based simply on deterioration rates, location, and traffic.

Both the materials and construction specifications used at the time of construction can affect pavement performance over time. As a result, it may be useful to document these properties in the PMS to evaluate their effect on performance. This provides the opportunity to evaluate design and construction specifications on performance of preservation treatments.

Including this documentation within a PMS may allow the original concept to be fulfilled, which should improve not only preservation treatment performance but also specifications, construction practices, and material selection.

Objective

The objective of this research is to develop information regarding the specific material properties and construction data that could be incorporated in existing PMS to enable more detailed evaluation of performance of specific treatments. The objective of this research is to determine the material properties and construction data that may impact preservation treatment performance as determined from pavement management data.

The following minimum tasks should be conducted:

1. Survey agency practices to determine which agencies include materials and construction specifications/properties data in their PMS and what data are available.
2. Based on the survey results, request performance data from the identified agencies to evaluate the effect of these properties on preservation treatment performance.

3. Determine the effect of specifications and material properties on preservation treatment performance.
4. Prepare a final report documenting the study efforts, findings, and conclusions. The report should identify which attributes affect performance and by how much, and provide methods for documenting material qualities and specifications.

RNS 16 – Use of 3D Imaging for Macrotexture, Friction, and Embedment Depth

Umbrella Topic

Materials

Background

Technological advances in imaging have resulted in use of three-dimensional (3D) imaging for observing and interpreting pavement distress. Some models have been developed to evaluate macrotexture from 3D images and to use those macrotexture determinations to model pavement frictional resistance. Until now, most pavement friction measurements were made with locked-wheel skid testing devices that could make tests intermittently along a roadway. More recent developments in skid testing allow continuous testing, but at a very high investment cost. More than a third of State agencies are using automated distress data collection, and that number is expected to grow along with the use of 3D technology. The automated distress data collection frequently includes transverse and longitudinal profiles, rut-depth measurements, faulting measurements, and downward imaging that is used to determine cracking types and locations. If a distress collection vehicle can collect images that relate macrotexture to pavement friction, there is a potential to reduce data collection costs without sacrificing safety related data.

In addition, chip embedment is an important performance measure for chip seals. Could the 3D images that are used for macrotexture also produce measures of chip embedment? Many agencies contract hundreds of miles of chip seal treatments each year. Use of automated data collection to determine embedment depth could enable more widespread detection of this important parameter than can currently be achieved using sand patch tests. This could affect both quality and safety, as the technician conducting the sand patch test kneels on the pavement and performs the test in the wheel path.

Objective

The objective of this research is to determine the current suitability of 3D imaging technology to determine pavement macrotexture, friction, and embedment depth. This project should consider use of 3D imaging to relate macrotexture to both pavement surface friction and to embedment depth of chip seals.

Regarding friction, the project should identify models being used to relate macrotexture to friction, the advantages and disadvantages of each model, and the feasibility of using each model in conjunction with 3D imaging technology. One or more of the models should be calibrated and validated with 3D imaging data. The project should develop recommended processes for agencies wishing to use the 3D imaging data, including imaging quality, data analysis methods, and relationship between the locked-wheel skid test and friction observations based on 3D imaging.

Regarding embedment depth, the project should develop a model for the relationship between measured embedment depth and modeled depths from macrotexture images for single and double chip seals. Embedment depth generally increases with time following construction, so the research team should need to carefully consider temporal changes. If a model is developed, it should be calibrated and validated. If no model is developed, the issues in developing such a model and the limitations in current capabilities should be enumerated.

Both uses of 3D imaging have the potential to provide more complete pavement data than is currently available. Locked-wheel testing may produce about 10 to 15 tests per mile. Embedment depth for field conditions is determined by coring or labor-intensive molding. It should be highly beneficial if we could use 3D images that we are already collecting.

The result of this research would be a final report covering all aspects of the work and including a methodology for using 3D imaging data for macrotexture, friction, and embedment. Limitations of use should be clearly defined.

RNS 17 – Performance of Micro Surfacing with Fibers

Umbrella Topic

Materials

Background

Micro surfacing is a pavement preservation treatment that is being used by numerous State departments of transportation (DOTs) in their pavement preservation programs. This process includes polymer modified asphalt (key in flexibility), aggregate, mineral filler, additives, and water in a mixture that can be applied to existing pavement using automated equipment. Micro surfacing can effectively seal, level, rejuvenate, and aid in skid resistance on existing paved surfaces. Micro surfacing can be applied in a wide range of thicknesses, allowing it to treat a large variety of road surfaces.

Slurry sealing may be less expensive surface treatment that is constructed by the same basic principles as micro surfacing but lacks the aggregate structure capable of supporting high and very high traffic loadings. It is usually applied on secondary roads and in lower-traffic residential areas. Compared with slurry sealing, micro surfacing may be a high-performance surface treatment that is well suited for high-traffic roadways.

Some potential drawbacks associated with micro surfacing are the potential for reflective cracking due to deficiencies in the pavement being treated, potential for raveling, and potential for damage caused by traffic, snowplows, etc. One approach used to address these problems is the addition of fibers to the micro surfacing mix to improve performance. Several types of fibers have potential for use in micro surfacing applications: fiberglass fibers, polymer-based fibers, cellulose fibers, etc.

Recent studies have shown that the addition of fibers increases the toughness and durability of conventional micro surfacing and helps reduce or delay cracking and resists raveling.

Objective

The objective of this research is to develop voluntary practices for the use of fiber in micro surfacing.

- What are the potential benefits of the use of micro surfacing with added fibers as a pavement preservation treatment over micro surfacing without fibers?

- Examine the process of mixing the fiber reinforcement into the micro surfacing mixture using equipment typically used in "standard" micro surfacing projects to identify and resolve potential problems in the mixing process and ensure acceptable compatibility of the mix components and uniform dispersion of the fibers throughout the mix. Identify, evaluate, and examine various types of fibers as well as the type of fibrous materials, material properties, specification, materials testing, and performance characteristics that would enable an evaluation of the enhanced performance of the fiber-reinforced mixes. Consider tensile strength, flexibility, resistance to cracking, and resistance to damage from traffic, snowplows, etc. Identify agencies with experience in using fibers in their micro surfacing or slurry seals. Review their specifications in light of the identified characteristics described above. What were or are their project selection criteria? What issues did they have to resolve in using fibers in micro surfacing? Collect performance data, including the conditions prior to placement and continuing after placement for up to 10 years. Identify practices for agencies wishing to use fibers in their micro surfacing.

RNS 18 – Performance-Based or Performance-Related Specifications for Use of Recycled or Marginal Materials

Umbrella Topic

Materials

Background

Marginal materials may not be able to fully (or partially) meet the high standards of conventional existing specifications, but their properties and quality may be sufficient to satisfy the purpose for which they are to be used. While marginal and recycled materials can be used in base, intermediate and surface layers, the concern of this problem statement is use in pavement preservation treatments including chip seals, cape seals, micro surfacing, slurry seals, and thin asphalt overlays. The greatest quantities are likely to be aggregates from low quality deposits, depleted sources, and waste materials (slag, mining tailings). In addition, recycled materials (asphalt, shingles, asphaltic concrete (AC), portland cement concrete pavement, etc.) are available in large quantities and there is a desire to use, rather than to landfill, these materials.

Use of marginal materials may have advantages such as local availability (less/cheaper transportation), and less environmental impact (use of existing rather than exploiting new sources).

Objective

The objective of this research is to develop best practices for use of performance-based or performance-related specifications for cases where use of marginal, local, or recycled materials are available but do not meet common method specifications.

Performance specifications can ensure that design assumptions are met during construction. Also, such specifications transfer substantial risk from the owner to the contractor, although this risk transfer usually comes at a higher price. Performance specifications have had limited application in preservation but may provide a means to use suitable materials from local sources.

Agencies may need information about a consistent approach describing in sufficient detail the circumstances and conditions when it would be advantageous to use marginal or recycled materials within performance/warranty specifications. They need to be aware of the types and frequencies of testing needed to ensure that the desired performance targets are reached.

The research should include a survey to determine States that have used performance-based specifications for pavement preservation treatments, and especially those who used recycled or marginal local materials. A copy of the specifications should be obtained, and information about the materials used, lessons learned, and any identified savings or benefits gained.

The research team should develop draft model performance specifications based on those that have been used successfully elsewhere. As a minimum, these should include chip seals, micro surfacing and slurry seals, and thin asphalt overlays.

Finally, it should be helpful to document several case studies where marginal or recycled materials of sufficient quality have been used successfully in pavement preservation applications.

RNS 19 – Development of Information about Concrete Pavements

Umbrella Topic

Materials

Background

With use of aggressive winter storm maintenance practices and a variety of product options, the use of sodium chloride as a deicer was reduced or augmented with the application of calcium and magnesium chloride. Although these solutions are very effective for winter storm maintenance, they react with the existing concrete pavement. In northern tier States, this has resulted in calcium oxychloride formation, which causes concrete pavement to deteriorate at the joints, causing substantial distress.

The Federal Highway Administration (FHWA) sponsored research to evaluate the mechanisms and causes of joint associated distress, including oxychloride formation. In addition, it found and documented that some concrete pavements were not produced at the quality needed to be to resist these mechanisms. Minnesota has reduced the allowable water/cement ratio in its portland cement concrete pavement (PCCP) to make more durable concrete that better resists (and has eliminated) the formation of calcium oxychloride problems in the short term (10 to 15 years). When the durability issues were identified, the FHWA and CP Tech Center developed a long-term research and technology transfer effort to improve the durability of concrete pavements. The early efforts resulted in the publication of AASHTO PP 84-17, Developing Performance Engineering Concrete Pavement (PEM) Mixtures, in 2017.

With the development of AASHTO PP 84-17, the effort is focused on the technical education of agencies and industry on how best to apply PEM within an integrated framework. Mixture qualification for local conditions, mixture verification at the project level, and mixture quality control and acceptance are included in the framework.

Objective

The objective of this research is to develop an approach for the preparation of specifications to ensure concrete mix durability and the new test methods that should be applied.

The following minimum tasks should be necessary:

1. Survey of State agency experience with joint-associated distress. The survey should solicit the extent and severity of the joint-associated distress issue within the agency. Have agencies changed specifications or construction procedures to combat or mitigate the problem? Have these changes been successful? Is joint-associated distress still an issue for the agency. Is the State using the AASHTO specifications and recommended test methods? Has the adoption of

these test methods been successful? Are other test methods necessary? Is additional training necessary? Is oxychloride damage occurring in middle-tier States, but at a slower rate?

2. Summarize and analyze the findings of the State agency survey to describe the current state-of-the-practice regarding joint-associated distress in North America. The analyze should discuss the outcomes of the previous survey questions,
3. Prepare a report documenting the work conducted in Tasks 1 and 2 and detailing the conclusions.

RNS 20 – Maintenance and Preservation of Mumble/Rumble Strips with Thin Treatments

Umbrella Topic

Treatment Application

Background

The benefits of rumble strips and mumble strips include providing both audio and vibration warning to drivers passing over the edge or center line, thereby allowing correction of the vehicle direction without an accident. Milled centerline rumble strips have reduced injury crashes by 38 to 50 percent on rural two-lane roads and by 37 to 91 percent on urban two-lane roadways. In addition to providing warning for distracted or drowsy drivers, the rumble strips also serve as navigational aids during bad weather.

When placed on asphalt pavements in fair to good condition, the strips do not cause acceleration of pavement distress, although they may be associated with longitudinal centerline joint issues. However, when placed on thin surface layers (less than 1 inch in thickness), maintenance and repair needs may arise. The depression of the milled rumble strip may reach or nearly reach the bottom of the thin surfacing. Raveling may occur. In addition, centerline and edge seams tend to open over time due to edge loadings, lack of compaction, and oxidation drying.

This project seeks methods that provide the same safety benefits as rumble or mumble strips and that are well suited to thin surface layers. Are there products, like specially formed pavement marking systems, that could provide similar service? Will the application process damage the thin surface layer? The research should include information about durability, ease and cost of installation, audible warning, and vibration warning methods. In addition, methods of maintaining and repairing rumble or mumble strips should be provided. Methods for installation of treatments, including chip seals, micro surfacing, slurry seals, and thin asphalt overlays on roadways with centerline and edge line rumble strips should be included.

Objective

The objective of this research is to identify alternatives to milled or rolled rumble strips that may be better suited for use on thin surface layers or provide construction recommended practices for rumble strips to minimize performance issues at centerline joints and edge lines. New or modified methods of milling or rolled-in rumble strips may also be included, if effective. As use of rumble strips moves to lower volume roadways, there may be an increased likelihood that thin surface layers, like chip seals, micro surfacing, slurry seals, or thin asphalt overlays could be used. A synthesis of current practice with regard to maintenance and distress of pavements around rumble strips should be conducted and should request information about alternative methods being used or considered. Experience with the alternative methods should include issues with construction, durability (both general and with regard to snowplow damage), and cost. Benefits and weaknesses of the alternative methods should also be provided.

In addition to identifying alternative methods, information should also be provided on maintenance practices for existing rumble or mumble strips. For example, if the existing pavement with milled rumble strips is scheduled for a chip seal, what should be done to the existing rumble strips so that the completed project performs as desired? How are the existing rumble strips covered up during construction when they are carrying diverted traffic? What methods of reinstalling the rumble strips are available? What are the benefits and costs for the second-generation rumble strips?

RNS 21 – IDIQ Contracts for Pavement Preservation

Umbrella Topic

Treatment Application

Background

Indefinite delivery indefinite quantity (IDIQ) contracts are a type of contract that allows a public agency to solicit an indefinite amount of supplies or services over a predetermined period. They can be awarded to a single contractor or to multiple contractors depending upon the needs of the agencies. They are used to provide continuous delivery of services or products, but only as the need arises.

IDIQ contracts may streamline the procurement process and reduce administrative overhead. They may also enable procurement of multiple contractors or provide flexibility to extend contracts over multiple years.

This type of procurement has been used for decades by government agencies for procuring materials and supplies and engineering services but may not have been widely used in the pavement preservation area until recent times.

Objective

The objective of this project is to develop helpful information about the use of IDIQ contracts for pavement preservation projects. This may include the evaluation of the use of indefinite delivery indefinite quantity contracts for procurement of preservation contractors, materials, and equipment. Potential issues associated with the contracting method should be identified.

The following minimum tasks should be accomplished:

1. Identify States and agencies that have used or are using IDIQ contracting processes. Once identified, survey the States to identify the treatments for which this contracting instrument is used, quantity of contracts let, method used to select contractors, lessons learned over time, potential future uses, and possible benefits or obstacles in using IDIQ contracts.
2. Identify States and agencies that are not using and have no plans to use IDIQ contracting. Once identified, survey the States/agencies to identify issues or obstacles to its use. Identify alternative contracting methods used, the preservation strategies they are used for, and the advantages to their use over IDIQ contracting.
3. From the results of the surveys, develop a document detailing the use of IDIQ contracts to achieve successful outcomes for pavement preservation construction and maintenance. The document should contain example contracts and voluntary specifications and outline any necessary training for implementation and IDIQ contract management.

RNS 22 –Common Practices for Adequate Inspector Training

Umbrella Topic

Treatment Application

Background

Considerable skilled labor and specialized equipment are needed for the construction and preservation of highway infrastructures. Historically, this construction/preservation consisted of the owner being responsible for the right of way acquisition, roadway design, establishing materials and contract specifications, contract procurement, and inspection of the awarded project during and after construction. The contractor provided the equipment, materials, labor, and expertise to construct the project. The agency then provided the preservation of the infrastructure either through in-house methods or through outsourcing.

Both the agency and contractor had to staff according to project schedules, volume of and quantity of work items, and expected environmental conditions, although in the design phase more latitude was often allowed because schedule slippage could more easily be tolerated by the owner. However, once a contract is awarded, on-time performance becomes a high priority. As such, agencies had to ensure a properly qualified workforce was available to ensure a final product in accordance with project specifications and the contractor's schedule. This is considered part of an agency's fiduciary responsibility.

Use of consultant inspection and alternate bidding methods such as design-build, design-bid-build, construction manager at risk (CMAR), may have created at least some increased competition in recruiting agency inspectors. Agencies may have reduced staffing; some are facing a loss of up to 50 percent of their department of transportation (DOT) personnel through retirement in the next five years. The loss of trained inspectors, competition from private sector inspectors, and administrative downsizing may have an effect on inspecting construction activity.

There may be a need to increase the number of and quality of trained inspectors and development of management practices to deploy those resources.

Objective

The objective of this research is to provide helpful practices for adequate inspector training for pavement preservation projects. The research team should develop methodologies for establishing the necessary inspector staffing levels, deployment strategies, and training and competency levels for each of the typical pavement preservation strategies. The potential costs and risks associated with inadequate inspection should also be studied.

At a minimum, the following tasks should be accomplished:

1. Conduct a literature search of agency and private sector procedures for establishing project staffing levels, training needs, qualification and competency needs, inspector deployment strategies, and management oversight procedures.
2. Based on the findings of Task 1, develop a targeted survey of both agency and private sector organizations to acquire the necessary data needed to accomplish the objectives.
3. Prepare an interim report that estimates the costs and risks to an agency for inadequate inspection and its impact on pavement preservation performance.
4. Prepare a final report documenting the research.

RNS 23 – Innovative Traffic Control for Work Zones for Preservation Treatments

Umbrella Topic

Treatment Application

Background

Pavement preservation treatments are typically applied faster than normal paving operations. Also, they typically involve less pieces of equipment. For example, a chip seal will involve a distributor to spray the emulsified asphalt, followed by a chip spreader. Rollers complete the equipment complement. A day or more after the initial effort, the road should be swept or vacuumed to remove loose stone. A subcontractor normally applies the pavement markings several days following the sweeping. The speed with which preservation treatments can be applied is one of its potential benefits.

Given the efficiencies possible with constructing preservation treatments, additional safeguards need to be in place to ensure safety. When lane closures, warning signs, flaggers and pilot cars are used, time may be lost as signs and barriers may need to be reset during operations.

The California Department of Transportation (Caltrans) demonstrated a piece of safety equipment that encircles workers and provides barrier-like protection during slow moving operations. Would such a vehicle be suitable for a range of preservation activities? What would be its cost and availability for other agencies? What other approaches are being developed, in California and elsewhere that may benefit traffic control related to preservation projects, especially as preservation work moves onto higher volume roadways? Are there options that are well suited to urban environments?

Objective

The objective of this research is to identify beneficial traffic control methods during the most common pavement preservation activities. One result may be a table outlining useful traffic control practices at various stages of pavement preservation treatment applications. Existing techniques may be sufficient for some projects while new approaches that could protect workers and reduce traffic delays may be appropriate for others.

Part of the objective of this research is to identify and critique new and innovative approaches to traffic control that could be well suited to pavement preservation activities. Suggested practices for experimental designs and testing the efficacy of the new approaches should be part of the project report.

RNS 24 – Establishing Distress Triggers

Umbrella Topic

Treatment Application

Background

There are two principal types of road and bridge construction warranty contracts. The first type is associated with reconstruction and rehabilitation work and covers materials and workmanship. The second type is associated with preventive maintenance and preservation work and covers performance thresholds that cannot be exceeded during the warranty period.

Both types of warranty contract contain parameters that act as triggers to initiate corrective action by the contractor if any of the parameters are exceeded. Any corrective action should be completed by the contractor (at its expense) to restore the warranted work back into compliance with the warranty contract.

Similarly, agencies typically use two types of inspection to monitor compliance with the provisions of the warranty contract: cursory and detailed. The cursory inspection is a simplified inspection to quickly identify segments in the project that may have distresses that exceed threshold values. This cursory inspection normally may be conducted without a lane closure and from the roadway shoulder, estimating distress lengths and widths. The detailed inspection needs direct measuring and reporting of all observed distress in each segment. Traffic control may be needed to complete the detailed inspection.

Objective

The objective of this project is to develop suggested practices for use of warranties for pavement preservation projects.

1. Agencies may need to know whether given project types are suitable candidates for warranty contracts.
2. If a project is a suitable warranty candidate, what distresses and failures of the work should be used as triggers to initiate remedial action by the contractor?
3. Are the triggers truly indicative of critical conditions which should invoke the warranty? Are the triggers readily understandable and acceptable to the contractor?
4. Can the triggers be observed by a cursory inspection or should a detailed inspection be made? Are automated methods available and effective?
5. Within the life of the project, when should trigger inspections be made? By whom?

If an agency intends to undertake multiple warranty projects, it may need to develop an accounting or warranty management system to facilitate its warranty management and track time deadlines. This project should outline the components of the warranty management system.

RNS 25 – Early Measurements for Warranty Contracts

Umbrella Topic

Treatment Application

Background

There are three types of pavement warranty contracts:

1. Materials and workmanship
2. Short-term performance
3. Long-term performance

(Note that short- and long-term performance contracts also include materials and workmanship.)

Adopting warranty contracts may involve reassigning part of the risk normally borne by the agency to the contractor. In return, the agency may relinquish some of its control of design decisions to the contractor. In some cases, the contractor purchases a surety bond to pay for any necessary remedial construction resulting from failure to meet the warranty specification, and whose cost would exceed the contractor's ability or willingness to pay.

Risk should be controlled and minimized. Agencies seek to avoid defective and non-functional pavements. Similarly, contractors seek to reduce risk exposure in fulfilling the contract.

Agencies and contractors may benefit from greater knowledge about the pavement's probable deterioration trajectory in planning remedial work at reduced cost.

Objective

The objective of this research is to develop information about practices for quality assurance (QA) and performance testing for warranty pavement preservation projects. The research should identify leading early indicators that may predict the nature and speed of a pavement's deterioration following preservation treatments performed under warranty. The following tasks should be accomplished:

1. For each strategy and specific treatment, establish observable or testable parameters to indicate pavement performance and deterioration. This task may need to address characterization of the structural condition and design.
2. Conduct a representative survey of State agencies in each major climatic region to determine the role of design, materials, traffic, and traffic on pavement performance and deterioration. If adequate high-quality data cannot be obtained, data for specific treatments may be

available. An alternative could be to develop practices for a State to enable it to make this determination.

3. Identify critical parameters and when they should be measured.
4. Document the importance of quality control (QC)/QA testing and establish points of diminishing marginal returns for continuing QA testing with warranty projects.
5. Document the results of the research in a report that should provide information for agencies and contractors.

RNS 26 – Bid Price versus Quantity for Preservation Work

Umbrella Topic

Treatment Application

Background

The total amount of pavement preservation treatment bid item quantities in a preservation project is one of several significant factors that may influence bid prices for the preservation treatments (e.g., chip seal, micro surfacing, slurry seals and thin lift overlays). To achieve economies of scale, some road agencies stockpile large quantities of materials such as aggregate, chips, etc., and have contractors draw materials from the stockpiles. Other factors may include distance between material source and processing plant and project site, prevailing prices at bid time, fluctuations in supply and demand, level of competition at bid time, etc. Any analysis of historical bid prices should consider each one of these factors. Agencies with higher materials quality standards may be willing to pay extra for premium quality either in the form of higher transportation costs or higher manufacturing costs.

Evaluating bid price versus quantity to identify cost-effective (minimum) quantity levels for pavement preservation treatments, will involve examining bid prices and isolating, as far as possible, the effect of bid quantities. Then bid quantities can be plotted against bid prices to evaluate the relationship and determine if there is a cost-effective (minimum) quantity level for each of the commonly applied treatments.

Objective

The objective of this research is to develop a methodology for developing more cost-effective pavement preservation project scopes based on bid quantities and level of competition. The research team will collect historical data on bid prices and project quantities for pavement preservation treatment projects. The data will be collated by treatment type (chip seal, micro surfacing, slurry seals, and thin lift overlays). The research team will review project documents to gather related information on factors other than bid quantities that would affect bid prices, and develop simple categories to separate each of the other factors' impact, e.g., level of competition (high, medium, or low).

The research should evaluate the relationships between varying levels of pavement preservation treatment bid item quantities and contract bid prices for those items while other significant price factors are held constant or near constant. Finally, the research should include information about cost-effectiveness.

RNS 27 – Impact of Construction Techniques and Quality on Performance

Umbrella Topic

Performance

Background

The success and cost-effectiveness of a preservation strategy is dependent, among other things, on design, materials, specifications, construction, climate, and traffic. Among these, the only controllable variables are those associated with the design and construction of the strategy. Some preservation strategies may be more susceptible to construction quality and design techniques than others, e.g., chip seals, slurry seals, micro surfacing, and thin lift overlays.

In some agencies, surface treatment design consists simply of generic application rates of the component materials and relies on field adjustments to provide the final design. It is now possible to develop mix designs for the various components ensuring both compatibility as well as a satisfactorily performing final product. Some agencies even require certified laboratories to ensure the procedures are conducted properly and a good design produced.

The impact of work force depletion on construction and design quality is unknown but is believed to be significant when viewed over an entire roadway network. There is a need to document the impact of construction quality on treatment performance.

Objective

The objective of this research is to develop a set of possible best practices for design and construction of surface treatments. The objective of this project is to document the impact of design and construction on the performance period of chip seals, slurry seals, micro surfacing, and thin overlays.

The following minimum tasks should be accomplished:

1. Interview agency personnel at various levels to ascertain historical knowledge regarding impacts of design and construction on surface treatment performance. Develop case examples of this impact and, if possible, quantifiable data describing the effect on performance. These data could consist of shortened resulting performance periods, higher percentages of failed projects, or both.
2. Based upon the interviews conducted, develop identify possible best practices about treatment service intervals.
3. Prepare a final report documenting the research.

RNS 28 – Impact of Pavement Condition on Future Performance of Preservation Treatments

Umbrella Topic

Performance

Background

Pavement managers make program decisions regarding pavements to treat with preservation, rehabilitation, and reconstruction. Preservation is intended to extend the functional performance of the road and is recommended when roads are in fair to good condition. If a preservation treatment is applied too late, the treatment may be less successful in extending the service life. If the treatment is applied too early, scarce resources may be used which could be better applied elsewhere. In practice, some States apply surface treatments one year after construction, and believe the treatments are beneficial. Conversely, treatments are also applied to roads that are in poor condition, or which have areas of poor pavement. In these cases, poorer performance and a shorter life extension should be expected.

The National Center for Asphalt Technology (NCAT and Minnesota Cold Weather Pavement Testing Facility (MnROAD) have constructed pavement preservation test sections on in-service roads in Alabama and Minnesota. Each 500-foot section has been subdivided into zones that are thoroughly mapped for distresses prior to application of the treatments and intermittently during the observation period. One of the stated goals of constructing and monitoring the preservation treatment test sections is to establish a link between preservation treatment performance and condition of the underlying pavement. Even if the test sections provide insight into the link between service life extension of the zone and pavement condition of the zone, it may be difficult to extrapolate the zone results to road networks.

Because the test sections are relatively short, the laydown process is not representative of actual field construction. A typical preservation project may consist of numerous roadways, each 1 to 5 miles in length. Failures in the pavement management system (PMS) may be indicated by some percentage of the section length, and section lengths may be 1 to 5 miles, or longer. The sections at NCAT were subdivided from the original 500-foot length, so are significantly smaller than typical PMS sections.

Objective

The objective of this project is to develop a methodology for using pavement management system data to predict the preservation treatment performance based on the pavement condition before the application of a treatment. This project should establish connections to pavement management condition data prior to treatment performance for single and double chip seals, micro surfacing, slurry seals, and thin asphalt overlays, as a minimum. Pavement management data should be obtained from agencies and should cover the four climatic zones and the range of pretreatment conditions from good to poor. A range of traffic loadings from low to moderately high should also be included. Performance data should be collected for at least six to eight years following placement of the treatment. Identification of end of service life criteria for each treatment type is critical to the project. The relative size of a failure area in a typical PMS to the size of the NCAT test section zones may be considered. The project should validate the results from NCAT and MnROAD test sections and extend their results to network-level roadways and demonstrate the impact of pavement condition on pavement preservation treatment life.

RNS 29 – Data Needed to Capture Performance of Pavement Preservation Treatments

Umbrella Topic

Performance

Background

An agency may apply several different preservation treatments to its network depending on traffic levels, pavement conditions, and other factors, including availability of adequate materials and contractors. The applications should be included in the construction history of each roadway as part of the pavement management system (PMS). Pavement condition surveys are conducted and data from those surveys are also part of the PMS system and are used to project future condition based on the rate of deterioration. Individual distresses can be monitored and usually consist of cracking, rutting, and International Roughness Index (IRI) for flexible pavements.

What data would enable an agency to differentiate performance of preservation treatments and determine the time to retreat for surface treatments? A chip seal, for example, does not address rutting and has only minor, if any, impact on IRI. Cracking is only temporarily covered. Yet the chip seal prevents water from entering the pavement and prolongs the time to rehabilitation. The chip seal's most common "distresses" are bleeding and chip loss.

In addition to differences in distresses, the performance of the preservation treatment may depend on traffic levels and type, freeze-thaw, soil type, temperature and moisture. The level and type of distresses on the roadway at the time of treatment placement also impacts future performance. Another factor in surface treatment performance is the emulsion type and use of polymers and fibers. Are these factors included in most PMS?

What types of data are more important to the performance of preservation treatments should be collected and included in a PMS? This will allow an agency to identify those factors that are most important for performance.

Objective

The objective of this project is to identify specific data that can be used to capture and predict the performance of pavement preservation treatments. The following preservation treatments should be considered as a minimum: chip seals, cape seals, micro surfacing, slurry seals, and thin asphalt overlays.

A survey of State practices should identify the types of data currently being entered into PMS for each treatment. If the agency has changed its practices, the timing of the change should be noted. For example, if they have changed from manual distress to fully automated distress, how many years of condition data do they have under the new system? Does the agency have an established approach for project selection for preservation treatments and does it verify that that approach is followed?

The research team should use the survey and a literature review, as well as expert knowledge, to identify data elements that could allow better differentiation of performance for thin surface treatments. In identifying the data elements, the research team should rank them in importance and discuss the practical issues associated with each. Interviews with two or more vendors of pavement management systems should add information about feasibility. Similarly, interviews with at least four agency pavement management engineers, representing at least two large systems and two smaller systems, should be conducted for feedback on the desirable data elements and the impacts on both data collection and PMS.

Suggested methods regarding use of data elements for improved performance evaluation of preservation treatments should be included in the final report.

RNS 30 – Identification of Performance Goals for Preservation Treatments

Umbrella Topic

Performance

Background

Each pavement preservation treatment has one or more goals whose achievement can be assessed by the degree to which certain related parameters are improved by the application of the preservation treatment. A particular preservation treatment may improve some broad performance goals while not affecting others. Broad goals for consideration could include:

1. Safety – can be achieved by increasing friction numbers to acceptable thresholds
2. Performance – can be achieved by increasing ride quality and treatment longevity
3. Economy – can be achieved by decreasing costs and increasing sustainability

A chip seal can provide excellent frictional characteristics if good quality aggregate is used. The treatment will not generally improve ride quality, but it seals the road surface from water intrusion and extends road life.

Objective

The objective of this research is to identify the performance goals that can be achieved with various preservation treatments for flexible, rigid and composite pavements. The project should begin with identification of broad performance goals and then "drill down" to specific treatment functions. Both flexible and rigid pavement preservation treatments should be included.

1. This research project should identify goals for each preservation treatment.
2. For each goal, the project should identify one or more measurable parameters which can indicate the degree to which the corresponding goal has been (is being) achieved. Examples of benefits based on each performance goal should be included, preferably with State agency data.
3. The project will produce a report summarizing the treatments, identified goals, and corresponding measurable parameters.

RNS 31 – Treatment Performance Life When Used in Preservation Mode

Umbrella Topic

Performance

Background

Numerous surveys of State agencies have been conducted on particular preservation treatments' longevity. For example, a 2018 survey conducted by the Midwest Pavement Preservation Partnership gave the following ranges of service lives:

Treatment	Service Life
Chip Seal	3–10 years
Micro Surfacing	3–10 years
Thin HMA Overlay	4–12 years
Ultra-Thin HMA Overlay	3–9 years

An agency with no performance data of its own but wanting to use the preservation treatments may use the average of the ranges and expect 6.5 years of performance. In practice, the lower range of treatment life is frequently associated with pavements in poor condition, or a roadway that should not have been considered for a particular treatment.

This project should provide more accurate performance estimates for pavement preservation treatments by considering only treatments that are applied to pavements in fair to good condition and with a treatment suitable for its distresses, e.g., distresses limited low severity cracking for micro surfacing projects.

Objective

The objective of this research is to determine treatment and service life extensions for pavements when preservation treatments are applied while the pavement is in fair to good condition. This project should solicit pavement management data from agencies for roadways treated with preservation treatments and subsequent performance data for a period of 8 to 10 years. The pretreatment condition may be used to eliminate any treatment applied to a pavement that is not suitable for preservation or which has distresses indicating structural inadequacy. The project should identify the State criteria used to define the end of the treatment service life, and different criteria may be appropriate for different preservation treatments. Treatment service lives should be calculated, and distribution functions provided for chip seals, micro surfacing, slurry seals, thin HMA overlays, and ultra-thin HMA overlays (< 1 in.). Regional values should be based on the experiences of at least three agencies per climatic region, although larger representation should be sought for wet-freeze and wet-no freeze, as many agencies fall in these regions. Traffic levels, including mixes of vehicle types should also be considered.

Development of treatment service life estimates and their distribution functions should assist State and local agencies considering use of "new to them" preservation treatments.

RNS 32 – Common Elements in State Data Quality Plans

Umbrella Topic

Performance

Background

Based on the National Performance Management Measures: Assessing Pavement Conditions for the National Highway Performance Program and Bridge Condition for the National Highway Performance Program (PM2) rule under 23 CFR 490.319(c), each State department of transportation (DOT) must develop a pavement distress data quality management plan (DQMP) that addresses the following minimum critical areas:

1. Data collection equipment calibration and certification
2. A certification process for persons performing manual data collection
3. Data quality control measures to be conducted before data collection begins
4. A data sampling, review, and checking processes
5. Error resolution procedures and data acceptance criteria

Undoubtedly, there are valid reasons why different DOTs could arrive at different approaches to data quality management. Those reasons may include differences in prevalent pavement distresses to be measured; the prevailing processes used by the DOT in its data collection and management methods, including reliance on automated data collection versus manual collection; or methods of post-collection data processing and storage. The data quality management plans are designed to allow for differences in plans but also suggest that future improvements in individual plans are encouraged as more experience is gained, technology improves or becomes more cost-efficient, etc.

The process of developing the data quality management plan involved States critically reviewing their distress data management procedures. At the same time, development of the plans is costly, both in time and in monetary resources. Are some components of the plans duplicative across a region, or across a data acquisition method? Could these components be standardized so that State resources are focused on the remaining topics, reducing the reporting burden for the States?

Objective

The objective of this research is to evaluate the data quality management plans submitted by State agencies and to determine whether there are components that may benefit from standardization. The research should consider various approaches to grouping the data quality management plans:

- Regional,

- System size,

- Data acquisition method (manual, automated with manual data reduction, fully automated), or others. For each group of agencies,

- Common elements and approaches from the plans should be identified.

- Identify components of the plans that are significantly different between agencies as those may need individual agency attention as revised plans are submitted.

- Request input from agencies on the approaches (and costs) they used in developing their data quality management plans: in-house, consultant contract, or other methods.

- Query a sample of States regarding potential savings in time or funds from having standardized elements. Prepare information on application of those common elements that could enable standardizing some elements of all plans.

RNS 33 – Societal Benefits of Pavement Preservation

Umbrella Topic

Benefits

Background

Good roads are generally recognized as an essential contributor to a region's economic development and growth and promote important social benefits. Surveys show that adequately maintaining road infrastructure is essential to preserving and enhancing these benefits. Lack of adequate funding and maintenance may produce a construction backlog that leads to deteriorating network conditions and the need for costly rehabilitation and reconstruction.

Reconstruction itself is always disruptive and impedes the orderly flow of commerce and other travel. Preservation maintains the functional condition of the road network, raises the quality of the experiences of road users, is relatively inexpensive (compared with reconstruction), and delays the need for expensive reconstruction.

Benefits of preservation may include:

1. Benefit of the influence of good pavement conditions on housing values and time to resale
2. Benefits for commercial facilities and industry in having few work zones for short time periods and free flowing traffic
3. Benefits of good pavements for farm-to-market activities in rural areas
4. Value of good pavement in allowing commuting over longer distances
5. Protection of the investment in roads for society as a whole

Other benefits may include lower carbon footprint, improved fuel efficiency, reduced maintenance costs for personal and commercial vehicles, reduced freight damage, and safety improvement.

Objective

The objective of this research is to develop a methodology for calculating and presenting the benefits of pavement preservation. The approach should include examples not only of calculating benefits but of conveying them to non-technical stakeholders. Benefits may accrue from practicing preservation.

Research should be undertaken to demonstrate how preservation can enhance the five benefits listed above. One or more case studies involving different types of preservation can highlight how each treatment type can contribute to overall benefits.

The results of these case studies should be documented and widely distributed in a report that can be understood by the general public (whose support of the concept is crucial) and agencies charged with maintaining the road system using available resources. The methodology used to quantify the societal benefits should be explained in sufficient detail for an agency to apply it to its own data to determine local benefits.

RNS 34 – Improving Definitions of Costs

Umbrella Topic

Benefits

Background

The NCHRP Report 858, Quantifying the Effects of Preservation Treatments was presented at the 2018 meeting of the Midwestern Pavement Preservation Partnership (Madison, Wisconsin, November 7, 2018). This research did not report cost figures because the seven States contacted used different cost measures. As a result, the report was based on condition.

Agencies may benefit by comparing treatment costs. While each agency uses its own cost methodology, this research project should identify for comparison specific and carefully defined cost components from State cost methods. Relevant data components include costs for: traffic control, inspection, mobilization, Americans with Disabilities Act (ADA) compliance, guardrail and guiderail adjustments, shoulder adjustments, seeding, and mulching.

Objective

The objective of this project is to provide a potential approach for expressing costs of common preservation treatments in a framework that enables comparisons between agencies. This project should begin with a synthesis of State practices to identify how they define the costs of the following preservation treatments: chip seal, micro surfacing, slurry seal, thin asphalt overlay, ultra-thin asphalt overlay (< 1 in.), diamond grinding or pavement grooving, and concrete partial-depth or full-depth patching. Samples of cost data should be solicited from five to seven agencies. The synthesis should identify common elements as well as appropriate units, and conversion factors. If several different methods of defining cost are identified in the synthesis, the research should identify strengths and weaknesses of each.

Based on the synthesis of practice, the study should provide information about a method of defining cost for each of the preservation treatments. It should carefully define each of the components and describe units of cost. The final product should report model cost methodologies for each preservation treatment.

Information about each methodology should be applied to the sample cost data supplied with the synthesis to demonstrate that States can use their data to provide the requested cost data. Examples may be used to demonstrate the recommended approaches.

RNS 35 – Achieving a Good Mix of Reconstruction, Rehabilitation, and Preservation

Umbrella Topic

Benefits

Background

Pavement management systems (PMS) are vital for departments of transportation (DOTs) to be able to collect, analyze, maintain, and report data describing network pavement condition. Performance-based planning for pavement preservation involves the use of the PMS to predict future network performance and to implement strategies to meet performance and spending targets. A prudent strategic approach allocates limited resources where they can have the greatest benefit.

PMS rely on structured approaches to develop predicted future conditions based on historical performance to enable strategy selection. Often, these strategies consist of a mix of fixes such as preservation, rehabilitation, and reconstruction. However, the necessary PMS data attributes for each of these strategies may not be sufficiently robust; particularly in the case of preservation strategies where data capture may be insufficient to define performance. This sometimes results in an agency establishing a fixed percentage of funding to ensure effective treatments are applied.

One consideration not typically included in achieving a good mix of fixes within a PMS is the value of competition. By having enough alternatives between overall categories, as well was within the pavement preservation category, contractors maintain consistent markets allowing better trained and retained personnel. With the opportunity for better workforce development and higher equipment utilization, better quality construction and pavement performance should result.

This aspect also applies to agencies where the maintenance divisions need to maintain enough equipment and personnel to produce quality preservation activities.

Objectives

The objective of this research is to develop potential best practices and recommendations on establishing a mix of fixes between pavement preservation, rehabilitation, and reconstruction strategies. The following minimum tasks may be conducted:

1. Conduct a literature search of the available body of work which describes the PMS strategies employed within the U.S. This effort should focus on the current state of the practice, such as the strategies practiced in the last 10 to 15 years, and should identify the procedures used for strategy selection and differentiation among the various categories.

2. Based on the literature search findings, identify necessary data elements, determine if the necessary data to conduct this study are available, if the necessary data could be achieved through additional agency surveys or other research, and, finally, if the original objective can be achieved.
3. Prepare an interim report summarizing the initial data collection effort and finding, and develop an enhanced work plan, if appropriate, to accomplish the task. If it is determined that the original objective can be met, collect the remaining necessary data and perform the appropriate analysis.
4. Prepare a final report documenting the results, findings, and conclusions of the study.

RNS 36 – Treatments Leading to Noise Reduction

Umbrella Topic

Benefits

Background

Application of a pavement preservation treatment is likely to change the levels of pavement noise depending on the treatment and possibly other factors such as traffic levels, weather, etc.

For example, chip seals increase the potential for windshield damage and produce excessive noise. The larger stones are more skid-resistant and produce more noise.

The following treatments may produce less pavement noise:

- Fog seals – when applied over a chip seal
- Ultra-thin bonded wearing course (UBWC) – a thin (0.375 to 0.75 inches thick) gap-graded modified hot-mix asphalt (HMA) layer placed on a polymer-modified emulsified asphalt membrane
- Diamond grinding – for concrete pavements
- Next-generation concrete surface (NGCS) – combines grinding and grooving to improve ride quality and lessen noise

Objective

The objective of this project is to develop a voluntary approach to noise mitigation and factors affecting pavement surface noise. This project should investigate noise potentials for a range of pavement preservation treatments to learn the following for each treatment:

- How is payment noise affected by the treatment? What sound frequencies are affected?
- How do external factors such as traffic (volume and speed) and weather affect noise generation?

Project findings should be documented and summarized in a report covering the range of pavement preservation treatments.

RNS 37 – Communicating with the Media

Umbrella Topic

Benefits

Background

Reporting on pavement conditions in the media (newspapers, online articles, TV news broadcasts, etc.) often focuses on the negative. Potholes often are featured since they are arguably the most prominent feature of poor pavement condition that the traveling public and commercial traffic sees and feels. The efforts of highway owners to preserve pavements in good condition and prevent or minimize potholes are often less reported. In some cases, the desired message is not received and understood by the public.

To increase public support for system preservation, it is necessary to deliver the message that system preservation is effective and cost efficient. The message should also highlight the benefits received by the public when pavement preservation treatments result in less obstruction (scope as well as duration) to traffic and fewer instances of vehicle damage or accident incidents resulting from wheels impacting a pothole, poor skid resistance, etc.

State department of transportation (DOT) websites can be effective tools for delivering key program information to road users as well as legislators. The following are two examples:

- *The Gray Book* is the Washington State Department of Transportation's quarterly performance and accountability report. Each edition features quarterly and annual updates on key agency functions and provides in-depth analysis of topics aligned with the agency's strategic plan emphasis areas as well as the State's transportation goals.
- *VDOT's [Virginia Department of Transportation's] Quarterly Report Card* shows performance on core business outcomes: construction and maintenance contracts. It provides a snapshot of how well current projects are meeting their schedules and budgets. More specifically, *VDOT's Quarterly Report Card* shows the status of each pavement project scheduled on roads maintained by VDOT, along with other details captured in the description. The report uses different colors to show projects that are scheduled, in progress, or completed.

Objective

The objective of this research is to develop best practices for sharing information with road users regarding pavement preservation treatments and their impact on the pavement network. Develop and effectively deliver information to road users that raises their awareness of the effectiveness of applying pavement preservation treatments to prevent or minimize potholes (and other forms of pavement deterioration); highlight tangible public benefits of cost/time savings as well as improved safety and vehicle performance.

- Identify States that have successfully developed system preservation messaging practices and templates and that use effective media platforms—websites, press releases, public service announcements, roadside messages, community meetings, etc.—for delivering the message.

- Evaluate the types of information being delivered, including the types of system preservation benefits being described and how those benefits are explained.

- Evaluate which benefits resonate most highly with road users and develop models for succinct, easy-to-absorb messages that convey those benefits.

APPENDIX C: SYNTHESIS STATEMENTS

Synthesis Topic 1 – Including Pavement Preservation Treatments in Pavement Management Systems

Umbrella Topic

Asset Management, Pavement Management, and Pavement Preservation

Background

Historically, pavement preservation treatments were considered to be maintenance treatments and were frequently self-performed by an agency. Records of exact locations and even treatment types were locally maintained. Preservation has now advanced to be an important tool for an agency in meeting its network condition goals. It is frequently contracted out rather than being self-performed. In addition, agencies want and need to be able to project performance of their networks and, to do so, need to have accurate records of treatment types, application dates, and locations in their pavement management system (PMS).

Preservation treatment information should be included in two sections of the PMS. First, the preservation construction history as discussed above should be updated. Second, pavement preservation treatments can and should be included in the decision trees or matrices, as this provides guidance on project selection and encourages use of the treatments.

Objective

This synthesis of agency practices should identify the extent to which pavement preservation treatments are included in agency PMS. The synthesis should identify the types of preservation treatments included in the agency's decision matrices or trees. What are the decision criteria associated with each treatment? Flexible and rigid pavement treatments should be addressed.

The synthesis should request a description of how construction history is recorded in the agency's PMS. For example, does the PMS differentiate between double chip seals and single chip seals? Is polymer modified emulsion differentiated from unmodified emulsion? Is the emulsion type recorded? What issues have made inclusion of preservation treatments more difficult for the agency and how have they been resolved? How has the agency linked project termini to PMS segments (noting that contracts for preservation frequently are described from intersection to intersection as opposed to PMS section limit to PMS section limit)?

Case studies may be used to demonstrate differing approaches in more detail.

Synthesis Topic 2 – Agency Selection of Preservation Treatments, Timing, and Triggers

Umbrella Topics

Treatment Design; Performance

Background

During initial deployment of pavement preservation, some agencies made all decisions regarding treatment timing, road selection and triggers as a small group, usually at the central office. While this approach was beneficial in creating consistent project selection, it did not allow the program to grow and increase support from the local maintenance offices. Over time, many agencies have decentralized both the project selection and the project oversight.

This synthesis considers both centrally managed and decentralized pavement preservation programs to identify the methods used to make roadway selections, treatment timing and trigger values. Is information from the pavement management system (PMS) considered in selecting roadways and treatments for preservation treatments? If not, what issues make the PMS information difficult to implement? Does the agency have information about treatment selection criterion and trigger values for specific distresses? How does the agency follow up on the roadway selections to increase the percentage of its program that is treated while in fair to good condition?

Objective

This synthesis will determine the state of the practice in roadway selection, treatment selection, and trigger values for pavement preservation treatments. For agencies where these decisions are made by a group in central office, what decision criterion are applied? How are projects distributed statewide? How does the agency build support for the preservation program among regional groups? How far in advance does the agency program plan?

For agencies with decentralized decision making, what criteria are used and are those criteria common to all districts? To what extent is PMS information used in deciding the preservation program? If they are not, what are the obstacles to using PMS in identifying meaningful projects? Is there a feedback loop established to identify whether project selections are consistent with pavement preservation goals, i.e., are most of the roadways being treated while in fair to good condition? What training is provided to support sound decision making?

Synthesis Topic 3 – Agency Design Methods for Chip Seals, Micro Surfacing, and Slurry Seals

Umbrella Topic

Treatment Design

Background

Most of the design methods used in the United States date from the 1950s and 1960s. The most common method of chip seal design is the McLeod method, developed in the 1960s and adopted by the Asphalt Institute in 1969. Some agencies, such as the California Department of Transportation (Caltrans) and the North Carolina Department of Transportation (NCDOT), have developed design methods as part of agency research programs. Other agencies do not use any design method but specify a range of application rates for aggregate and binder. Modifications of design methods by Hanson, Kearby, and McLeod have been made but may not have been widely publicized.

Objective

This synthesis of agency practices should collect design methodologies from agencies for chip seals (single and double), micro surfacing, and slurry seals. If an agency used rubber, recycled asphalt pavement, recycled asphalt shingles, or fibers in its treatments, the method used should be documented. If a design method is locally developed, it should be described in sufficient detail to allow another agency to apply it. Similarly, if an agency is using design methods developed in Australia, New Zealand, South Africa, or the United Kingdom, those methods should also be described in some detail. If the agency has calculated the benefits to be gained from using designed surface treatments, those benefits should be reported. The training level requested or provided associated with treatment design should also be requested. Whether treatment design is handled by the central office or regional personnel or contracted out should also be part of the synthesis.

For agencies that do not use a design methodology, the specific application rates should be collected along with information used in selecting a rate from a table. If an agency uses a range of application rates instead of a designed treatment, its reason(s) should be explained and documented.

Case studies may be used to demonstrate differing design approaches in more detail.

Synthesis Topic 4 – Agency Approaches to Contractor Prequalification for Preservation Contracts

Umbrella Topic

Treatment Application

Background

During the early days of pavement preservation, most agencies applied their own preservation treatments. The work force received on-the-job training, and teams worked together for many years. In the last decade, there has been a significant shift toward contracting out preservation work. The transition has produced issues for both agencies and contractors: agency inspectors were trained in flexible and rigid new pavement construction rather than preservation, and some contractors were new to preservation construction. Training has been critical to making the transition successful.

This synthesis looks at contractor prequalification, an alternative approach that an agency could take to ensure that preservation contractors are able to construct quality projects. Some States prequalify based only that the contractor meet the agency's bonding level. Other States prequalify based on contractor certification for preservation treatments, indicating that the contractor possesses the knowledge and capabilities to perform the work satisfactorily. Other States may have other approaches.

Objective

This synthesis should determine the state of the practice in qualifying contractors to perform specific preservation treatments. The agency could simply prequalify based on the construction bond. Does the agency ensure that the contractor's crew have training, and if so, what type and how much? Does the agency prequalify based on contractor's key personnel being certified, and if so, what kind of certification? Does the agency offer training opportunities for both contractors and agency personnel? If the agency has a more robust prequalification program, has it been effective? Has there been an improvement in the quality of work? Has the agency developed its program in reaction to one or more project failures? How have issues of quality been resolved during construction to avoid a project failure and deliver a quality project? What changes would the agency like to see to enhance its pool of high-quality contractors? Is there a sufficient pool of contractors for preservation work or are there areas of the State where there is only one bidder for preservation projects? Has this impacted the desire to prequalify contractors?

Synthesis Topic 5 – Methods of Increasing Competition for Preservation Projects

Umbrella Topic

Treatment Application

Background

As part of the Federal Highway Administration's (FHWA's) "Every Day Counts-4" initiative, regional peer exchanges were held to discuss issues with construction and contracting. One of the topics raised in these discussions was the issue of limited competition for pavement preservation work. Numerous States had areas where only one contractor bids for the work. For certain preservation treatments, no in-state contractors are available. State agency contracting strongly prefers that multiple bids be submitted for agency projects. This synthesis will identify areas where competition is very limited and approaches to increase competition.

Objective

This synthesis will describe the state of the practice regarding competition for pavement preservation projects within State agencies. Different levels of competition may exist for different preservation treatments and for different districts in the State. What approaches have been tried to increase the number of bidders for preservation work? How successful have they been? Has the agency bundled projects across district lines to increase the number of bidders? Does the agency bundle projects with different treatments to increase competition? Has the agency stopped offering projects with specific treatments due to lack of competition? Does the State bid alternate treatments for the same roadways in an effort to increase the number of bidders?

It may provide insights if the researcher requests names and contact information for preservation contractors in areas where competition is limited. The contractors could be queried regarding maximum distance they will travel for a preservation project, whether they travel across State lines for projects, issues with the contracts or specifications that they believe limit competition, and their ideas for increasing competition for preservation work.

Case studies of some approaches used to increase competition should be included.

Synthesis Topic 6 – Use of Ground Tire Rubber in Surface Treatments

Umbrella Topic

Materials

Background

Each year, automobiles in the United States account for 246 million waste tires, of which about 26 percent are ground into filler for asphalt and insulation, 49 percent are burned for fuel (producing pollution), 11 percent are dumped in landfills, and 14 percent are used for other industrial by-products such a gravel substitute, crumb rubber, landfill medium, waste treatment filters and garden mulch. The interest in incorporating more tire rubber in pavement goes back to the early 1990s, but issues with construction slowed the implementation.

Not everyone gave up on the concept of recycling tires in pavement materials. States in the southwestern U.S. have successfully used ground tire rubber for many years. An earlier synthesis on this subject is now more than 20 years old.

Technology has also been developed in recent years that allows grinding of the tire rubber to -30 mesh size. At this size, the rubber can be dispersed in asphalt and the asphalt can be emulsified. The material can be placed using conventional equipment. These developments have renewed interest in use of ground tire rubber in surface treatments, including in areas that are new to the approach, including New England, the Midwest, and the Southeast.

Objective

This synthesis is to identify the current state of the practice for use of ground tire rubber in pavement surface treatments. States that are using ground tire rubber in surface treatments should be requested to submit their specifications. They should also describe the process they use for preparing the ground tire rubber. Do they use hot applied chip seals or emulsified asphalt? When were the projects constructed and what has been the performance to date? Were there issues during construction and how were they resolved? Does the State intend to expand use of ground tire rubber in surface treatments, and if so, by how much? Did contractors have concerns with the process? Did the use of ground tire rubber influence the choice of emulsion, rate of application of emulsion, or aggregate application rate? Did the rolling patterns differ from those used for similar treatments without ground tire rubber?

For agencies not using ground tire rubber, what are their major concerns?

Synthesis Topic 7 – Alternatives to Portland Cement for Full- and Partial-Depth Patching of JPCP and CRCP

Umbrella Topic

Materials

Background

Full- and partial-depth patching are common preservation treatments for rigid pavements. Portland cement concrete patches need longer curing periods than normal-strength concrete patches. Shorter curing periods, as little as 24 hours or less, are needed for high-strength concrete, but these materials can have issues with shrinkage cracking and durability.

Bridge maintenance engineers have used a variety of materials to patch concrete bridge decks. This synthesis will explore alternatives to portland cement concrete that have been used or are being used for pavements, including both jointed concrete and continuously reinforced concrete. The synthesis will include the materials, their placement methods, performance, and issues observed by the agency.

Objective

This synthesis will outline the state of the practice in placing full-depth and partial-depth patches in jointed and continuously reinforced concrete pavements. Participating agencies should describe the materials they use, the time needed for placement and curing, if any, equipment used, pavement conditions suitable for the materials, cost, and performance. Copies of specifications or special provisions should be obtained. While the synthesis is focused on non-portland cement concrete, it may be helpful to ask the same questions for concrete patching as with alternate materials so that comparison can be made.

It would also be helpful to learn of issues that occurred, whether in design, procurement, or construction, and how the agency addressed those issues. Case studies where alternate materials were used successfully should also be provided.

Synthesis Topic 8 – Early Opening of Concrete Pavement to Traffic Following Preservation Treatments

Umbrella Topic

Treatment Application

Background

Full- and partial-depth patching are common pavement preservation treatments for rigid pavements. Portland cement concrete patches need longer curing periods than normal-strength concrete patches. Use of maturity concepts as well as specially designed mixes have allowed agencies to open roadways to traffic earlier, sometimes in only a few hours.

Earlier opening to traffic reduces user impacts and is desirable if performance is not affected negatively. This synthesis will capture the current state of the practice for early opening of roadways to traffic.

Objective

This synthesis will outline the state of the practice in determining when a rigid pavement repair is ready for opening to traffic. Agencies should be queried regarding how they accomplish earlier opening to traffic: by mix design, by maturity testing, whether based on traffic volume or make-up or other means. Variables that the agency has found that alter the time of opening to traffic should be described. Examples might include ambient temperature, wind speed, and relative humidity. Is the early opening practice used for all concrete construction, or is it limited by traffic volume or vehicle classifications? If the agency allows partial opening by restricting traffic to automobiles and light trucks, that should be described. Most importantly, did early opening affect the longer term performance of the roadway? Were there issues associated with the practice of early opening to traffic about which other agencies should be aware? How does the agency describe its practices in specifications or special provisions? Samples would be helpful.

Synthesis Topic 9 – Traffic Control Practices for Chip Seal Applications

Umbrella Topic

Treatment Application

Background

Application of chip seals is one of the most common pavement preservation activities and consists of well-defined activities. The roadway is cleaned prior to treatment. An emulsion is sprayed on the roadway using a distributor, usually one lane at a time, and this is followed by application of aggregate in a single stone thickness using a chip spreader. Following this, the aggregates (or chips) are rolled to embed them into the emulsion. Excess stone is broomed or vacuumed from the roadway to complete the job.

For many years, chip seals were only applied to low-volume roadways, some with traffic levels so low that only limited traffic control was needed. Now chip seals are applied both on low-volume roadways and on much higher traffic level roadways. Traffic control practices may vary based on road category, average daily traffic, or percentage truck traffic. This synthesis will capture the current state of the practice regarding traffic control for chip seal applications.

Objective

This synthesis will describe the state of the practice regarding traffic control for chip seal projects. What traffic control is typically used for low-volume two-lane roadways? Does it vary depending on roadway length, line of sight, or other variables? For how long is traffic flow restricted for a typical low-volume roadway application? Does the agency commonly use pilot cars to bring traffic around the work zone? Is brooming or vacuuming done as part of the initial traffic control? If not, how long after the application and using what traffic control?

Does the agency apply chip seals to higher traffic roadways? What is the maximum annual average daily traffic (AADT) for chip seals? Does the agency use chip seals on Interstate highways? For higher AADT roadways, what methods of traffic control are used? Are there concerns when working adjacent to high-speed traffic? What additional issues or concerns should be considered for higher traffic application areas?

Case studies of some approaches to traffic control for chip seal applications should be included.