1. Report No. FHWA/TX-11/0-6586-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle REVIEW OF BEST PRACTICES FOR THE SELECTION OF REHAB AND PREVENTIVE MAINTENANCE PROJECTS: TECHNICAL REPORT		5. Report Date Published: April 2011 6. Performing Organization Code
7. Author(s) Samer Dessouky, Paul Krugler, A.T. Papagiannakis and Tom Freeman		8. Performing Organization Report No. 0-6586-1
9. Performing Organization Name and Address University of Texas at San Antonio Department of Civil and Environmental Engineering San Antonio, Texas 78249 Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		10. Work Unit No. (TRAIS) 11. Contract or Grant No. Project 0-6586
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Technical Report September 2009–August 2010 14. Sponsoring Agency Code

15. Supplementary Notes
Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.
Project Title: Review of Best Practices for the Selection of Rehab and Preventive Maintenance Projects
URL: http://tti.tamu.edu/documents/0-6586-1.pdf

16. Abstract
With finite resources and an extensive road network to maintain, Texas Department of Transportation (TxDOT) personnel must select the roadways to receive rehabilitation and preventive maintenance treatments as well as select rehabilitation and preventive maintenance (PM) methods that are structurally sound, capable of being opened to traffic quickly, straightforward construction methods and, most importantly, minimize the associated costs. This research project focuses on developing guidelines to aid TxDOT personnel in making optimal selections of rehabilitation and PM projects. TxDOT district personnel have implemented various selection procedures, but there is a tremendous need to have a comprehensive, logical approach developed. The study objectives are to determine best practices of selecting and prioritizing PM and rehab projects in the districts and to develop a simple effective prioritization Excel-based tool to aid TxDOT personnel in decision making.

17. Key Word Preventive Maintenance, Rehabilitation, Project Prioritization, PMIS	18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service Alexandria, Virginia 22161 http://www.ntis.gov

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	138	

REVIEW OF BEST PRACTICES FOR THE SELECTION OF REHAB AND PREVENTIVE MAINTENANCE PROJECTS: TECHNICAL REPORT

by

Samer Dessouky
Assistant Professor

A.T. Papagiannakis
Professor
Department of Civil and Environmental Engineering
University of Texas at San Antonio

and

Paul Krugler
Research Engineer

Tom Freeman
Engineering Research Associate

Texas Transportation Institute
The Texas A&M University System

Report 0-6586-1
Project 0-6586
Project Title: Review of Best Practices for the Selection of Rehab and Preventive Maintenance Projects

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

Published: April 2011

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

UNIVERSITY OF TEXAS AT SAN ANTONIO
Department of Civil and Environmental Engineering
San Antonio, Texas 78249

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The researcher in charge was Samer Dessouky (P.E. Ohio # 71368), Department of Civil and Environmental Engineering, The University of Texas at San Antonio, San Antonio, Texas.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

ACKNOWLEDGMENTS

This project is currently being conducted in cooperation with TxDOT and FHWA. The authors thank the Project Director Mr. Lowell Choate, panel members; Mr. Dan Perry, Dr. Dar Hao Chen, Mr. Jack Moser, Mr. Jesse Fleming, Mr. Michael Beaver, Mr. Mike Craig, Mr. Randy Hochstein and Mrs. Tina Massey, Research Engineer Dr. German Claros, and contract specialist Mrs. Sandra Kaderka for their time and support.

The authors also acknowledge the assistance of graduate student Jaya Lakshmi Kunisetty for serving in the data analysis and organization of this report.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

OVERVIEW

With finite resources and an extensive road network to maintain, the Texas Department of Transportation (TxDOT) personnel must select the roadways to receive rehabilitation and preventive maintenance (PM) treatments as well as identify the best treatments given the site conditions. These methods should be structurally sound, capable of being opened to traffic quickly, straightforward construction methods and, most importantly, minimize the associated costs.

TxDOT districts choose specific maintenance treatments for a variety of reasons. Many districts choose a specific maintenance treatment because of either tradition, positive experience with that treatment, or because of material or contractor availability. Districts use various methods of selecting projects for rehabilitation or PM project funding each year. It is important to document all practices these districts use to ensure that best practice and experience are used in project selection for treatment in the future.

This research project focuses on developing guidelines to aid TxDOT personnel in making optimal selections of project rehabilitation and PM. TxDOT district personnel have implemented various selection procedures, but there is a need to have a comprehensive, logical approach for doing so.

OBJECTIVES AND TASKS

TxDOT has a Needs Assessment Tool as part of its Pavement Management and Information System (PMIS). This tool assists districts in identifying roadway sections that are candidates for rehabilitation and PM activities. Moreover, the PMIS uses a comprehensive decision tree to differentiate between the conditions that warrant PM and rehabilitation treatments. However, PMIS does not optimize these candidate projects, given the available budget scenario in which TxDOT operates. Developing assistance in optimally selecting projects is the goal of this research project.

The study objective is to determine best practices for selecting and prioritizing PM and rehab projects in a district and to develop a simple yet effective prioritization tool to aid TxDOT personnel in making such decisions.

To accomplish this objective, the following tasks were carried out.

Task 1. Kick-Off Meeting with TxDOT's Project Monitoring Committee at the Start of the Project.

Task 2. Information Search.

A comprehensive literature search was undertaken related to preventive maintenance and rehabilitation project selection process, project prioritization, and factors affecting the selection and effectiveness of the process.

Task 3. Data Collection through Questionnaire.

In this task, researchers prepared a comprehensive questionnaire to target primary decision maker(s) who select projects for rehabilitation and preventive maintenance in each district. The questionnaire was used to research how each district currently selects their rehab/PM projects, specifically what tools and data they use to make this selection, and determine best practices for use in the future.

Task 4. Conduct Site Interviews.

On-site interviews with TxDOT personnel were conducted at the 25 districts to seek responses to the questionnaire and to site visit pavement sections with future treatment plans.

Task 5. Identify Key Parameters for Best Practices Selection.

After analyzing the questionnaire responses, the researchers identified the factors that districts commonly used in deciding the treatment method and prioritizing the project. These parameters composed the baseline for building the prioritization tool.

Task 6. Development and Verification of a Procedure and Guidelines for Best Practices in Project Selection.

In this task, researchers developed an Excel-based spreadsheet using the key parameters and associated weight factors to rank each project as a candidate for rehab funding and as a candidate for PM funding.

Task 7. Prepare a Final Comprehensive Research Report Summarizing the Present Research Findings.

REPORT ORGANIZATION

This report consists of five chapters as follows:

Chapter 1 provides an introduction of the current problem, the significance of the project, research objectives and tasks, and the report's organization.

Chapter 2 provides a comprehensive literature review on the current methods available nationally and internationally in making decision for PM/Rehab project selections and prioritizations.

Chapter 3 documents information gathered from the districts using the questionnaire.

Chapter 4 presents the structure of the Excel-based tool including the key parameters and the associated weight factors. Instructions on how to use the tools is also presented. Tool verification was conducted using information gathered from project sites visited by the research team and for which the district has planned treatments.

Chapter 5 presents major conclusions and a summary of the research study.

CHAPTER 2:
LITERATURE REVIEW

A Pavement Management System (PMS) is a process to cost-effectively manage a roadway system. The formal process includes a systematic, consistent approach of gathering and analyzing data and generating recommendations and reports so those who control road maintenance budgets can make informed investment decisions. PMS generally include a subsystem for pavement maintenance which may contain models to determine the most cost-effective treatment (FHWA 1997 and 1998). It is critical, however, that the proper maintenance treatment be placed at the right time for the pavement to function as designed and for the maintenance program to be cost effective (Hicks et al., 2000). They implied also that a limitation of many systems is their inability to comprehensively analyze individual projects and determine the proper timing and cost of PMS treatment.

The foundation of all PMS is a database that includes the following four general types of data (Flintsch et al., 2004):

- Inventory (including pavement structure, geometrics, and environment).
- Road usage (traffic volume and loading).
- Pavement condition (ride quality, surface distresses, friction, and/or structural capacity).
- Pavement construction, maintenance, and rehabilitation history.

PMS analysis capabilities include network-level and project-level tools. “Network-level” analysis tools support planning and programming decisions for the entire network or system. “Project-level” analysis tools are used to select the final alternatives and to design the projects included in the work program. A PMS process is usually conducted in six steps (Peng and Ouyang, 2010):

- Determine pavement condition indices.
- Develop prediction model.
- Define treatments.
- Build decision tree.
- Determine criteria.
- Develop prioritization approach.

DETERMINE PAVEMENT CONDITION INDICES

One of the key components of any pavement management system is the pavement rating system. These systems involve calculating a numerical score or index based on the pavement distress and surface condition to make a comparison between roadway segments based on their condition (Peng and Ouyang, 2010). The most commonly used pavement condition indices include distress, rutting, and roughness. The indices for distress depend on the pavement conditions, e.g. of various types, such as Condition Rating Survey (Illinois), Pavement Distress Index (Arizona), and Pavement Structural Condition (Washington).

Nebraska uses surface condition and rutting or faulting measurements to provide a single value termed the Nebraska Serviceability Index (NSI). Minnesota uses the Ride Quality Index (RQI), a measure of pavement smoothness, and the Remaining Service Life (RSL), an estimate of the pavement's remaining life. In addition, the Pavement Quality Index (PQI) is a composite index reflecting both pavement smoothness and cracking.

New Mexico uses the RQI as a rating method for surface roughness and the pavement serviceability index (PSI) to account for distresses such as cracking, rutting, and faulting. Both indices are based on the International Roughness Index (IRI). The PSI considered a weight factor for each distress type as shown in Table 2.1. Full details on the pavement condition indices adopted by each state are documented in a recent study conducted by project 0-6386 "Pavement Scores Synthesis" (Papagiannakis et al., 2009).

Table 2.1. Weight Factors for Flexible Pavement Distresses.

Pavement Distress	Weight Factor
Raveling & Weathering	3
Bleeding	2
Rutting & Shoving	14
Longitudinal Cracking	12
Transverse Cracking	12
Alligator Cracking	25
Edge Cracks	3
Patching	2

PREVENTIVE MAINTENANCE AND REHABILITATION TREATMENT METHODS

The major outcome of any pavement treatment program is to identify the best treatment for the sections in need of treatment and decide on the timing of this treatment. Pavement distresses govern the choice of the best treatment based on their types and severity. Cracking, roughness, weathering, raveling, rutting, and bleeding are the most common flexible pavement distresses. If pavement distresses are related to structural deficiencies, the pavement section is most likely a candidate for rehabilitation or reconstruction. Lesser distresses can be corrected with pavement preventive maintenance.

Two types of pavement maintenance are generally recognized: preventive and corrective (Hicks et al., 2000). Preventive maintenance is used to treat minor deterioration, retard failures, and reduce the need for rehabilitation and corrective maintenance. PM targets pavements not showing signs of failure to provide a more uniform performing system. Corrective maintenance is performed after a deficiency occurs in the pavement, i.e., loss of friction, moderate to severe rutting, or extensive cracking. Corrective maintenance is typically a routine treatment maintenance (e.g., pothole patching). It is used as a stopgap measure until a major PM or Rehabilitation treatment is taken place.

Pavement treatments, applied after initial construction, are employed to preserve the life of the original pavement or extend it. Figure 2.1 provides an early classification for the variety of different treatments that highway agencies typically used (Monismith, 1981). Treatments fall under the maintenance category and rehabilitation category.

AASHTO defines PM as: *…the planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without substantially increasing structural capacity).*

Pavement PM narrows that focus to the application of one or more treatments, generally to the surface of a structurally sound roadway. Applying a series of low-cost preventive treatments can extend the service life of pavements. This translates into a better investment, better ride quality, and increased customer satisfaction and support (Foundation for Pavement Preservation, 2001). Other benefits for a comprehensive PM program are (Johnson, 2000):

- Control over future network conditions and funding requirements.
- Decision makers can anticipate routine maintenance, work load, safety deficiencies, and ride quality needs.
- Capability to achieve maximum benefit from available funds.
- Higher customer satisfaction.
- Ability to make better, more informed decisions.
- A more appropriate use of maintenance techniques.
- Improved pavement conditions over time.
- Increased safety.
- Reduced overall maintenance costs.

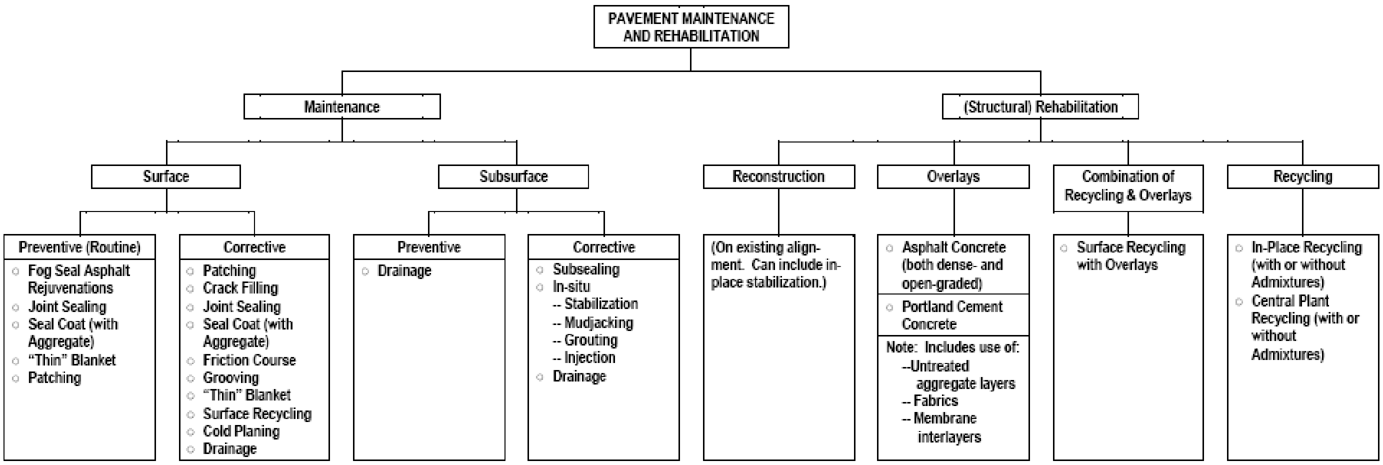


Figure 2.1. Pavement Maintenance and Rehabilitation Considerations (Monismith, 1981).

There are a number of PM treatments for flexible pavements. A comprehensive discussion of each treatment is reported in the Basic Asphalt Emulsion Manual (Asphalt institute, 1997). This manual describes the conditions in which each PM treatment can be effective, and the pavement distress(es) being repaired. A summary of PM activities are (Galehouse, 2008):

- Bituminous Crack Treatment.
- Overband Crack Fill.
- Chip Seals (Single and Multiple Course).
- Micro-Surfacing.
- Cape Seal.
- Fog Seal.
- Paver Placed Surface Seal (Nova Chip).
- Ultra-Thin Bituminous Overlay.
- Bituminous Overlay (<40mm).
- Profile Milling.
- Hot in-Place Bituminous Recycling (<40mm).
- Slurry Seal.

There are many studies that address the performance, expected life, and cost of each PM treatment. TxDOT has conducted several studies to evaluate the performance of single treatment and multiple treatments. Projects 0-4040 and 0-1772 are examples of studies that developed guidelines on using adequate treatment selection and timing. State DOTs have also conducted similar studies based on local and statewide experience to develop a handbook on the best practices of PM treatments in highways (e.g., Hall et al., 2003 and Jahren et al., 2003; Bausano et al., 2004; Cooper & Mohammed, 2004; Jackson et al., 2005; Cuelho et al., 2006).

Project 0-4040 “Analysis of the Supplemental Maintenance Effectiveness Research Program (SMERP) Experiment” was established to evaluate the cost-effectiveness of typical and promising maintenance treatments used in Texas to prolong the life of asphalt pavements. The study objectives were also to determine the optimum time and preventive maintenance strategies, and to demonstrate positive rates of return on preventive maintenance funds. The SMERP project evaluated the types of maintenance treatments typically used in Texas and allowed the contractor to use local materials. The project goal was to identify effective treatment for a particular distress. Treatments considered in the study were microsurfacing; fog seal; four chip seal types; asphalt rubber, latex modified, polymer modified, and conventional (Freeman et al., 2005).

Project 0-1722 “Maintenance Strategies for Pavements with Chemically Stabilized Layers” by (Freeman and Little, 2002) developed a protocol to identify proper maintenance strategy and timing for attempting various pavement distresses conditions given their type, severity extent, and level of importance on the pavement. The study focused on stabilized layers or semi rigid pavement systems and produced field guidance to assist TxDOT engineers in treatment selection.

Montana DOT has conducted a synthesis study on the current practice of preventive maintenance in highways (Cuelho et al., 2006). The study focused on quantifying the performance of various preventive maintenance treatments and their effect on pavement performance. The study indicates that ranges of reported life expectancies for treatment systems and the unit costs vary widely among state agencies. Table 2.2 lists expected lives and cost for PM treatments.

As mentioned earlier, rehabilitation is an appropriate treatment for pavement if the distresses present are related to structural deficiencies. Table 2.3 shows current rehabilitation treatments for flexible and rigid pavement and the corresponding service lives and cost.

TxDOT has sponsored implementation projects 5-1731 and 5-1712 to aid in the rehabilitation selection of rigid and flexible pavements, respectively. Two programs have been developed under these studies entitled: “Recommended Rehabilitation Options for Concrete Pavements” and “Selecting Rehabilitation Strategies for Flexible Pavement.” The first program describes the distress type commonly found on concrete pavements and how to use nondestructive testing equipment to investigate pavement problems, then makes recommendations on the selection and application of the concrete pavement maintenance and rehabilitation options. The second program provides a distress interpretation guide to describe common distresses found in Texas flexible pavements. Identification of possible causes, a methodology for conducting a failure investigation, and potential rehabilitation options are documented for each distress. Site investigations using non-destructive testing tools such as falling weight deflectometer (FWD) and ground penetrating radar (GPR) are suggested.

Table 2.2. Summary of Expected Lives and Costs for Preventive Maintenance Treatments (Cuelho et al. 2006).

Preventive Maintenance Treatment	Treatment Life (years)			Cost per Lane Mile (12-ft width)
	Min	Average	Max	
Crack Sealing	2	4.4	10	$5,300
Thin Overlay	2	8.4	12	$14,600
Chip Seal (Single)	1	5.9	12	$7,800
Chip Seal (Double)	4	7.3	15	$12,600
Microsurfacing	4	7.4	24	$12,600
Cold In-Place Recycling	5	10.6	20	$17,700
Ultrathin Friction Course	7	9.8	12	$31,100
Fog Seal	1	2.2	4	$2,200
Slurry Seal	1	4.8	10	$6,600
Cape Seal	6	9.8	15	$16,700
Scrub Seal	1	3.7	8	$5,800

OPTIMAL TIMING OF PM TREATMENT APPLICATIONS

Deterioration of pavement occurs as a result of the effects of the environment and traffic loading. The same treatment may perform differently when applied at different times in the life of the pavement. Applying treatment early in the pavement life would have different performance results than if applied near the end of the pavement life. Therefore, there is an optimal age or condition (or a range of age or condition) where the benefit/cost (B/C) ratio associated with a chosen treatment is maximized; this is defined as the optimal timing for the treatment (Peshkin et al., 2004).

Timely application of PM is an essential factor in retarding the deterioration process, extending the service life, and preventing loss of life, costly failures, and traffic delays. NCHRP study 14-14 developed a methodology to determine the optimal time to apply preventive maintenance treatments. This methodology established the timing of the treatment's application that provides the greatest ratio of improvement in condition (benefit) to cost (i.e., that time with the largest associated B/C ratio) (Peshkin et al., 2004).

Table 2.3. Normally Expected Pavement Rehabilitation Treatment Service Lives and Relative Cost (Transportation Association of Canada 1997).

Rehabilitation Alternative	Expected Service Life (Years)	Relative Cost
Flexible Pavements		
Reconstruction	Up to 12 - 15	High
Resurfacing (Thin Overlay)	Up to 8 - 10	Low
Resurfacing(Thick Overlay)	Up to 12 - 15	High
Milling and resurfacing	Up to 10 - 12	Medium
Hot in-place recycling	Up to 10 - 12	Medium
Cold in-place recycling	Up to 10 - 12	Medium
Full depth reclamation (Pulverization and resurfacing	Up to 12 - 15	High
Rigid Pavements		
Asphalt concrete surfacing	Up to 12 - 15	Medium
Diamond grinding	Up to 8 - 10	Low
Joint stabilization	Up to 5 - 10	Low
Crack, seat, and resurfacing	Up to 12 - 15	High
Rubblizing and resurfacing	Up to 12 - 15	High
Bonded concrete overlay	Up to 15 - 20	High
Unbonded concrete overlay	Up to 25 - 30	High
Surface treated Pavements		
Surface treatment reapplication	Up to 2 - 5	Low
Pulverization or scarification and resurfacing	Up to 8 - 10	Medium

TREATMENT SELECTION CRITERIA AND DECISION TOOLS

There are a number of indicators that highway agencies use as a basis for identifying an appropriate maintenance or rehabilitation treatment to address a given state of pavement deterioration (Hicks et al., 2000). The two most common simple tools—*decision trees* and *decision matrices*—are explained in detail in succeeding pages. Both depend on certain rules and criteria that the agency had established based on past experience, and represent a practical aid in the treatment timing selection process. The selection is generally based on the following factors (Johnson, 2000):

- Pavement surface type and/or construction history.
- Functional classification and/or traffic level.
- Condition index, including distress and/or ride quality.
- Type and extent of deterioration present.
- Geometrics.
- Cost of treatment.

- Expected life.
- Availability of qualified staff and contractors.
- Availability of quality materials.
- Time of year of placement.
- Pavement noise.
- Surface friction.
- Environmental conditions in which the treatment is to be used.

These tools reflect the decision processes that the highway agencies used, provide flexibility to modify the decision criteria, and generate consistent recommendations.

Decision trees incorporate a set of criteria for identifying a particular treatment using a set of conditions such as pavement type, distress type and level, traffic volume, and functional classification. Figure 2.2 provides an example of a maintenance and rehabilitation decision tree developed by Zimmerman (1997). The trees considered the pavement condition index to account for the combined distresses and the surface quality. The effectiveness of this tool tends to diminish if pavement is at high deterioration state and in applicable condition for rehabilitation (Hicks et al., 2000).

Decision Matrices are structurally similar to the decision trees as they rely on criteria to develop an appropriate maintenance or rehabilitation treatment methodology for a given pavement. However, the major difference is that decision trees provide a graphical approach to the selection process while decision matrices provide tabular forms that enable them to store more information in a smaller space (Hicks et al., 2000).

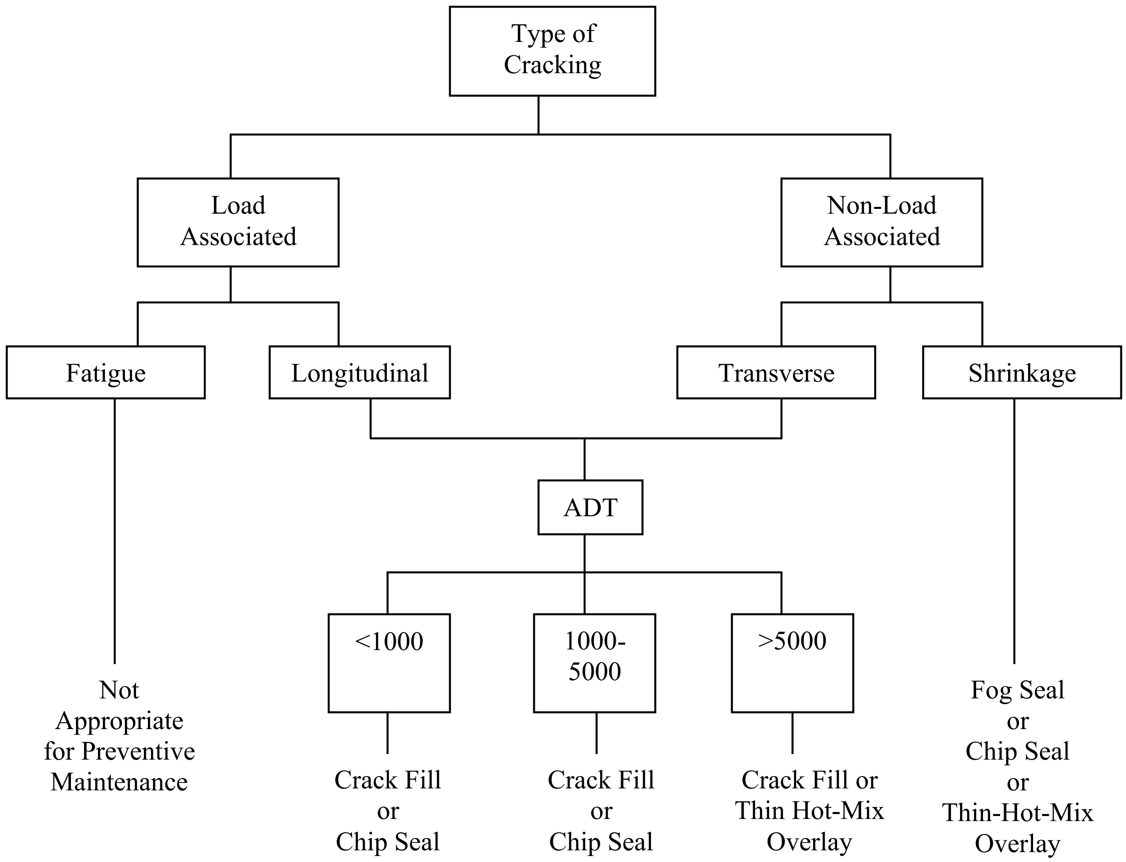


Figure 2.2. Example Decision Trees for PM Considering Cracking (Zimmerman, 1997).

PRIORITIZATION CRITERIA

Adequate funding for the current and future needs has always been a problem for the management of pavements. The introduction of prioritization principal has enabled engineers and managers to identify those pavement sections that need attention. By fixing priorities, the available budget can be directed to the sections that need to be rehabilitated first.

Prioritization of needs is based on the policy and resources of agency. The factors that need to be considered while assigning priorities are: condition index (in this case, PCI), branch use (runway, taxiway, apron, or service road), and pavement rank (primary, secondary, or tertiary). Prioritization also depends on traffic conditions, subgrade conditions, drainage condition, etc.

PRIORITIZATION APPROACHES

Funding levels, location, and specific conditions of a highway agency are controlling the framework of most prioritization methods ranging from a simple ranking of projects based on judgment to comprehensive optimization by mathematical programming models. Figure 2.3

demonstrates a framework of most of current prioritization methods that should be able to respond to the following (Tighe et al., 2004):

- Identify the sections of the network that need to be rehabilitated or maintained.
- Identify the type of treatment that should be applied to a certain section.
- Determine the time when each section should be rehabilitated.
- Determine how much the selected treatment for the selected section will cost.

Four categories of methods can be used to prioritize alternative strategies and candidate sections: ranking, heuristic prioritization, optimization, and prioritization based on weight factors.

Ranking

Ranking projects with respect to particular criteria (e.g., effectiveness/cost, PCI, distress score, etc.) is a straightforward method. This method of prioritization is based on the worst condition of sections. A section with the least PCI value in the network is placed on the top of the priority list with other sections of unacceptable conditions following on reverse PCI order. The projects at the top of the list are selected until the available budget is spent.

One of the problems of this approach is potentially selecting sections that are functionally less important than others. As a result, this method is not effective for larger networks. However, this method may be sufficient for small networks where all other conditions are the same, or where there are minimal differences in functional or operational classification between the sites being considered.

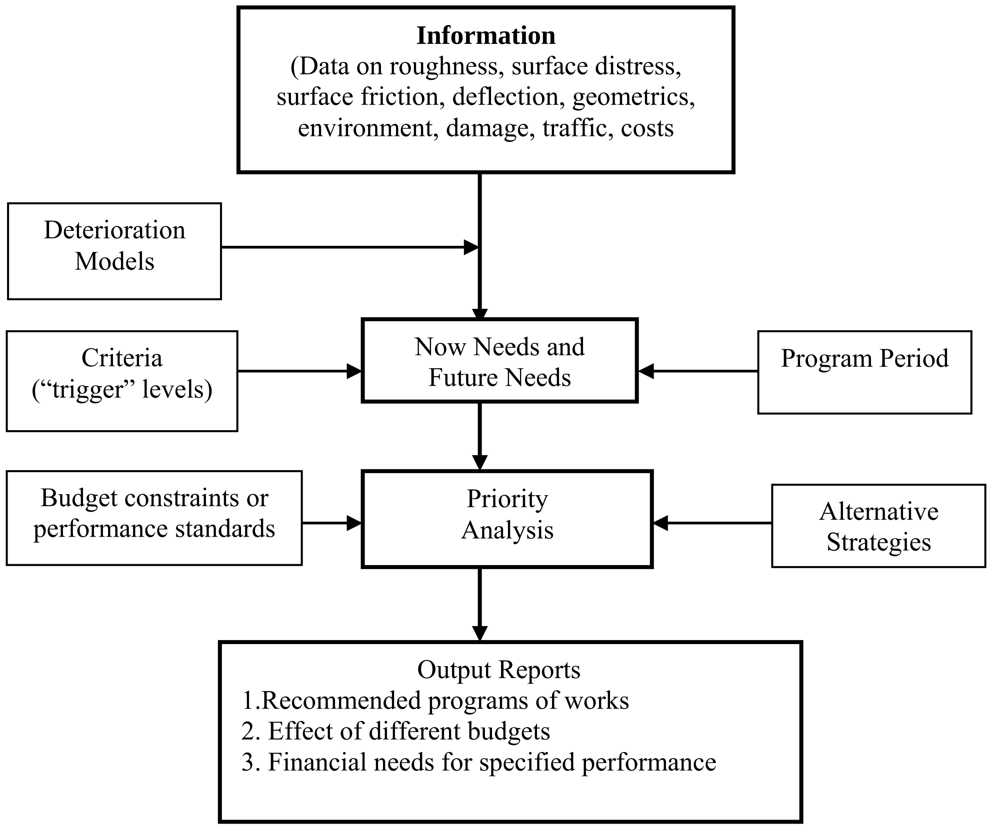


Figure 2.3. Framework for the Priority Programming Process (Transportation Association of Canada 1997).

Heuristic Prioritization

This method includes the marginal cost-effectiveness (MCE) analysis and the incremental benefit-cost (IBC) analysis. A number of highway agencies have used this method for prioritization. It is considered as the basis for a comprehensive and integrated pavement managements system (Haas et al., 1994) and is usually capable of yielding near-optimum solutions. This method includes the following steps (Tighe et al., 2004):

1. Consider each combination of section, treatment alternative, year, associated life cycle cost analysis (LCCA) and timing of the rehabilitation.
2. Determine the Effectiveness, E, of each combination.
3. Determine the cost, C, in net present value terms, of each treatment alternative in each combination. LCCA is taken into account to make the investment decisions objective. The net present value of a rehabilitation alternative can be calculated by the following equation (Tighe et al., 2004).

$$NPV = (IRC)_{x_1} + \sum_{t=0}^{t=n} PWF_{i,t}\left[FRC_{x_1,t} + MC_{x_1,t}\right] - (SV)_{x_1,n} \times PWF_{i,n}$$

Where *NPV= Net Present Value*

$(IRC)_{x_1}$ = Initial Rehabilitation Cost of Alternative $x_{1.}$

$(FRC)_{x_1,t}$ = Future Rehabilitation Costs of Alternative x_1 in year *t.*

$(MC)_{x_1,t}$ = Maintenance Costs of Alternative x_1 in year *t.*

PWF = Present Worth Factor = $1/(1+i)^n$

i = Discount rate.

n = Year when the cost is incurred.

$(SV)_{x_1,n}$ = Salvage Value of Alternative x1 at end of the analysis period.

4. Determine the cost-effectiveness of each combination by dividing the effectiveness (E) of a section by the cost (C) in terms of a net present value.
5. Select the combination of treatment alternative and year for each section which has the best cost-effectiveness, until the budget is exhausted.

The MCE approach calculates the MCE for every project at the beginning of a series of iterations. In each iteration, it uses the strategy with the highest MCE to replace the current selected strategy for a pavement section into consideration, and recalculates the MCE of other unselected strategies for same pavement as:

$$MCE_i = \frac{E_i - E_s}{C_i - C_s}$$

where E_i and C_i are the effectiveness and cost of any strategy *i*, and E_s and C_s are those of the current selected strategy.

The IBC approach first ranks the strategies by cost within every pavement section, and calculates their IBC as follows:

$$IBC_i = \frac{B_i - B_{i-1}}{C_i - C_{i-1}}$$

where B_i and C_i are the effectiveness and cost of strategy *i.* The project is conducted based on the calculated IBC Re-ranking. The highest IBC replaces the current selected strategy for the pavement section into consideration in a similar fashion as the MCE approach. However, unlike MCE, IBC is not recalculated in each iteration.

If the pavement PM/rehab program is conducted for multiple years with a single treatment strategy (or project), there are two alternative methods to implement multi-year prioritization:

- Prioritize for each year separately.
- Prioritize for all years simultaneously.

With the first method, prioritization is repeated for each consecutive year. With the second option, projects in different years are put together for prioritization.

Optimization

Optimization is quite complex and the most computer-intensive. However, it has the advantage of producing the most optimal decision. Optimization is conducted in the form of algorithms that tend to find optimal solutions, such as maximize pavement conditions subject to budget constraints or to minimize cost subject to minimum requirements on road conditions. Most optimization algorithms are implemented in the network level to maximize cost-effectiveness. This method is adopted by Arizona, Kansas, and Alaska DOTs (Alviti et al., 1997).

Prioritization Based on Weight Factors (Tighe et al., 2004)

This method assigns a numeric score (0 to 100 percent) to different parameters affecting the list of priorities. Major parameters can be assigned higher weight factors (e.g., Pavement Condition Index [PCI], traffic, functional classification). The priority score can be determined by multiplying each assigned weight factor to the governing parameters. Generally, the PCI has the highest weight factor in the prioritization program. Thus, if a section has a lower value of PCI, it will indicate a higher weight in calculating a priority score.

STATE EXPERIENCE WITH PMS

Based on a national survey (Cuelho et al. 2006), the average annual state DOT's budget for PM was about $40 million. About 70 percent of the jurisdictions have a written manual for their decision trees that include PM activities. However, there is no standardized 'one size fits all' approach for selecting an appropriate PM measure for a given roadway. Overall, this survey indicated that visual or measured data is collected to monitor the performance of treatments. These include measures such as: qualitative evaluation of thermal cracking, fatigue cracking, raveling, and bleeding or quantitative measures of rutting, friction, and roughness (IRI) (Cuelho et al. 2006). The study implied that most respondents base their selection of a particular system on their previous experience, followed by ADT or number of trucks, location (urban or rural), and availability of contractors, equipment, and materials.

Information from the literature review implied that there are few well-documented and reliable quantitative approaches for selecting the optimum treatment system and for determining when the optimum time occurs for implementing a system. Consequently, this lack of quantifiable metric necessitates a heavy reliance on the experience of personnel and rules of thumb.

Texas

TxDOT introduced the Texas PM Research Program at the annual District SHRP Coordinators meeting in October 1990. The name of this program was later changed to the Supplemental Maintenance Effectiveness Research Program (SMERP). One million dollars was allocated to this experiment to build test sections for evaluating PM treatments of interest to Texas, but not considered in the SHRP national experiment. SMERP was designed to study more closely the types of maintenance treatments typically used in Texas, and it allowed the contractor to use local materials if desired. The treatments constructed in the SMERP study were asphalt rubber chip seal, polymer modified emulsion chip seal (also called CRS-2P), latex modified AC (asphalt cement) chip seal, unmodified AC chip seal, and a microsurfacing treatment (Freeman et al. 2003).

In the 1990s, TxDOT was spending approximately $450 million per year on its overall maintenance program and approximately $150 million per year on their PM program (Freeman et al. 2003). In 2008, total maintenance expenditures (contract and non-contract) was over $3 billion for maintaining 192,500 lane miles of roadway including $250 million dedicated to the PM Program.

TxDOT has a Needs Assessment Tool as part of its Pavement Management and Information System (PMIS). This tool assists districts in identifying roadway sections that are candidates for rehabilitation and PM activities. Moreover, the PMIS uses a comprehensive decision tree to differentiate between the conditions that warrant PM and rehabilitation treatments. However, PMIS does not optimize these candidate projects, given the available budget scenario in which TxDOT operates.

TxDOT districts choose specific maintenance treatments for various reasons. Many districts choose a specific maintenance treatment because of either tradition positive experience with that treatment, or because of material/contractor availability. Districts use various methods of selecting projects for rehabilitation or PM project funding each year. For instance, Fort Worth district developed a formula to assist in prioritizing projects. The formula is:

$$SC = \frac{P_l}{C} * A * R_t$$

Where:

SC = Pavement section condition.
P_l: = Project length (mile).
C: = Estimate cost.
A: = Age of last surface, yrs.
R_t: = Percent of roadway treatment according to PMIS.

Currently, TxDOT's PMIS uses a comprehensive decision tree to assign PM and rehabilitation treatments. The current PMIS uses a hierarchical approach running through the decision tree. The PMIS proposes the following types of treatments for each Section:

- Needs Nothing.
- Preventive Maintenance (PM).
- Light Rehabilitation (LRhb).
- Medium Rehabilitation (MRhb).
- Heavy Rehabilitation or Reconstruction (HRhb).

As with the Needs Estimate, the PMIS optimization program is able to prioritize current and future pavement treatments using the following 10-step process:

Step 1. User selects run/report parameters.
Step 2. Program selects records that can be analyzed.
Step 3. Program determines the age of all records from the first Fiscal Year selected by the user.
Step 4. Program selects treatments (using the decision tree statements) and costs.
Step 5. Program computes "after treatment" distress ratings and ride quality.
Step 6. Program computes "Benefit" and "Effective Life" of the Needs Estimate treatment for each section.
Step 7. Program computes "Cost Effectiveness Ratio" for each section.
Step 8. Program determines sections to be funded.
Step 9. Program lists results for each report that the user has requested in Step 1.
Step 10. Program returns to Step 3 if a multi-year Optimization was requested.

The purpose of computing the Benefit and Effective Life for each section is to develop a measure that can be used to rank the sections in order of increasing "Effectiveness." The Optimization program in PMIS deals with the limited funding to determine which sections will provide the highest overall cost-effectiveness. The PMIS optimization program defines a "Cost-Effectiveness Ratio" for each section, as shown in the following equation:

$$CERatio = 10000 \times \left[\frac{LM \times B}{EffLife \times UACost} \right] \times \log_{10} VMT$$

where:

CERatio = Cost-Effectiveness Ratio.
LM = Lane Miles.
B = Benefit (distress and ride quality).
EffLife = Effective Life of the Needs Estimate treatment, in years.
UACost = Uniform Annual Cost of the Needs Estimate treatment, in dollars.

VMT = Vehicle Miles Traveled.

As shown above, the Cost-Effectiveness Ratio includes a weight factor for VMT. In cases where identically effective sections are competing for funding, this factor gives preference to the section with the higher traffic. The Cost-Effectiveness Ratio annualizes cost over the Effective Life of the Needs Estimate treatment using:

$$UACost = TCost \times \left[\frac{DRate(1 + DRate)^{EffLife}}{(1 + DRate)^{EffLife} - 1} \right]$$

where:

UACost = Uniform Annual Cost of the Needs Estimate treatment, in dollars.
TCost = Treatment Cost (current or future) of the Needs Estimate treatment, in dollars.
DRate = Discount Rate, in percent per year.
EffLife = Effective Life of the Needs Estimate treatment, in years.

Illinois (Peng and Ouyang, 2010)

The Illinois Department of Transportation (IDOT) uses the Illinois Roadway Information System (IRIS), to store roadway network information. IDOT uses another mainframe database, the Program Planning System (PPS), to store candidate multi-year highway improvement projects information.

The candidate projects are submitted by nine districts every year. The central office reviews these candidate projects and finally selects around 7,000 to 8,000 projects to be included in the Proposed Multi-Year Highway Improvement Program (MYP). The MYP is updated every year, and the program for the first year in the MYP becomes the highway program for the current fiscal year.

IDOT uses CRS as the measure of pavement conditions. The CRS values, traffic, and functional class are used to prioritize roadway deficiencies. The categories and definitions for pavement needs are:

- Needs Improvement—improvement is recommended now. If the improvement is delayed, the ultimate cost could be much higher.
- Acceptable—no need for an immediate improvement.

Washington

The Washington Department of Transportation (WSDOT) uses Washington State PMS as the primary tool, and the Highway Development and Management System, developed by the World Bank, as a supplement. Several measures of pavement conditions are obtained from Pavement

Structural Condition (PSC), Pavement Rutting Condition (PRC) and Pavement Profile Condition (PPC). Treatments are classified into four levels: Routine Maintenance (RM), Preventive Maintenance (PM), Overlays and Rehabilitation (OVR), and Reconstruction. The main tool used for selecting candidate projects is the LCCA (Peng and Ouyang, 2010).

Michigan

The Michigan Department of Transportation (MDOT) has classified its pavement systems into six categories (from I to VI) based on RSL. Category I pavements are those with low RSL (0–2 yrs) and category VI are those with high RSL (25–30 yrs). The MDOT uses RSL as the measure of current pavement condition and the Road Quality Forecasting System (RQFS) to predict the future condition of pavements. The treatment methods are identified according to the pavement category and classified into three types: Reconstruction and Rehabilitation (R&R), Capital Preventive Maintenance (CPM) and Reactive Maintenance (RM). The R&R is applied to category I pavements; the CPM is applied to category II, III, IV, or V pavements and increases these categories by one or two; and the RM keeps the poor road conditions safe until R&R is possible (Peng and Ouyang, 2010).

Nebraska (Craig, 2009)

Projects are categorized into groups consisting of highway segments and functional characteristic consideration for construction, reconstruction, resurfacing, or rehabilitation projects. The "Needs Assessment" provides an investment analysis, including a network-level analysis that estimates total costs for the present and projected conditions across the state highway system.

A project-level analysis is performed to produce a list of candidates that have the best benefit/cost ratio for improvement with a given limited budget. This analysis supplements the current decision-making processes that exist at the project level. If certain projects are not included in the six-year cycle, these are carried forward to the next year of analysis. These projects then compete with those that have deteriorated to the extent to justifying their inclusion in the program. Those projects carried forward will be ranked again on the basis of their existing condition.

INTERNATIONAL EXPERIENCE

The FHWA, AASHTO, and NCHRP jointly sponsored an international scanning study in an effort to document and evaluate innovative techniques, materials, procedures, and equipment used in other countries for pavement preservation for potential application in the United States (19). The scanning team visited France, South Africa, and Australia, which had been identified as nations with innovative programs and state-of-the-art treatments for pavement preservation. The following actions taken in the host countries have had a significant impact on pavement preservation activities and program success:

- Focusing on maintenance activities on the surface to preserve the large investment in underlying layers. This promotes the use of relatively low-cost seals and thin overlays as the primary maintenance techniques, instead of more costly types of rehabilitation.
- Using only quality materials for both bitumen and aggregate, ensured through the use of rigorous specifications. Materials sources are specified and there is no inhibition to using sources a great distance away from the project site.
- Getting warranties on contracts, which cover friction, rutting, and smoothness. This has resulted in the innovation of materials and mixtures by contractors and material suppliers.
- In France, governments and industry share the risk in experiments to develop new and innovative products. Successful products are then accepted nationally for inclusion in the preventive maintenance program.

The team identified the following innovative and successful practices in pavement preservation in the host countries (FHWA 2002):

- In France, the primary preservation treatment on high-volume roadways is mill and inlay. Also, cold asphalt concrete has been used extensively with good success on low-volume roads as a riding surface (75 to 100 millimeters). The cold asphalt concrete mix process focuses on achieving good coating of the aggregates and is preferred over hot-mix asphalt for low-volume roads.
- South Africa makes extensive use of chip seals. Their pavement management system has verified that surface seals are effective treatments for preserving pavement life. In some instances, hot-mix asphalt overlays are covered immediately with chip seals to provide sufficient surface friction and, at the same time, ensure a system more impervious to water.

SUMMARY

The following is a summary of Chapter 2:

- Decision tree and decision matrix are the most commonly used methods by state agencies for identifying appropriate PM or rehabilitation treatments to address pavement deterioration.
- There are many factors considered in pavement project selection and prioritization, such as condition index, pavement use, traffic conditions, subgrade conditions, and drainage condition.
- Project prioritization is controlled by funding levels, location, and specific conditions of a highway agency. Four categories of methods are used to prioritize alternative strategies and candidate sections: ranking, heuristic prioritization, optimization, and prioritization based on weight factors.

- TxDOT has a Needs Assessment Tool as part of its Pavement Management and Information System (PMIS). This tool assists districts in identifying roadway sections that are candidates for rehabilitation and PM activities. Moreover, the PMIS uses a comprehensive decision tree to differentiate between the conditions that warrant PM and rehabilitation treatments. However, PMIS does not optimize these candidate projects, given the available budget scenario in which TxDOT operates.

CHAPTER 3: DISTRICT QUESTIONNAIRE

This chapter summarizes the findings of the questionnaire responses. A formal questionnaire was developed to seek input from the district offices on the process of PM/Rehab project selection. The organization of this chapter starts with the description of questionnaire structure and ends with a summary of responses.

QUESTIONNAIRE STRUCTURE AND ORGANIZATION

The questionnaire is the main source of information gathering in this project. Therefore, the development of a well-designed, short-as-possible list of clear, concise, and well-targeted questions was one of the most important single aspects of this project. The questionnaire targets primary decision maker(s) who select projects for rehabilitation and PM in each district. The person—or groups of persons—within the district organization providing this information varies by district.

The questionnaire is divided into five sections. The first section reflects the individual's experience and familiarity with PM applications, the second reflects the treatment activities most frequently used in the district, and the third section reflects questions on the personnel involved in the selection process and timing when the process starts. The fourth section covers the factors and tools the district used to assist in the selection and prioritization. The final section covers information on the distresses types warranting particular treatments, performance evaluation of applied treatments, and overall suggestions that those interviewed wished to make. Appendix A shows a copy of the questionnaire.

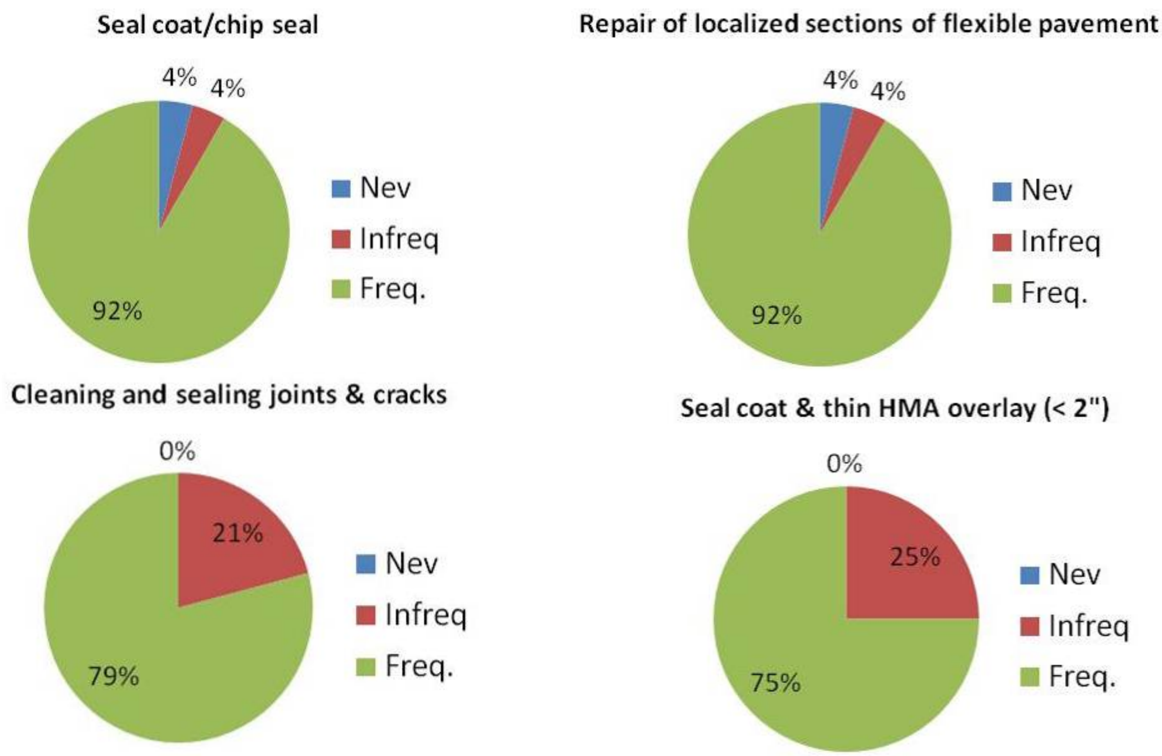
The research team obtained comprehensive responses to the questionnaire by visiting the districts and meeting TxDOT personnel and district engineers in the 25 TxDOT districts. This ensured collecting adequately comprehensive information about rehabilitation and PM project selection methods. In addition, district visits allowed the research team to photograph examples of pavement conditions that are factors in their selections.

Interview discussions were voice recorded to ensure accurate capturing of the information. After the interview discussion, pavement site visits occurred. Selected sites included pavements with various types of rehabilitation and preventive maintenance needs. The objective of the pavement sites was to obtain examples of pavement treatments sites and factors considered for the selection of those sites. After each district visit, the voice recording was transcribed for later review and comparison with information collected from other districts. The following section summarizes the results of the questionnaire responses. Section I describes responses of the engineer position and experience (Appendix A). Section II summarizes the district's treatment methods. Section III targets questions on the personnel and timing of initiating the project selection process in the district. Section IV documents the tools that the district uses in selecting treatments. The final section includes closing remarks on the distresses considered as governing factors to control the treatment selections.

SECTION II: DISTRICT USE OF PM AND REHAB PAVEMENT TREATMENTS

How would you describe your district's use level of each of the listed treatment methods?

This section targets information on the types and frequencies of treatments that the districts use for each project category. Each choice was given three alternative responses: *Frequently* (more than five projects per fiscal year), *Infrequently* (less than five projects or planning to use in future), and *Never* (never used or suspended use due to poor experience). Figure 3.1 shows an example of the overall most common treatments.



a) PM treatments b) Rehab treatments

Figure 3.1. Example of Most Common Treatments Identified by Percentage Used in Districts for a) PM and b) Rehab.

To analyze the most commonly used treatments as a function of climatic and environmental conditions, the TxDOT districts were grouped into five zones as shown in Table 3.1 and Figure 3.2. The source of this climatic data is the weather maps of the State of Texas. The frequent use of PM/Rehab treatments in each district zone is listed in Tables 3.2 and 3.3. Distribution of treatments in urban and rural districts is also studied.

Table 3.1. Climatic Information on the District Zones.

	Geographic location	Average annual Temperature (F)	Average annual precipitation
Zone 1	South	>75	18–34 in
Zone 2	West	60–65	<18 in
Zone 3	North	50–60	18–26 in
Zone 4	North-East	60–65	26–50 in
Zone 5	East	60–70	>50 in

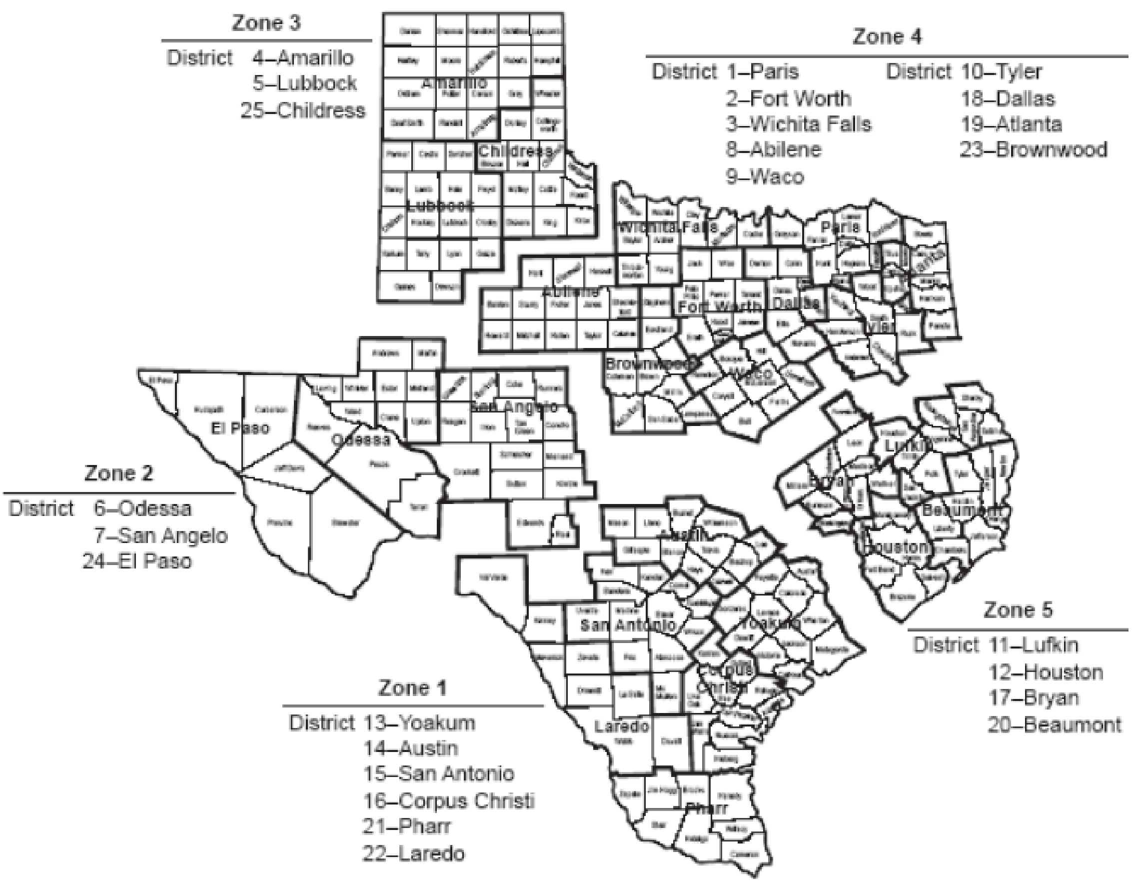


Figure 3.2. TxDOT Districts Distributed in Various Climatic Zones.

Table 3.2 shows that seal and fog seal, joints sealing, microsurfacing and planning and texturing in flexible pavement are among the most common PM treatments in all zones. On the other hand, slurry seal and rigid pavements texturing are among the least common PM treatments in 21 percent to 42 percent of the districts, respectively. Although multiple course microsurfacing is the third least common treatment (54 percent), it is mostly used in northern districts (zones 3 and 4) with moderate to cold temperatures. Overall, there is no significant difference noticed between treatments among zones 1, 2, and 5 and among zones 3 and 4. As expected, due to the higher precipitation in the eastern districts, permeable friction course overlays are commonly used (e.g., zone 3).

The urban districts are Austin, Houston, Dallas, Fort Worth, and San Antonio while all others are considered rural districts. The PM treatment is identical in urban and rural districts. However, rural districts tend to use seal coat, multiple microsurfacing, and texturing more often than urban districts. On the other hand, due to the high percentage of rigid pavements in urban districts, the PM/rehab treatments are more frequently used compared to rural districts. Moreover, the urban districts have more rehab applications compared to the rural districts, such as fabric under-seal with thin overlays, hot in-place recycling, and full depth repair of concrete pavement.

Table 3.2. PM Treatments Distributed in Different Climatic Zones, and Urban and Rural Districts.

PM Pavement Treatments	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Urban	Rural
Fog seal	√√	√	√√	√√	√√	√√	√√
Cleaning and sealing joints & cracks	√√	√√	√√	√√	√√	√√	√√
Seal coat/chip seal	√√	√√	√√	√√	√√	√√	√√
Multiple course seal coat	√√	√			√√	√	√
Asphalt rubber seal coat	√	√	√√	√	√	√	√√
Permeable friction course overlay	√	√	√		√√	√	√
Paver-laid surface treatment (Novachip)	√		√√	√		√	√
Wheel path microsurfacing			√	√√	√	√	√
Full-width microsurfacing	√√	√√	√√	√	√√	√√	√√
Multiple course microsurfacing			√√	√			√
Slurry seal							
Planning and texturing flexible pav.	√√	√√	√	√√	√√	√	√√
Planning and texturing (rigid) pav.						√	

Blank: 50% or less of the zone district are implementing the treatment

√: >50% or more in the zone districts are implementing the treatment

√√: >80% or more in the zone districts are implementing the treatment

Table 3.3. Rehab Treatments Distributed in Different Climatic Zones, and Urban and Rural Districts.

Rehab Pavement Treatments	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Urban	Rural
Fabric underseal & thin HMA overlay		√	√	√		√	
Seal coat & thin HMA overlay (< 2")	√√	√√	√√	√√	√√	√√	√√
Thin HMA overlay (< 2")	√√	√√	√	√√	√√	√√	√√
Ultra-thin bituminous overlay (< ¾")			√		√		
Hot in-place recycling & thin overlay	√						
Hot in-place recycling	√					√	
Cold in-place recycling & seal coat					√		
Cold milling & overlay (< 1 ½")	√√		√√	√√	√	√	√
Repair of localized sections	√√	√	√√	√√	√√	√√	√√
Full-depth repair of concrete pav.			√√	√	√√	√√	√
Bituminous shoulder (remove & replace)		√√	√√	√√		√	√

Blank: 50% or less of the zone districts are implementing the treatment

√: >50% or more in the zone districts are implementing the treatment

√√: >80% or more in the zone districts are implementing the treatment

SECTION III: GENERAL QUESTIONS ABOUT THE DISTRICT'S PM/REHAB PROJECT SELECTION PROCESSES

Are project selection decisions made by the same group of decision-makers?

Do you split the pavement budget into PM and Rehab from the outset?

Does the PM budget include any non-pavement items (e.g., grass cutting)?

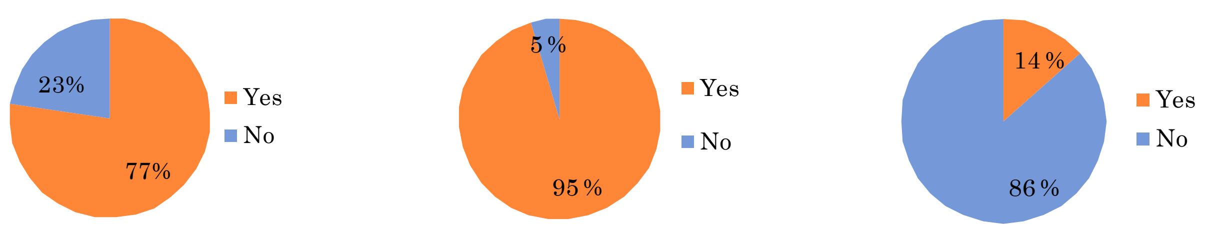


Figure 3.3. Responses on the Budget Split between Categories.

What levels of the district organization and offices are involved, from putting together initial project nominations to final project selections, for both PM and rehabilitation projects?
(DoC: Director of Construction, DoT: Director of TP&D, DoM: Director of Maintenance, DoO; Director of Operation, MS: Maintenance Supervisor, AE: Area Engineer, PE: Pavement Engineer, DE: District Engineer)

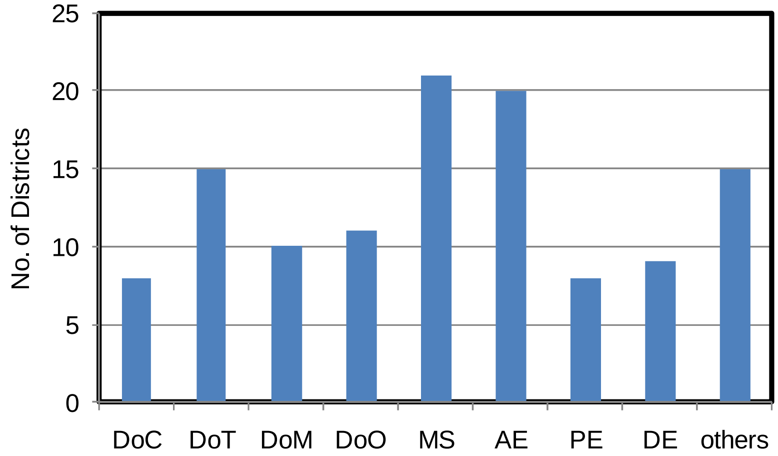


Figure 3.4. Personnel Engaged in the Flexible Pavement Project Selection Process.

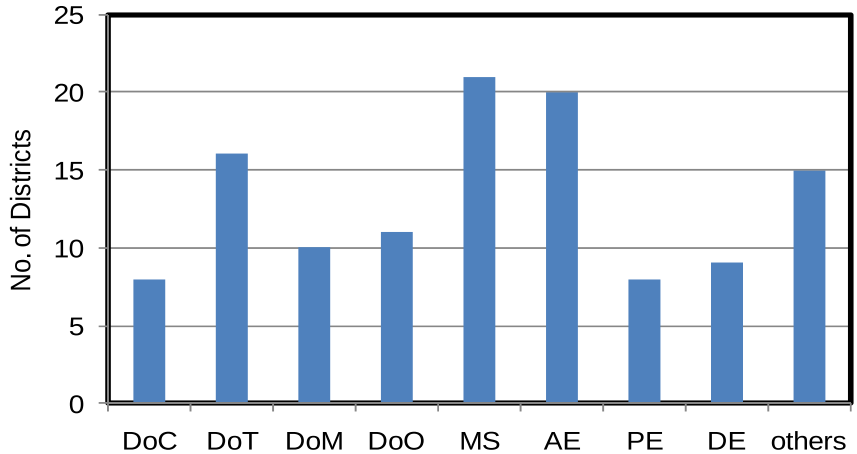


Figure 3.5. Personnel Engaged in the Rigid Pavement Project Selection Process.

At what organization level does consideration of whether PM or rehab funding is most appropriate begin?

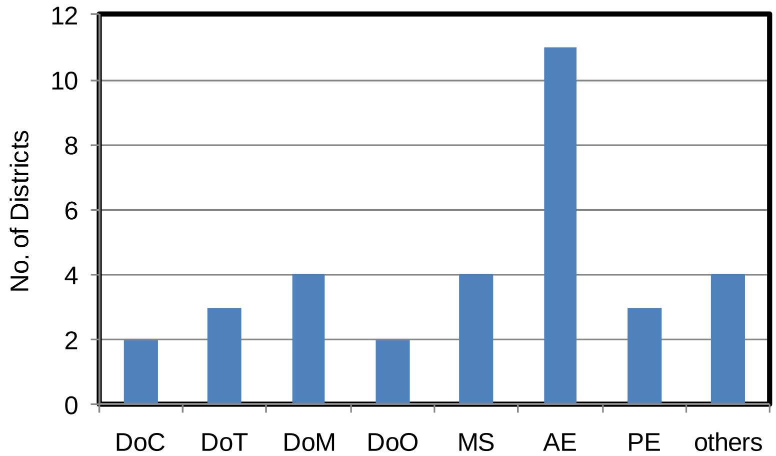


Figure 3.6. Personnel Engaged in Identifying the Timing for Project Selection.

At what level is the final decision made?

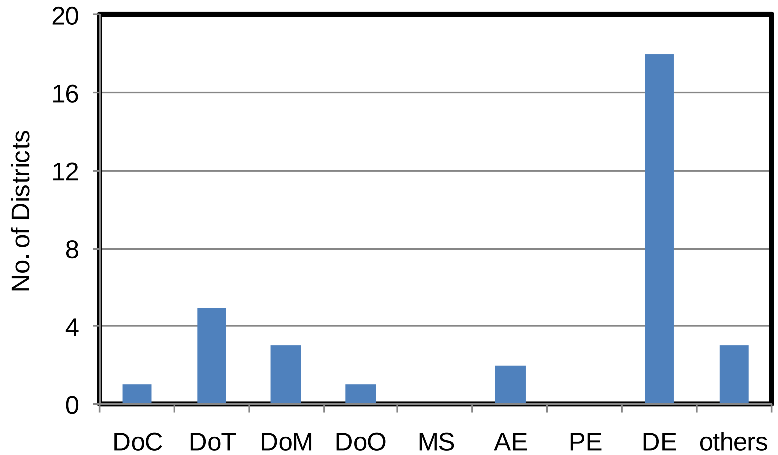


Figure 3.7. Personnel Charged with Making the Final Decision in Project Selection and Funding Allocations.

It is shown that in 77 percent of the districts, the same group of engineers establishes the selection process. Results also indicated that the maintenance supervisors and area engineers primarily start the selection process and the district's engineer finalizes this. The area engineers in each county office establish the initial project list and submit it to the district office. The directors prioritize the initial list and identify the selected sites.

SECTION IV: TOOLS CURRENTLY USED BY YOUR DISTRICT IN SELECTING PAVEMENTS FOR TREATMENT AND IN DECIDING BETWEEN PM AND REHAB PAVEMENT TREATMENTS

Which of the following tools does your district use for deciding a PM or Rehab action in your district?

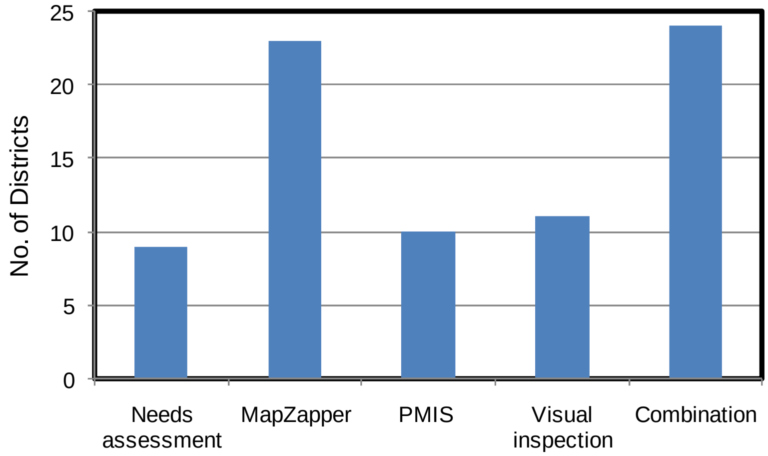


Figure 3.8. Tools Used by Districts in Making Decisions.

Is this approach somehow documented?

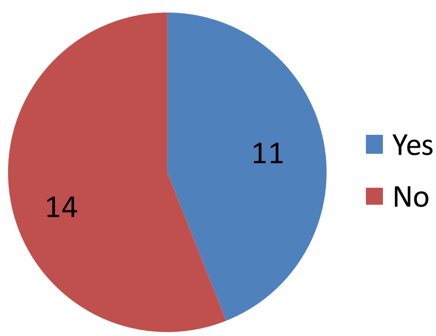


Figure 3.9. Number of Districts that Documents the Approach of Making Their Project Selection.

If your district uses own approach, does it consider the following factors/threshold?
(ADT: average daily traffic, SI: Structure index, FN: Functional class number, IRI: International roughness index)

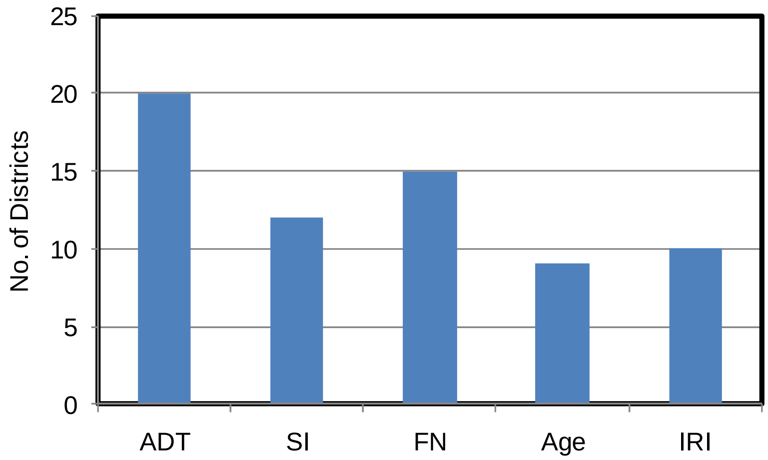


Figure 3.10. The Factors Considered in Project Prioritization.

Figures 3.8–3.10 implied that most districts use the MapZapper as their main tool to extract existing field site condition (e.g., condition score) combined with other tools such PMIS and visual inspection to identify the candidate projects. Nearly more than half the districts do not document their protocol of identifying and finalizing the candidate projects. Moreover, the major factors considered into the projects selection are the average daily traffic (ADT) and roadway functional class.

Does your district's approach include threshold values for any individual distress types which necessitate treatment? If so, indicate the probable treatment corresponding to the distress level below.

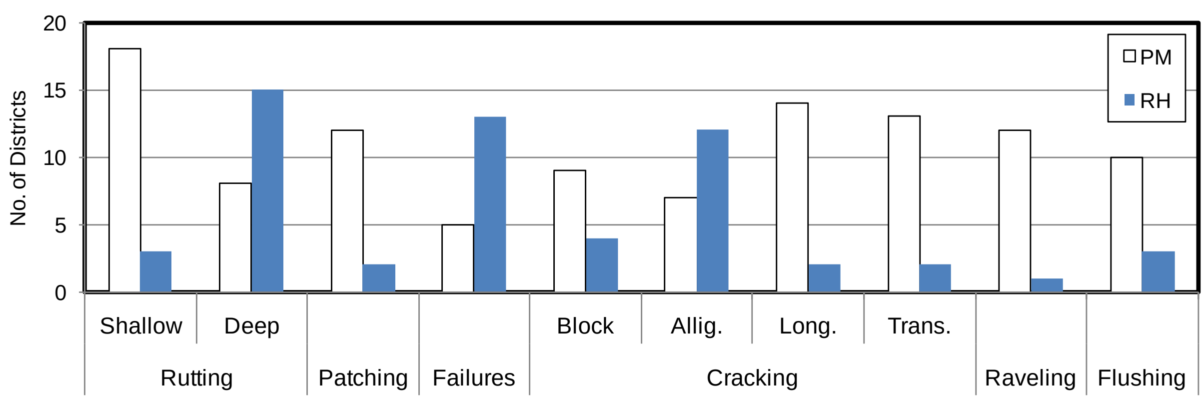


Figure 3.11. The Flexible Pavement Distresses Governing the Selection of Treatment Method.

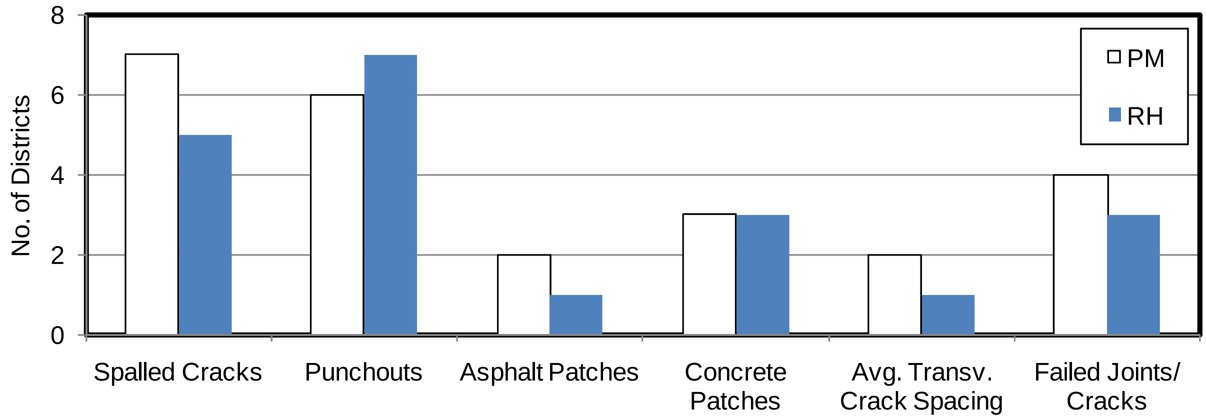


Figure 3.12. The Rigid Pavement Distresses Governing the Selection of Treatment Method.

What other considerations impact selections of projects for specific PM or rehabilitation techniques?

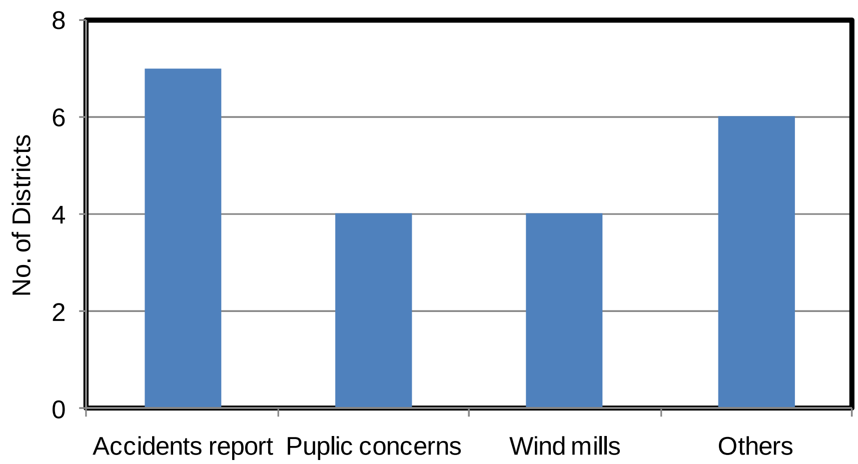


Figure 3.13. Additional Factors Considered in Project Prioritization.

When deciding which project or two gets the last funding available in each of the two funding categories, PM and rehab, what do you use as tie-breakers?

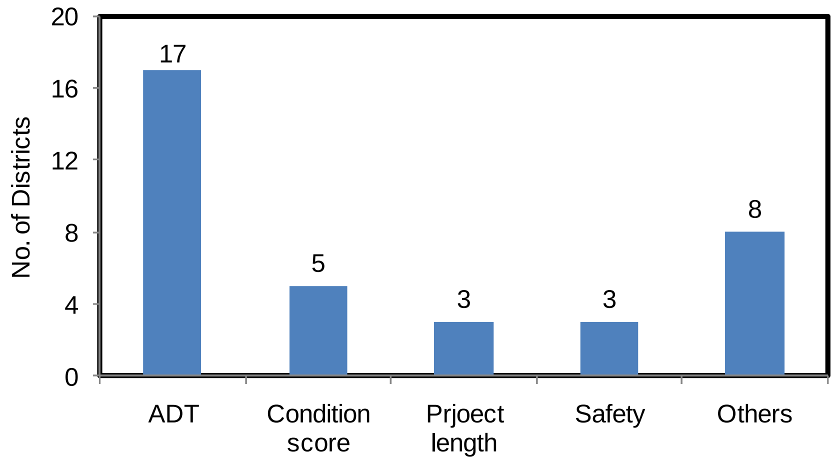


Figure 3.14. Factors Considered as Tie-Breakers to Identify Projects for Use of Remaining Funding.

Do PM or rehab needs for rigid pavements take some degree of preference over flexible pavement needs, or vice versa, when selecting projects for limited funding? If so, how?

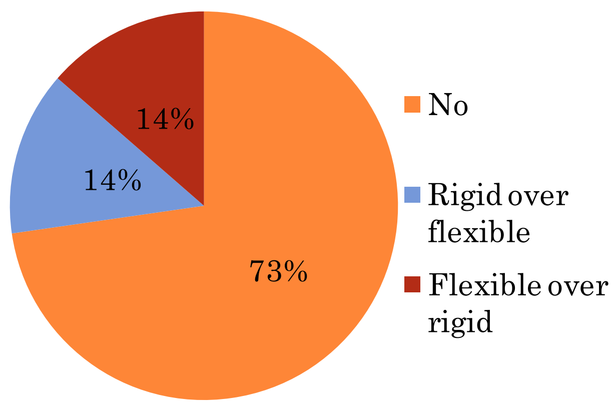


Figure 3.15. Effect of Pavement Type in Making the Project Selection Measured by Percentage of Total Number of Districts.

Most of the responses have not identified thresholds for each distress; however, responses have identified the proper treatment category for each distress as shown in Figure 3.11. Deep rutting, failures, and alligator cracking are mostly treated with rehab projects; otherwise, PM is the proper treatment for the rest of distresses. For rigid pavements, only ten districts responded to the pavement distress question. Figure 3.12 implies that punchouts are mostly treated as a rehabilitation project while other distresses are treated as PM projects.

Figures 3.13–3.15 implied that accident reports and public concerns are among the secondary factors considered in the selection of projects. For projects with similar distress conditions, the ADT is the main factor considered as the tie-breaker in deciding and selecting the project for treatment. Also, it is noted that consideration for rigid over flexible pavement treatment and vice versa is taking same priorities among districts.

SECTION V: CLOSING QUESTIONS

In your district, what type or types of distresses or other conditions most frequently warrant planning for rehabilitation instead of PM for a pavement under consideration?

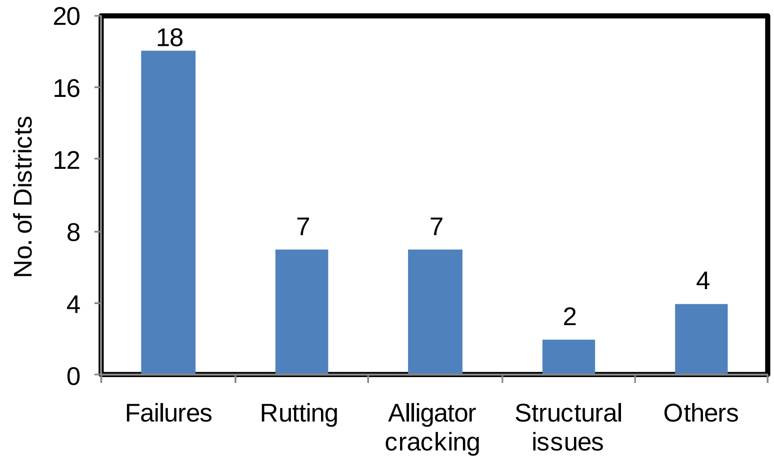


Figure 3.16. Distresses Governing the Selection for Rehab Treatments.

Conversely, in your district, what type or types of distresses or other conditions most frequently warrant PM instead of rehabilitation for a pavement under consideration?

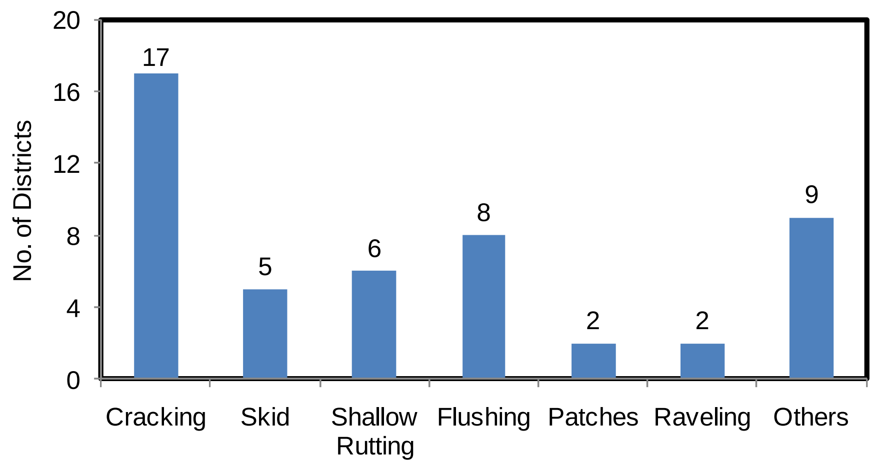


Figure 3.17. Distresses Governing the Selection for PM Treatments.

What would you say is the most important distress consideration when selecting the PM or rehab method for flexible pavements? For rigid pavements?

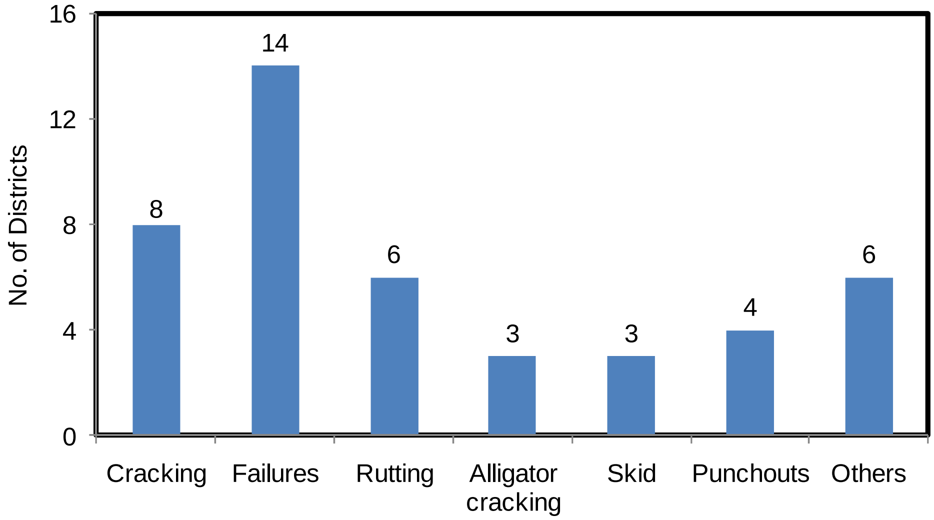


Figure 3.18. Overall Governing Distresses Used in Project Prioritization.

Does your district have a formal or informal method of evaluating performances of various PM/rehab methods frequently used?

Has your district done informal experiments to determine when certain PM or rehab methods are most appropriate?

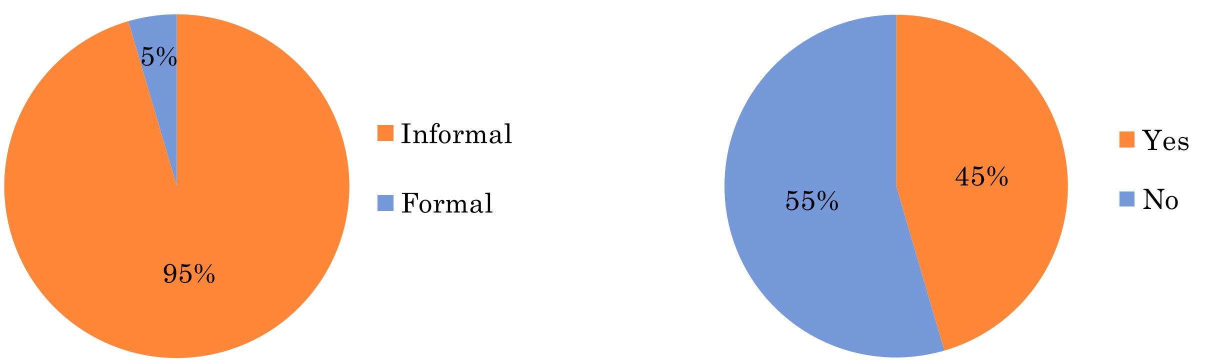


Figure 3.19. Responses Related to Performance Evaluation of Treatments after Applications.

Figures 3.16–3.18 indicated that pavement failure is the main distress form to warrant rehab treatment while surface cracking is the main distress to warrant PM treatment. It is also implied that districts have no formal procedure to track the performance of the applied treatments. The informal procedure consists of frequent visual inspections to monitor the service life of the treatment.

SUMMARY

This chapter summarizes the findings of the questionnaires regarding the state of practice in PM/Rehab project prioritization in TxDOT districts. The following are the highlights:

- For flexible pavements, seal coat/chip seal and crack and joint sealing are the most common PM treatments, while repair of localized flexible pavement sections and seal coat with thin HMA overlays are the most common rehab treatments. Slurry seal is the least used treatment in all districts.
- Urban districts have more PM/Rehab applications for rigid pavement compared to rural districts. However, rural districts have more tendencies to implement rubber seal coat, multiple microsurfacing, and texturing more than urban districts.
- There are many engineers at all levels in each district engaged in the project selection process. In most cases, they tend to be the same personnel who makes the final selection for each treatment category (e.g., PM and Rehab) and pavement type (e.g., flexible and rigid).
- Typical timing for starting the selection process initiated in late fall to early spring (from December to March) each year.
- Most districts use the MapZapper as their main tool to extract existing field site condition (e.g., condition score) combined with other tools such as PMIS and visual inspection to identify the candidate projects.
- Nearly more than half the districts do not have any document describing their protocol of identifying and finalizing the candidate projects.
- The major factors considered into the projects' selection are average daily traffic (ADT) and roadway functional class.
- There are no distress thresholds identified that warrant particular treatment in each decision category. However, major distresses such as rutting, failures, and alligator cracking are mostly treated through rehabilitation while PM is typically used for the rest of distresses. For rigid pavements, punchouts are mostly treated by rehabilitation projects while other distresses are treated by PM.
- Accidents reports and public concerns are among the factors considered in project selection.
- For projects with similar distress conditions, the ADT is the main factor considered as the tie-breaker in deciding and selecting the project for treatment.
- Consideration for rigid over flexible pavement treatment and vice versa is gaining equal ground among districts.
- Failure (deep rutting and/or alligator cracking) is the major distress warranting rehab treatment. Fatigue cracking, shallow rutting, and skid are the most governing distresses to warrant PM treatment.

CHAPTER 4:
DEVELOPMENT OF PROJECT PRIORITIZATION TOOL

OVERVIEW

This project included the development of a simple Excel-based tool to assist district decision makers in prioritizing candidate projects for rehabilitation and PM funding. It was developed using Microsoft Excel 2007 and operates within 32-bit Windows XP or Windows 7 operating systems.

In its current form input to the Excel tool, the user manually enters the candidate projects' information. The tool applies weight factors to the entered information to derive a total score for each project proposed for a rehabilitation treatment and for a PM treatment. A comparison of total scores provides prioritization of the candidate projects. The tool, however, can be automated to acquire the candidate project information directly from the PMIS database and prioritize these according to individual score values.

The user may modify the default weight factors supplied with the tool should this be desirable to reflect local conditions. This tool is designed for the use of experienced personnel. It is not a substitute for sound engineering judgment, nor can it consider external factors that sometimes impact project selection decisions.

KEY PROJECT CHARACTERISTICS

The research team selected key project characteristics for use within the tool in prioritizing projects. The key characteristics were a consensus decision of the research team after team members had visited districts throughout the state to discuss the methods used. No two district methodologies were exactly identical, although there are many similarities. Key characteristics were not selected solely on frequency of mention during district visits. Both frequency of mention, the logic expressed for using them, and ultimately the combined experience of the research team resulted in the list of key project characteristics to be implemented in the tool.

Eight key project characteristics were identified for implementation in the tool. Six of these relate to rehabilitation project selection and six relate to PM project selection. The key characteristics and the resulting prioritization are shown in Table 4.1.

Table 4.1. Key Project Characteristics and Project Prioritization Applicability.

Project Characteristics	Rehabilitation Project Prioritization Impact	PM Project Prioritization Impact
Average Condition Score	X	
Average Distress Score		X
Number of Failures per Mile	X	X
Average Ride Score	X	
Average Maintenance Expenditure	X	X
Skid Number	X	X
Age of Surface		X
Average Annual Daily Traffic	X	X

REVIEW OF TOOL SCREENS

Main Menu and Tool Overview. The home menu is found on the first sheet of the Excel file and is shown in Figure 4.1. The menu is divided into three sections, described below.

The project information entry section has a single tab that allows the user to transfer information to the "Project Data Input" sheet.

- Project Data Input: The "Project Data Input" sheet is where the user enters project location and key project characteristic information for all candidate projects to be prioritized for rehab and PM funding. Project location is identified in terms of district, county, highway ID, and reference markers. Key project characteristic information includes Condition score, Distress score, Ride score, Skid number, Number of failures, Age of surface, Maintenance expenditure, and Average daily traffic

The project prioritization listing section contains four tabs (Figure 4.1) offering differing displays of tool prioritization output: "Rehab Priority List," "PM Priority List," "Combined Priority List," and "Project Scoring Details."

- Rehab Priority List: This tab allows the user to transfer to the "Rehab Prioritized Project List" sheet where the total rehab score for each project and the rehab priority ranking for each project are displayed.
- PM Priority List: This tab allows the user to transfer to the "PM Prioritized Project List" sheet where the total PM score for each project and the PM priority ranking for each project are displayed.
- Combined Priority List: This tab allows the user to transfer to the "Combined Prioritized Projects" sheet where both the rehab and PM total scores for each project are displayed. In this sheet, the user has the option to sort the project list according to project prioritization rankings for either PM or rehab.

- Project Scoring Details: This tab allows the user to transfer to the “Detailed Scoring Breakdown” sheet where the weighted score is shown for each key project characteristic considered in the rehab and PM prioritization ranking. The user is thereby able to determine the relative impact of each key factor on the total prioritization score. As in the “Combined Prioritized Project” sheet, the user has the option to sort the project list according to project prioritization rankings for either PM or rehab.

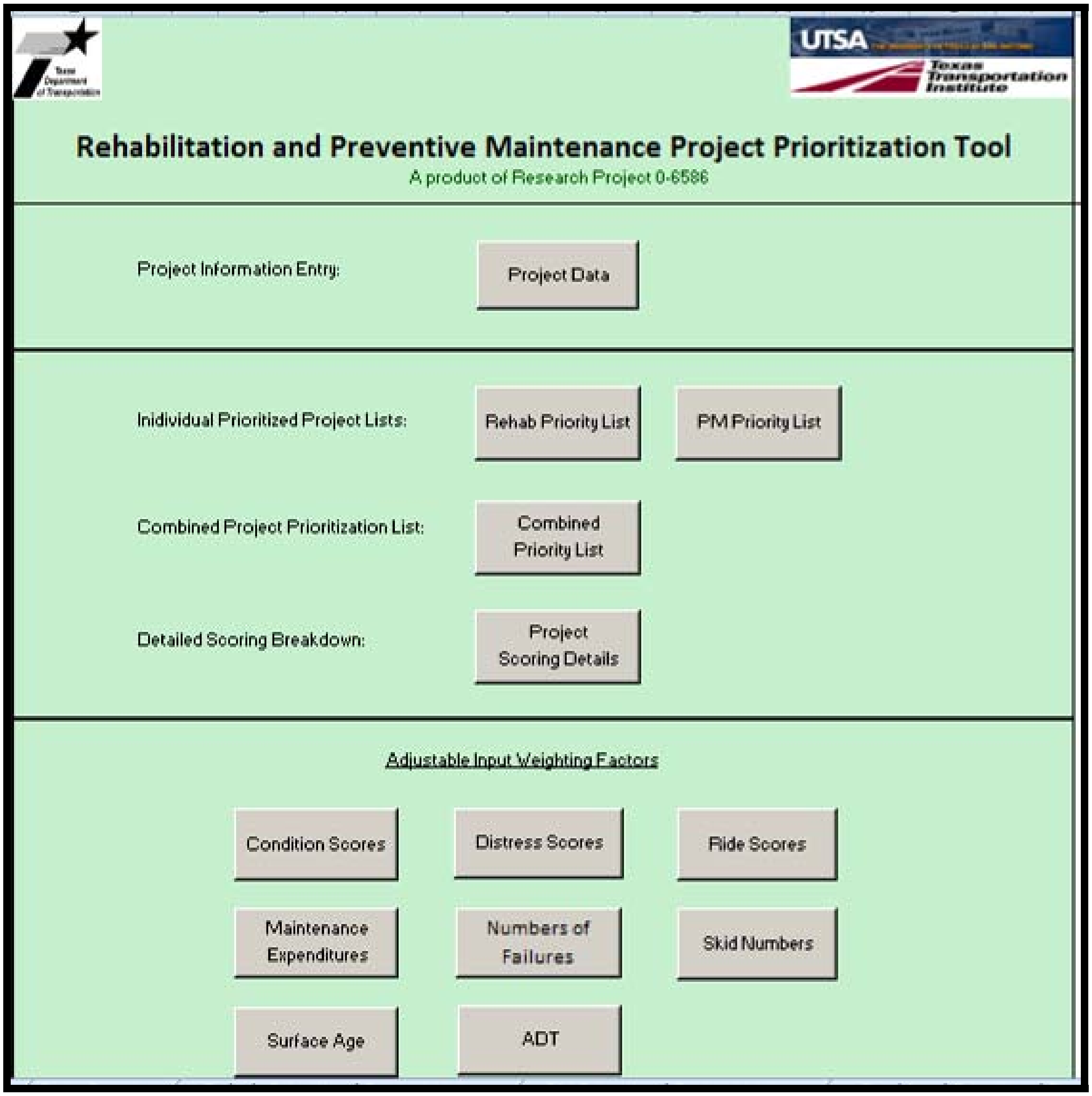


Figure 4.1. The Main Menu Showing the Command Tabs.

The adjustable input weight factor section contains eight tabs for accessing the weight factors applied by the tool to each key project characteristic considered in the project prioritization calculations. Clicking on any tab will transfer the user to a sheet showing the range of weight factors corresponding to the range of values possible for the key project characteristic. As an example, Figure 4.2 displays the sheet with default weight factors for Condition Score. The user may adjust the weight factors shown on these sheets if necessary to fine-tune the tool for local conditions.

Condition Score Prioritization Weighting Assignment Table

Condition Score Range		Rehab Score	PM Score
0	24.9999	30.0	0
25	34.9999	29.0	0
35	44.9999	28.0	0
45	54.9999	24.0	0
55	59.9999	22.0	0
60	64.9999	20.0	0
65	69.9999	12.0	0
70	74.9999	5.0	0
75	79.9999	4.0	0
80	84.9999	2.0	0
85	89.9999	1.0	0
90	94.9999	0.0	0
95	100	0.0	0

Maximum	100	30
Minimum	0	0

Figure 4.2. Condition Score Weight Factor.

RELATIVE IMPACTS OF KEY PROJECT CHARACTERISTICS— WEIGHT FACTORS

The next sheet after the Menu in the Excel file is named "Weight Factors." Figure 4.3 displays the information on this sheet. As it is an informational sheet without any impact on tool functionality, it has no associated tab on the Menu sheet. Instead, it is accessed by clicking the second tab at the bottom of the Excel screen. The table on this sheet shows differences in impact of the various key project characteristics on the project's total prioritization scores when the default weight factors are utilized. The tool focuses on eight key project characteristics, with six being considered for rehab project prioritization and six being considered for PM project prioritization. The total summation of all weight factors is 100 percent for each type of project prioritization. The source of each factor is identified in a separate column. Some constraints have been applied to key factor considerations based on the existing condition score. For instance, skid number is neglected if the condition score is higher than 65.

	Rehab Weight factor %	PM weight factor %	Source of Information	Notes
Condition Score	30		PMIS	
Distress Score		30	PMIS	
Ride Score	10		PMIS	
Skid Number	15	25	PMIS	This number is considered only when condition score is lass than 65
Maintenance Expenditures per	5	5	PMIS	
Number of Failures	30	10	PMIS	
Age of Surface, years		20	District records	If the conditions score is less than 80, a 30% reduciton in the weight factors is applied
Annual Daily Traffic (ADT)	10	10	TxDOT Traffic maps	http://www.txdot.gov/travel/traffic_map.htm
Total	100	100		

Figure 4.3. The Default Values for the Weight Factors of Each Key Project Characteristic.

EXAMPLE OF TOOL USE

Project Information Entry

Click on the Project Data tab on the main menu screen and access the "Project Data Input" sheet. Enter all required information for each candidate project for rehab or PM funding. Figure 4.4 shows example project information.

Project Data Input												
Roadway Information												
Input Number	Highway	County	Begin (RM)	End (RM)	Average Condition Score	Average Distress Score	Average Ride Score	Average Skid Number	Average Three-Year Total Maintenance Expenditure per PMIS Section	Average Three-Year Total Number of Failures per Lane Mile	Age of Surface, years	Average Annual Daily Traffic (ADT)
1	FM 2328	Cass	236	240	72.3	72.3	3.57	55.1	$9,050.14	0.00	13	225
2	US 59	Cass	234	234+1.0	88.0	92.0	3.15	32.5	$388.67	0.00	20	3,400
3	FM 2199	Harrison	276+1.0	280+0.4	62.4	64.4	2.98	19.6	$8,063.14	1.00	10	872
4	IH 20	Harrison	597	614+0.5	95.0	95.0	4.39	41.1	$11,220.00	0.53	3	8,010
5	Loop 281	Harrison	722	724+0.5	89.7	90.7	3.88	44.5	$0.00	0.19	4	4,730
6	US 59	Panola	320+1.0	326	81.8	81.8	4.46	32.0	$2,033.50	0.00		3,550
7	SH 21	Bastrop	580+0.5	582+1.5	64.2	67.3	3.36	26.0	$3,938.58	0.17		2,020
8	RM 967	Hays	533	530	58.5	71.4	2.94	38.0	$17,850.00	3.55		3,633
9	SH 71	Llano	500+1.0	516+1.0	47.3	47.3	3.89	35.3	$706.82	11.91		1,165
10	IH 35 (South	Williamson	266+0.5 L1	277+0.8 L1	87.3	87.3	4.23	33.1	$243.25	0.82		13,641
11	US 82	Fannin	668+1.0	688	48.0	51.5	3.98		$1,357.83	0.00		2,572
12	US 75	Grayson	210	214	64.0	67.9	3.38		$5,916.19	0.13		10,029
13	FM 2285	Hopkins	230	240	73.6	88.9	2.50		$2,397.37	0.76		665
14	Bus US 82	Lamar	656+0.5	658	45.0	52.8	2.98		$1,970.54	0.00		3,437
15	FM 6	Hunt	616	618+1.5	78.9	97.8	2.90		$3,510.83	0.83		1,600
16	FM 3243	Navarro	612	616+1.0	53.3	54.7	2.36	62.9	$1,190.82	6.12	6	179
17	FM 982	Collin	242+1.5	246	100.0	100.0	4.32	40.2	$5,213.60	0.00	7	900

Return to Menu

Figure 4.4. Example of "Data Input" Sheet.

As seen, the sheet consists of the following input parameters:

- Input Number: the serial number of the projects.
- Highway: the highway ID (e.g., FM 2328, US 281, IH 10).
- County: the county where the project is located.
- Begin RM: identifies the beginning reference marker of the project.
- End RM: identifies the ending reference marker of the project.
- Average Condition Score: defined as the average of current condition scores (potential range of 0 to 100) from all PMIS sections contained within the project length.

Calculation Example (1): If a three-mile candidate project has six PMIS segments with current condition scores of 80, 75, 75, 50, 65, and 65, the average condition score is determined as follows:

Average Condition Score = (80+75+75+50+65+65)/6 = 68.33

- Average Distress Score: This parameter is defined as the average of the current distress scores (potential range of 0–100) from all PMIS sections contained within the project length. The calculation method is the same as for Average Condition Score in Example 1.
- Average Ride Score: This parameter is defined as the average of current ride scores (potential range of 0–5) from all PMIS sections contained within the candidate project. The calculation method is the same as for Average Condition Score in Example 1.
- Average Skid Number: This parameter is defined as the average current skid number determined for the candidate project.
- Average Three-Year Total Maintenance Expenditures per PMIS Section: This parameter is defined as the average of all roadway maintenance expenditures totaled over the most recent three-year period for all PMIS sections contained within the project length.

Calculation Example (2): If a three-mile project has six PMIS segments with maintenance expenditures as follows:

- *Four segments with $5,000 expenditures and two segments with $10,000 of expenditures in 2009.*
- *All six sections with $2,000 of expenditures in 2008.*
- *All six with no maintenance expenditures in 2007*

The Average Three-Year Total Maintenance Expenditure for this project is determined as follows:

Segment 1: $5,000 + $2,000 + $0 = $7,000
Segment 2: $5,000 + $2,000 + $0 = $7,000
Segment 3: $5,000 + $2,000 + $0 = $7,000
Segment 4: $5,000 + $2,000 + $0 = $7,000
Segment 5: $10,000 + $2,000 + $0 = $12,000
Segment 6: $10,000 + $2,000 + $0 = $12,000
Sum of all segments = $52,000

The Average Three-Year Total Maintenance Expenditure = $52,000/6 (segments) = <u>$8,667</u>

- Average Three-Year Total Number of Failures per lane mile: This parameter accounts for the average number of failures occurring per segment in the project during the last three years.

Calculation Example (3): If a three-mile project has the following number of failures per segment:

The first segment had three failures and the rest had one failure in 2009. The first two segments had two failures and the rest had none in 2008, and there were no failures in any of the segments in 2007.

The Average Three-Year Total Number of Failures per lane mile is determined as follows:

Segment 1: 3 + 2 + 0 = 5
Segment 2: 1 + 2 + 0 = 3
Segment 3: 1 + 0 + 0 = 1
Segment 4: 1 + 0 + 0 = 1
Segment 5: 1 + 0 + 0 = 1
Segment 6: 1 + 0 + 0 = 1
Sum of all segments = 12

The Average Three-Year Total Number of Failures =
12/6 (segments) × 2(segments/lane mile)= 4.0 failures per lane mile

- Age of Surface (years): This parameter accounts for the age of the pavement surface in years.
- Average Annual Daily Traffic (AADT): This parameter accounts for the traffic volume on a given project.

Calculation Example (4): If a four-lane two-directional project has 5,000 ADT, then the average annual daily traffic will be determined as follows:

*ADT per lane mile = 5000 * (0.5 per direction) * (0.9)= 2,250*

The 0.5 factor is the directional traffic ratio to account for ADT in one direction and 0.9 is the average of the directional proportion for roadways with two lanes in a single direction according to Table 4.2 guidelines.

Table 4.2. Proportion of Directional ADT in the Design Lane.

Number of directional lanes	*Proportion of directional ADT in the design lane*
1	*1.00*
2	*0.8–1.00*
3	*0.6–0.8*
4	*0.5–0.75*

Project Ranking Optional Displays

Each candidate project is automatically scored for both rehab and PM funding prioritization as the information is entered into the Project Data Input sheet. The user may go back to the Project Data Input sheet and change input values at any time. Appropriate adjustments are automatically made in project rankings when input values are changed.

Project rankings may be displayed in several formats. Prioritizations of the example set of projects are displayed below in Figures 4.5–4.9 as they would be created by clicking the various tabs in the project ranking section of the Menu screen.

Rehab Prioritized Project List

Return to Menu

Project Information						
Input Number	Highway	County	Begin (RM)	End (RM)	**Total Rehab Score**	**Rehab Priority**
9	SH 71	Llano	500+1.0	516+1.0	66.0	1
18	SH 289	Dallas	260+0.5	264+0.5	60.0	2
16	FM 3243	Navarro	612	616+1.0	54.5	3
3	FM 2199	Harrison	276+1.0	280+0.4	51.5	4
8	RM 967	Hays	533	530	51.5	4
7	SH 21	Bastrop	580+0.5	582+1.5	45.0	6
12	US 75	Grayson	210	214	38.5	7
22	FM 740	Kaufman	268+1	272+1.0	35.5	8
14	Bus US 82	Lamar	656+0.5	658	35.0	9
11	US 82	Fannin	668+1.0	688	32.5	10
10	IH 35 (South	Williamson	266+0.5 L1	277+0.8 L1	25.5	11
19	FM 428	Denton	566	568+0.5	24.0	12
4	IH 20	Harrison	597	614+0.5	23.5	13
13	FM 2285	Hopkins	230	240	18.5	14
15	FM 6	Hunt	616	618+1.5	18.5	14
5	Loop 281	Harrison	722	724+0.5	17.5	16

Figure 4.5. "Rehab Priority Project List" Sheet with Example Project Rankings.

PM Prioritized Project List

Return to Menu

Project Information						
Input Number	Highway	County	Begin (RM)	End (RM)	Total PM Score	PM Priority
4	FM 2199	Harrison	276+1.0	280+0.4	50.7	1
22	FM 740	Kaufman	268+1	272+1.0	48.7	2
20	US 377	Denton	226	240	46.7	3
9	SH 71	Llano	500+1.0	516+1.0	45.3	4
18	SH 289	Dallas	260+0.5	264+0.5	43.2	5
2	US 59	Cass	234	234+1.0	41.0	6
16	FM 3243	Navarro	612	616+1.0	40.3	7
7	SH 21	Bastrop	580+0.5	582+1.5	33.7	8
19	FM 428	Denton	566	568+0.5	29.0	9
11	US 82	Fannin	668+1.0	688	27.5	10
14	Bus US 82	Lamar	656+0.5	658	27.5	10
10	IH 35 (South or	Williamson	266+0.5 L1	277+0.8 L1	26.0	12
1	FM 2328	Cass	236	240	25.8	13
5	Loop 281	Harrison	722	724+0.5	23.7	14
8	RM 967	Hays	533	530	23.3	15
17	FM 982	Collin	242+1.5	246	22.2	16
6	US 59	Panola	320+1.0	326	21.5	17

Figure 4.6. "PM Priority Project List" Sheet with Example Projects Rankings.

Combined Project Prioritizations

Return to Menu

Project Information					Scores		Prioritization	
Input Number	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	Rehabilitation	Preventive Maintenance
1	FM 2328	Cass	236	240	11.5	25.8	21	13
2	US 59	Cass	234	234+1.0	13.5	41.0	20	6
3	FM 2199	Harrison	276+1.0	280+0.4	51.5	50.7	4	1
4	IH 20	Harrison	597	614+0.5	23.5	21.3	13	18
5	Loop 281	Harrison	722	724+0.5	17.5	23.7	16	14
6	US 59	Panola	320+1.0	326	16.0	21.5	17	17
7	SH 21	Bastrop	580+0.5	582+1.5	45.0	33.7	6	8
8	RM 967	Hays	533	530	51.5	23.3	4	15
9	SH 71	Llano	500+1.0	516+1.0	66.0	45.3	1	4
10	IH 35 (South	Williamson	266+0.5 L1	277+0.8 L1	25.5	26.0	11	12
11	US 82	Fannin	668+1.0	688	32.5	27.5	10	10
12	US 75	Grayson	210	214	38.5	19.5	7	19

Sort By Rehab Score

Sort By PM Score

Return To Original Order

Figure 4.7. "Combined Project Prioritizations" Sheet with Example Projects Displayed in the Order They Were Entered into the Tool by the User.

Combined Project Prioritizations

Return to Menu

Project Information					Scores		Prioritization	
Input Number	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	Rehabilitation	Preventive Maintenance
9	SH 71	Llano	500+1.0	516+1.0	66.0	45.3	1	4
18	SH 289	Dallas	260+0.5	264+0.5	60.0	43.2	2	5
16	FM 3243	Navarro	612	616+1.0	54.5	40.3	3	7
3	FM 2199	Harrison	276+1.0	280+0.4	51.5	50.7	4	1
8	RM 967	Hays	533	530	51.5	23.3	4	15
7	SH 21	Bastrop	580+0.5	582+1.5	45.0	33.7	6	8
12	US 75	Grayson	210	214	38.5	19.5	7	19
22	FM 740	Kaufman	268+1	272+1.0	35.5	48.7	8	2
14	Bus US 82	Lamar	656+0.5	658	35.0	27.5	9	10
11	US 82	Fannin	668+1.0	688	32.5	27.5	10	10
10	IH 35 (South	Williamson	266+0.5 L1	277+0.8 L1	25.5	26.0	11	12
19	FM 428	Denton	566	568+0.5	24.0	29.0	12	9
4	IH 20	Harrison	597	614+0.5	23.5	21.3	13	18
13	FM 2285	Hopkins	230	240	18.5	7.0	14	21

Sort By Rehab Score

Sort By PM Score

Return To Original Order

Figure 4.8a "Combined Project Prioritizations" Sheet with Example Projects Listed in Rehab Score Priority Order.

Combined Project Prioritizations

Return to Menu

Project Information					Scores		Prioritization	
Input Number	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	Rehabilitation	Preventive Maintenance
3	FM 2199	Harrison	276+1.0	280+0.4	51.5	50.7	4	1
22	FM 740	Kaufman	268+1	272+1.0	35.5	48.7	8	2
20	US 377	Denton	226	240	15.5	46.7	18	3
9	SH 71	Llano	500+1.0	516+1.0	66.0	45.3	1	4
18	SH 289	Dallas	260+0.5	264+0.5	60.0	43.2	2	5
2	US 59	Cass	234	234+1.0	13.5	41.0	20	6
16	FM 3243	Navarro	612	616+1.0	54.5	40.3	3	7
7	SH 21	Bastrop	580+0.5	582+1.5	45.0	33.7	6	8
19	FM 428	Denton	566	568+0.5	24.0	29.0	12	9
14	Bus US 82	Lamar	656+0.5	658	35.0	27.5	9	10
11	US 82	Fannin	668+1.0	688	32.5	27.5	10	10
10	IH 35 (South	Williamson	266+0.5 L1	277+0.8 L1	25.5	26.0	11	12
1	FM 2328	Cass	236	240	11.5	25.8	21	13
5	Loop 281	Harrison	722	724+0.5	17.5	23.7	16	14

Sort By Rehab Score

Sort By PM Score

Return To Original Order

Figure 4.8b. "Combined Project Prioritizations" Sheet with Example Projects Listed in PM Score Priority Order.

Detailed Scoring Breakdown

Return to Menu | Sort By Rehab Score | Sort By PM Score | Return To Original Order | Return to Menu

Roadway Information					Average Condition Score		Average Distress Score		Average Ride Score		Average Skid Number			Average Three-Year Total Maintenan			Average Three-Year Total Number of Failures per Lane Mile			Age of Surface, years		Average Annual Daily Traffic (ADT) per Lane Mile			Total Rehab Score	Total PM Score	Rehab Priority	PM Priority
Input Number	Highway	County	Begin (RM)	End (RM)	Value	Rehab Score	Value	PM Score	Value	Rehab Score	Value	Rehab Score	PM Score	Value	Rehab Score	PM Score	Value	Rehab Score	PM Score	Value	PM Score	Value	Rehab Score	PM Score				
1	FM 2328	Cass	236	240	72.3	5	72.3	6	3.57	0	55.1	2.5	4.2	$9,050.14	3	2.5	0.0	0	0	13	12.13	225	1	1	11.5	25.8	21	13
2	US 59	Cass	234	234+1.0	88.0	1	92.0	0	3.15	0	32.5	7.5	12.5	$388.67	1	4.5	0.0	0	0	20	20.00	3,400	4	4	13.5	41.0	20	6
3	FM 2199	Harrison	276+1.0	280+0.4	62.4	20	64.4	15	2.98	5	19.6	12.5	20.8	$8,063.14	3	2.5	1.0	9	1	10	9.33	872	2	2	51.5	50.7	4	1
4	IH 20	Harrison	597	614+0.5	95.0	0	95.0	0	4.39	0	41.1	5	8.3	$11,220.00	3.5	2	0.5	9	1	3	4.00	8,010	6	6	23.5	21.3	13	18
5	Loop 281	Harrison	722	724+0.5	89.7	1	90.7	0	3.88	0	44.5	5	8.3	$0.00	0.5	5	0.2	6	0	4	5.33	4,730	5	5	17.5	23.7	16	14
6	US 59	Panola	320+1.0	326	81.8	2	81.8	2	4.46	0	32.0	7.5	12.5	$2,033.50	2.5	3	0.0	0	0		0.00	3,550	4	4	16.0	21.5	17	17
7	SH 21	Bastrop	580+0.5	582+1.5	64.2	20	67.3	10	3.36	2.5	26.0	10	16.7	$3,938.58	2.5	3	0.2	6	0		0.00	2,020	4	4	45.0	33.7	6	8
8	RM 967	Hays	533	530	58.5	22	71.4	6	2.94	5	38.0	5	8.3	$17,850.00	3.5	2	3.5	12	3		0.00	3,633	4	4	51.5	23.3	4	15
9	SH 71	Llano	500+1.0	516+1.0	47.3	24	47.3	20	3.89	2.5	35.3	5	8.3	$706.82	1.5	4	11.9	30	10		0.00	1,165	3	3	66.0	45.3	1	4
10	IH 35 (So	Williamso	266+0.5 L	277+0.8 L	87.3	1	87.3	1	4.23	0	33.1	7.5	12.5	$243.25	1	4.5	0.8	9	1		0.00	13,641	7	7	25.5	26.0	11	12
11	US 82	Fannin	668+1.0	688	48.0	24	51.5	20	3.98	2.5		0	0.0	$1,357.83	2	3.5	0.0	0	0		0.00	2,572	4	4	32.5	27.5	10	10
12	US 75	Grayson	210	214	64.0	20	67.9	10	3.38	2.5		0	0.0	$5,916.19	3	2.5	0.1	6	0		0.00	10,029	7	7	38.5	19.5	7	19
13	FM 2285	Hopkins	230	240	73.6	5	88.9	1	2.50	0		0	0.0	$2,397.37	2.5	3	0.8	9	1		0.00	665	2	2	18.5	7.0	14	21
14	Bus US 8	Lamar	656+0.5	658	45.0	24	52.8	20	2.98	5		0	0.0	$1,970.54	2	3.5	0.0	0	0		0.00	3,437	4	4	35.0	27.5	9	10
15	FM 6	Hunt	616	618+1.5	78.9	4	97.8	0	2.90	0		0	0.0	$3,510.83	2.5	3	0.8	9	1		0.00	1,600	3	3	18.5	7.0	14	21
16	FM 3243	Navarro	612	616+1.0	53.3	24	54.7	20	2.36	5	62.9	2.5	4.2	$1,190.82	2	3.5	6.1	20	6	6	5.60	179	1	1	54.5	40.3	3	7
17	FM 982	Collin	242+1.5	246	100.0	0	100.0	0	4.32	0	40.2	5	8.3	$5,213.60	3	2.5	0.0	0	0	7	9.33	900	2	2	10.0	22.2	22	16
18	SH 289	Dallas	260+0.5	264+0.5	33.6	29	63.0	15	2.48	5	21.5	10	16.7	$203.76	1	4.5	1.2	9	1		0.00	6,063	6	6	60.0	43.2	2	5
19	FM 428	Denton	566	568+0.5	69.3	12	87.4	1	2.95	0	27.3	7.5	12.5	$90.42	0.5	5	0.0	0	0	7	6.53	2,363	4	4	24.0	29.0	12	9
20	US 377	Denton	226	240	98.6	0	98.8	0	3.76	0	21.8	10	16.7	$75.14	0.5	5	0.0	0	0	15	20.00	4,520	5	5	15.5	46.7	18	3
21	FM 548	Kaufman	266	272+1.0	95.7	0	96.1	0	3.37	0	31.9	7.5	12.5	$60,714.49	4.5	1	0.0	0	0		0.00	1,600	3	3	15.0	16.5	19	20
22	FM 740	Kaufman	268+1	272+1.0	86.6	1	93.1	0	3.82	0	25.7	10	16.7	$2,920.00	2.5	3	5.9	18	5	15	20.00	3,227	4	4	35.5	48.7	8	2
23						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
24						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
25						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
26						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
27						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
28						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
29						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
30						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
31						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
32						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
33						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23
34						0		0		0		0	0.0		0	0		0	0		0.00		0	0	0.0	0.0	23	23

Figure 4.9. "Detailed Scoring Breakdown" Sheet Showing the Individual Score Contributions of Each of the Key Project Characteristics for the Example Projects.

The user has the option to list the projects in either of their priority orders using the set of tabs at the top of this page. Figure 4.9 shows that:

- In each sheet, the "Return to Menu" tab allows the user to transfer to the main menu.
- The remaining sheets from "CS weight table" to "ADT Weight Table" are suggested ranges of weight factors corresponding to the key factor with maximum value assigned in "weight factor" sheet.
- The user has the option to revise the suggested "weight factors" for rehab and PM. However, the total sum of factors has to remain 100 percent.

VERIFICATION

One cycle of verification was conducted on the Excel-based tool using expected treatment for current projects. After the questionnaire interview with district personnel, the visited sites information was considered to verify the prioritization tool. Examples of verification are explained in the following tables. The planned treatment by districts is compared with the tool output. Atlanta, Pharr, Dallas, and San Antonio District have revealed an overall successful implementation. Matching results with planned treatment is evident in the chosen districts with the exception of one project (highlighted in bold) in Atlanta, Pharr, and Dallas Districts as shown in Tables 4.3–4.6.

Table 4.3. Prioritization Tool Output for Atlanta District.

Project Information					Scores		Prioritization		Planned treatment
Input	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	RH	PM	
1	FM 2328	Cass	236	240	11.5	27.3		√	PM
2	US 59	Cass	234	234+1.0	9.5	26.3		√	PM
3	FM 2199	Harrison	276+1.0	280+0.4	32	31.8	√		RH
4	IH 20	Harrison	597	614+0.5	13.5	13.0	√		RH
5	**Lp 281**	**Harrison**	**722**	**724+0.5**	**7**	**11.3**	√		**RH**
6	US 59	Panola	320+1.0	326	10.5	11.0		√	PM

Table 4.4. Prioritization Tool Output for Pharr District.

Project Information					Scores		Prioritization		Planned treatment
Input	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	RH	PM	
1	US 83	Hidalgo	857	859.5	12	15.5		√	PM
2	FM 907	Hidalgo	714.5	716	6.5	11.0		√	PM
3	**US 281**	**Hidalgo**	**764**	**769.5**	**7.5**	**12.0**		**√**	**RH**
4	FM 2557	Hidalgo	724	731.4	43	33.0	√		RH
5	FM 2220	Hidalgo	716.5	721.1	27	28.0		√	PM

Table 4.5. Prioritization Tool Output for Dallas District.

Project Information					Scores		Prioritization		Planned treatment
Input	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	RH	PM	
1	FM 3243	NAVARRO	612	616+1.0	33.5	34.6		√	PM
2	FM 982	Collin	242+1.5	246	3.5	17.3		√	PM
3	**SH 289**	**Dallas**	**260+0.5**	**264+0.5**	**44.5**	**30.0**	**√**		**PM**
4	FM 428	Denton	566	568+0.5	16	16.3		√	PM
5	US 377	Denton	226	240	6	26.0		√	PM
6	FM 548	Kaufman	266	272+1.0	5.5	8.0		√	PM

Table 4.6. Prioritization Tool Output for San Antonio District.

Project Information					Scores		Prioritization		Planned treatment
Input	Highway	County	Begin (RM)	End (RM)	Total Rehab Score	Total PM Score	RH	PM	
1	US 90	1	554	560	15.5	16.0		√	PM
2	FM 1535	2	486	494.1	9.5	12.0		√	PM
3	FM 758	5	518	524.7	18.5	15.5	√		RH
4	FM 725	7	482	489.7	36	15.5	√		RH

CHAPTER 5:
SUMMARY AND CONCLUSIONS

The technical objectives of this project were to:

- Research how TxDOT districts currently select their rehab/PM projects.
- Identify the tools and data they use to make this selection.
- Select best practices for project selection.
- Use the collected information to develop a procedure and simple system to aid on project selection.

DISTRICT PROCESS IN PM/REHAB PROJECT SELECTION/PRIORITIZATION

The following steps summarize the interviews with district personnel to describe how TxDOT districts currently select their rehab/PM projects:

1. Preliminary screening is performed to select project candidates for maintenance consideration. Area engineers conduct visual inspection in each district's roadway network and by MapZapper to allocate sections with low condition scores. Practically, sections not chosen in the previous fiscal year are included in the list, and most of the time they become strong candidates.
2. The preliminary list of projects is submitted to the district office along with a recommendation of the suggested treatments. The district office personnel will meet with area engineers to review the submitted list. Further information from the PMIS database using Map Zapper is extracted for the proposed projects (e.g., previous year maintenance cost, ADT, condition score, distress score, skid resistance, etc).
3. Area engineers combine the information from the visual inspection along with PMIS data, and classify sections into two treatment groups, PM and Rehabilitation. The distress type is the main factor in selecting the treatment method. Suggested treatment according to Section V in the questionnaire for each project is identified based on the distress severity. If the cause of the distress is unidentified, forensic analysis is proposed. Depending on the nature of distress and the size of the project, forensic analysis may be an option.
4. If a prioritization tool or formula is available in the district, a project can be ranked and a priority list can be identified. If no such tool is available, a combination between the condition score, the need assessment report, ADT, funding history, public concerns, and safety issues is considered to identify the priority list of the district office personnel.
5. The district office allocates the available funding for each treatment category until the available funds are exhausted. The remaining sections are reconsidered for treatment in the next fiscal year.

6. Final selection of the projects is done. District office personnel conduct an in-field visual inspection of the proposed projects to validate the treatment selection and priority of the sections.
7. Recommendation of the priority list is submitted to the district engineer for final approval.

The following is a summary of the questionnaire responses:

- There are numerous treatment applications for each project category (PM and Rehab) available to TxDOT. However, most districts use only two to three options for their network due to good experience and performance. Seal coat and chip seal are the most common PM applications in the districts. Cleaning and sealing cracks and texturing of flexible pavement are also frequently used applications. Slurry seal, texturing rigid pavement and multiple course microsurfacing are the least used applications for PM projects. Repair of localized sections (spot repair) and HMA overlay are the most used applications in rehab projects. Hot and cold in-place recycling were the least used applications in rehab projects.
- A group of engineers and administrators including area engineers, maintenance supervisors, district pavement engineers, directors of maintenance, operation, TP&D and construction and district engineer are involved in the project selection process until the final decision is made.
- Districts use a combination of tools and information sources along with visual inspection to prioritize their PM/rehab projects. The condition score, PMIS data, and the needs assessment report are examples of these tools.
- Existing pavement distress conditions have a major influence on treatment selections. Pavement with failures, deep rutting, and alligator cracking are good candidates for rehab treatment. Other distresses can be treated with PM applications. For rigid pavement, punchouts are mostly treated with rehab applications.
- ADT is one of the main factors used to prioritize the projects, particularly when deciding between similar project conditions and limited funding.
- Failures and structural deficiencies are the most critical conditions for pavements and are the major factors to impact rehab project selections. Surface cracking, flushing (skid), and shallow rutting are the major factors to impact PM project selections.

TOOLS AND DATA USED TO MAKE THE SELECTION/PRIORITIZATION

Questionnaire responses implied that districts use Map Zapper as the main tool to access the PMIS database and extract pavement conditions. Visual inspection is also used as a screening tool for identifying preliminary selection and as a confirmation tool for validating final selections.

BEST PRACTICES FOR PROJECT SELECTION/PRIORITIZATION

The project selection is conducted in the same manner in all districts according to the process described above. The variation between districts takes place in step 4, where priority and ranking tool may be used. The lack of documentation to report the selection process in the district offices has limited the resources to identify the best practice of project selection. Those districts with documented process are limited to the formulas used for the prioritization process only. Throughout the 25 district interviews, the Austin district has provided a logical and systematical process for the selection of rehab and PM projects shown in Appendix D. The process acquires input of many factors including traffic level, truck traffic, ride score, skid number, crash analysis, structural index, treatment level, and cost. It also requires area engineers and maintenance supervisors to submit their input and conduct visual inspections.
Non destructive testing is used for finalizing and identifying the best treatment methods. An optimization process using the input data with the proposed treatment cost is established to identify the selected projects.

EXCEL-BASED TOOL DEVELOPMENT AND VERIFICATIONS

The primary goal of this project was to develop an Excel-based tool to assist TxDOT personnel in making efficient selection and prioritization for PM and rehabilitation treatment projects. This tool allows engineers to input the project information extracted from the PMIS database along with associated weight factors to determine a prioritization score for each project. The prioritization score (ranged 0–100) is determined for each project category. The tool allows ranking the projects based on the prioritization score to identify the most needed projects in the network for treatment. The tool also allows the engineer to identify what treatment category is needed (PM or rehab) according to the score value. For instance, a project with higher PM scoring value will be most likely a candidate for PM treatment.

The baseline for developing the Excel-based tool is the group of key factors identified during district visits. Eight key factors have been selected: condition score, distress score, surface age, average daily traffic (ADT), failure, skid number, ride score, and maintenance expenditures. While the impact of key parameters in the prioritization score are varied, a set of weight factors are assigned for each key parameter. This study suggests an initial set of weight factors. However, the weight factors may be adjusted by the user if necessary to fine tune the tool for local conditions.

An Excel-based spreadsheet tool was developed. Chapter 4 shows the details on tool instructions. Findings from the Excel-based tool verification have implied that it is capable to identify the project with critical conditions in the network. One cycle of verifications using the visited sites during the course of the study has implied that the tool has matched the treatment selection with 85 percent of the projects. The verifications were conducted on Atlanta, Dallas, San Antonio, and Phar Districts.

REFERENCES

1- *Pavement Management Systems*. Participant's Manual, Federal Highway Administration, National Highway Institute, Washington, D.C., 1998.
2- *Pavement Management Analysis, Multi-Year Prioritization. Demonstration Project No. 108,* Publication No. FHWA-SA-97-071, Federal Highway Administration, National Highway Institute, Washington, D.C., 1997.
3- Hicks, Seeds and Peshkin (2000). "Selecting a preventive maintenance treatment for flexible pavements." Foundation for Pavement Preservation, Washington, D.C.
4- O'Brien, L.G. Evolution and Benefits of Preventive Maintenance Strategies. *NCHRP Synthesis 153*, Transportation Research Board, December 1989, 69 pages.
5- Ivan Damnjanovic, Seok Kim and Vighnesh P. Deshpande (2008) "Developing Specifications for Performance-Based Maintenance Contracts" Southwest Region University Transportation Center, Report # SWUTC/08/167161-1, College Station, TX
6- "Pavement Preventive Maintenance Guidelines" Report prepared by the Foundation for Pavement Preservation, March 2001, Washington, D.C.
7- A Basic Asphalt Emulsion Manual, Manual Series No. 19, Third Edition. The Asphalt Institute and the Asphalt Emulsion Manufacture's Association, 1997.
8- Johnson A. M. (2000), *Best Practices Handbook on Asphalt Pavement Maintenance,* Report No. 2000-04, Minnesota T2/LTAP Program, Center for Transportation Studies, University of Minnesota.
9- Al-Mansour, A.I. and K.C. Sinha. Economic Analysis of Effectiveness of Pavement Preventive Maintenance. in Transportation Research Record 1442, Transportation Research Board, 1994.
10- Galehouse L., A Pavement Preventive Maintenance Program. (accessed 2008) http://leadstates.transportation.org/pp/PP_maintenance.stm
11- The Asphalt Institute. *Asphalt in Pavement Maintenance*. MS-16, 3rd Edition.
12- Monismith, C.L. *Pavement Management: Proceedings of National Workshop*. FHWATS-82-203, Federal Highway Administration, June 1981, 74 pages.
13- Hicks, R.G., K. Dunn, and J.S. Moulthrop. Framework for Selecting Effective Preventive Maintenance Treatments for Flexible Pavements. in Transportation Research Record 1597, Washington, D.C., 1997.
14- Southern Region SPS Tour, October, 1995. Brent Rauhut Engineering, Austin, TX.
15- Freeman T.J., H. Ren, C.H. Spiegelman, D.A. Pinchott. (2003) "Analysis and Treatment Recommendations from the Supplemental Maintenance Effectiveness Research Program (SMERP), Report Number: 0-4040-3, Texas Transportation Institute, College Station, TX.
16- Tammy Booker Sims "Texas Pavement Preservation Program" http://www.utexas.edu/research/tppc/pubs/sims.pdf.
17- Cuelho E., Mokwa R. and Akin M. (2006) "Preventive Maintenance Treatments of Flexible Pavements: A Synthesis of Highway Practice" Western Transportation Institute, College of Engineering, Montana State University–Bozeman, MO.

18- Hall, K.T., C.E. Correa, and A.L. Simpson. 2003. "Performance of Flexible Pavement Maintenance Treatments in the Long-Term Pavement Performance SPS-3 Experiment" Transportation Research Record 1823. Transportation Research Board, National Research Council, Washington, D.C., pp.47–54.
19- Jahren, C.T., W.A. Nixon, and K.L. Bergeson. 2003a. Thin Maintenance Surfaces: Phase Two Report with Guidelines for Winter Maintenance on Thin Maintenance Surfaces. Iowa Department of Transportation and the Iowa Highway Research Board, Project TR 435. Final Report: January 2003.
20- Pavement Preservation Technology in France, South Africa and Australia, sponsored by the Federal Highway Administration, the American Association of State Highway Transportation Officials, and the National Cooperative Highway Research Program, Report # FHWA-PL-03-001, October 2002.
21- Freeman T., Ren H., and Spiegelman C. (2005) "Analysis of the Supplemental Maintenance Effectiveness Research Program (SMERP) Experiment" Report 0-4040-S, TxDOT, Austin, TX.
22- Freeman T. and Little D. (2002) "Maintenance Strategies for Pavements with Chemically Stabilized Layers" Report FHWA/TX-01/1722-6, TxDOT, Austin, TX.
23- Hall, K.T., C.E. Correa, and A.L. Simpson. 2003. "Performance of Flexible Pavement Maintenance Treatments in the Long-Term Pavement Performance SPS-3 Experiment" Transportation Research Record 1823. Transportation Research Board, National Research Council, Washington, D.C., pp. 47–54.
24- Jahren, C.T., W.A. Nixon, and K.L. Bergeson. 2003. Thin Maintenance Surfaces: Phase Two Report with Guidelines for Winter Maintenance on Thin Maintenance Surfaces. Iowa Department of Transportation and the Iowa Highway Research Board, Project TR 435. Final Report: January 2003.
25- Jackson, N.M.; D. Deepak; P.E. Sebally and G.L. Porritt. 2005. "Preventive Surface Treatments vs. Traditional Corrective Maintenance Measures." Transportation Research Circular No. E-C078: Roadway Pavement Preservation 2005: Papers from the First National Conference on Pavement Preservation, Kansas City, Missouri October 31–November 1, 2005. Transportation Research Board, National Research Council, Washington, D.C.
26- Bausano, J.P.; K. Chatti and R.C. Williams. 2004. "Determining Life Expectancy of Preventive Maintenance Fixes for Asphalt-Surfaced Pavements," Transportation Research Record 1866. Transportation Research Board, National Research Council, Washington, D.C., pp. 1–8.
27- Cooper, S.B. and L.N. Mohammad. 2004. Novachip™ Surface Treatment: Six Year Evaluation, Theriot Canal Bridge–St. Charles Bridge. Louisiana Transportation Research Center Technical Assistance Report Number 04-2TA, State Project No. 407-04-0034.

28- Cuelho E., Mokwa R. and Akin M. (2006) Preventive Maintenance Treatments of Flexible Pavements: A Synthesis of Highway Practice" FHWA/MT-06-009/8117-26, Western Transportation Institute, Montana State University, Bozeman, Montana
29- Craig J. (2009) "Nebraska Pavement Management System" http://www.dor.state.ne.us/mat-n-tests/pdfs-docs/npms.pdf accessed Oct 2010.
30- MNDOT (2009) "Pavement Condition Executive Summary" Report #: MnDOT/ OMRR-PM--2009-01, Office of Materials and Road Research, Minnesota
31- Flintsch G.W., Dymond R., and Collura J. (2004) "Pavement Management Applications Using Geographic Information Systems: *A Synthesis of Highway Practice" NCHRP synthesis 355, Transportation Research Board, Washington, D.C.*
32- Papagiannakis A., Gharaibeh N., Weissmann J., and Wimsatt A. (2009) "Pavement Scores Synthesis" FHWA/TX-09/0-6386-1, Texas Transportation Institute, The Texas A&M University System, College Station, Texas
33- Peshkin, D.G., T.E. Hoerner, and K.A. Zimmerman (2004) "Optimal Timing of Pavement Preventive Maintenance Treatment Applications" NCHRP Report 523, Transportation Research Board, Washington, D.C.
34- Zimmerman, K.A. Pavement Management Methodologies to Select Projects and Recommended Preservation Treatments. NCHRP Synthesis 222, Transportation Research Board, 1997.
35- Haas, R., Hudson, W. Ronald, and Zaniewski, John, *Modern Pavement Management*, Malabar, Florida, Krieger Publishing Company, 1994.
36- Transportation Association of Canada, "Pavement Design and Management Guide," 1997.
37- Peng F. and Ouyang, Y. (2010) "Pavement Program Planning Based on Multi-Year Cost-effectiveness Analysis" Research Report ICT-R27-34, University of Illinois at Urbana-Champaign.

APPENDIX A:
QUESTIONNAIRE STRUCTURE AND QUESTIONS

District: ______________________________ Date: ______________________________

Responder(s): ______________________________ Interviewer(s): ______

Preventive Maintenance and Rehab Decision Process Interview Questions

(Research Project 0-6586: Review of Best Practices for the Selection of Rehab and Preventive Maintenance Projects)

DEFINITION: Preventive Maintenance (PM) relates to pavement treatments that do not add structural capacity, but rather improve the surface condition of the pavement.

A. Responder(s) Information:

1. What is your current position in the district?

2. How long have you been working for TxDOT? Do you also have non-TxDOT experience?

3. Please describe your role in selecting rehab and PM activities in your district.

B. District Use of PM and Rehab Pavement Treatments:

1. How would you describe your district's use level of each of the listed treatment methods?

PM Pavement Treatments	Use Level		
	Never	*Infrequently*	*Frequently*
a. Fog seal (Item 315)			
b. Cleaning and sealing joints & cracks in flexible pavements (Item 712)			
c. Seal coat/chip seal (Item 316)			
d. Multiple course seal coat (Item 316)			
e. Asphalt rubber seal coat (Item 318)			
f. Permeable friction course overlay (Item 342)			
g. Paver-laid surface treatment (Novachip)			
h. Wheel path microsurfacing (Item 350)			
i. Full-width microsurfacing (Item 350)			
j. Multiple course microsurfacing (Item 350)			
k. Slurry seal			

l. Planing and texturing flexible pavements (Item 354)			
m. Planing and texturing rigid pavements (Item 354)			
n. Others for rigid or flexible pavements: ____________________ ____________________			

Rehab Pavement Treatments	Use Level		
	Never	*Infrequently*	*Frequently*
a. Fabric underseal & thin HMAC overlay (< 2 inches) (Items 356 and 340, 341, 344, or 346)			
b. Seal coat & thin HMAC overlay (< 2 inches) (Items 316 and 340, 341, 344, or 346)			
c. Thin HMAC overlay (< 2 inches) (Items 340, 341, 344, and 346)			
d. Ultra-thin bituminous overlay (< 20 mm and ¾ inch)			
e. Hot in-place recycling & thin HMAC overlay (Items 358 and 340, 341, 344, or 346)			
f. Hot in-place recycling (Item 358)			
g. Cold in-place recycling & seal coat			
h. Cold milling & bituminous overlay (< 40 mm or 1 ½ inch)			
i. Repair of localized sections of flexible pavement (Item 351)			
j. Full-depth repair of concrete pavement (Item 361)			
k. Bituminous shoulder work (remove & replace shoulder)			
l. Others for rigid or flexible pavements: ____________________ ____________________			

C. General Questions about the District's PM/Rehab Project Selection Processes:

1. When do the PM and rehab project selection processes generally begin each year, and who initiates the processes in your district?

2. Are PM and Rehab project selection decisions made simultaneously and by the same group of decision-makers in your district? Yes__ No__

3. Do you split the pavement budget into PM and Rehab from the outset? Yes__ No__

4. Does the PM budget include any non-pavement items (e.g., grass cutting?) Yes__ No__

5. What levels of the district organization and offices are involved, from putting together initial project nominations to final project selections, for both PM and rehabilitation projects?

6. At what organization level does consideration of whether PM or rehab funding is most appropriate begin? At what level is the final decision made?

D. Tools Currently Used by Your District in Selecting Pavements for Treatment and in Deciding between PM and Rehab Pavement Treatments:

1. Which of the following tools does your district use for deciding a PM or Rehab action in your district?
   a. Needs Assessment Report from PMIS
   b. Pavement PMIS condition scores
   c. A district-developed approach based on:
      ____ PMIS data
      ____ Site visual inspection
      ____ Other, or combination

2. If your district uses own approach, please give details:
   a. Is this approach somehow documented? ___Y, ____N. **If Yes, please supply the study team with a copy.**
   b. Does it consider traffic level? If so, what are the ADT/lane break points?
      _________ ADT/lane
      _________ ADT/lane
      _________ ADT/lane

c. Does it consider pavement structural information? If so, how, and are there SI breakpoints?

SI: (1-100)	Functional Class/ Traffic Level
1) ______________	1) ______________/_____________
2) ______________	2) ______________/_____________
3) ______________	3) ______________/_____________
4) ______________	4) ______________/_____________

d. Is friction (skid data) an overriding consideration to cause selection of a project for available PM or rehab funding? Yes___ No___
If yes, what are the threshold values? Do they vary by functional class or traffic level?

FN	Functional Class/ Traffic Level
1) ______________	1) ______________/_____________
2) ______________	2) ______________/_____________
3) ______________	3) ______________/_____________
4) ______________	4) ______________/_____________

e. Is pavement age an overriding consideration to cause selection of a project for available PM or rehab funding? Yes___ No___
If Yes, what are the threshold values?

Age (years)	Functional Class/ Traffic Level
1) ______________	1) ______________/_____________
2) ______________	2) ______________/_____________
3) ______________	3) ______________/_____________
4) ______________	4) ______________/_____________

f. Is pavement roughness an overriding consideration to cause selection of a project for available PM or rehab funding? Yes___ No___
If Yes, what are the threshold values?

IRI or Other	Functional Class/ Traffic Level
1) ______________	1) ______________/_____________
2) ______________	2) ______________/_____________
3) ______________	3) ______________/_____________
4) ______________	4) ______________/_____________

g. Similarly to the above four questions, does your district's approach include threshold values for any individual distress types which necessitate treatment? If so, please indicate the probable treatment corresponding to the distress level below. Also, or alternatively, does your district consider specific combinations of factors, possibly including both distress levels and structural, skid, age, and/or roughness levels which necessitate treatment? If so, please describe.

Distress Type	Probable Rehab or PM Technique	Threshold Value	Functional Class / Traffic Level	Threshold Value	Functional Class/Traffic Level
Shallow Rutting					
Deep Rutting					
Patching					
Failures					
Block Cracking					
Allig. Cracking					
Long. Cracking					
Trans. Cracking					
Raveling					
Flushing					
Spalled Cracks (Rigid Pavements)					
Punchouts (Rigid Pavements)					
Asphalt Patches (Rigid Pavements)					
Concrete Patches (Rigid Pavements)					
Avg. Transverse Crack Spacing (Rigid Pavements)					
Failed Joints/Cracks (Rigid Pavements)					

h. What other considerations beyond those discussed so far impact selections of projects for specific PM or rehabilitation techniques?

i. When deciding which project or two gets the last funding available in each of the two funding categories, PM and rehab, what do you use as tie-breakers when needs for the work are very similar among a number of projects?

j. Do PM or rehab needs for rigid pavements take some degree of preference over flexible pavement needs, or vice versa, when selecting projects for limited funding? If so, how?

E. Closing Questions:

1. In your district, what type or types of distresses or other conditions most frequently warrant planning for rehabilitation instead of PM for a pavement under consideration?
2. Conversely, in your district, what type or types of distresses or other conditions most frequently warrant PM instead of rehabilitation for a pavement under consideration?
3. What would you say is the most important distress consideration when selecting the PM or rehab method for flexible pavements? For rigid pavements?
4. Does your district have a formal or informal method of evaluating and comparing performances of the various PM and rehab methods and materials you most frequently use? If so, please describe how this is done.
5. Has your district done informal experiments to determine when certain PM or rehab methods are most appropriate? Is so, please describe what you did and learned.
6. What advice would you give to someone asked to provide initial PM and rehab project nominations for the first time?
7. Additional comments, if any.

****

Pavement Site Visit Portion of Interview

****

Desired Pavement Examples for Viewing and Photography while in District:

1. Strong PM candidate flexible pavement with higher end ADT.
2. Strong PM candidate flexible pavement with lower end ADT.
3. Strong PM candidate rigid pavement.
4. Strong rehab candidate flexible pavement with higher end ADT.
5. Strong rehab candidate flexible pavement with lower end ADT.
6. Strong rehab candidate rigid pavement.
7. One or two pavements that straddle PM and rehab warrants and could go either way.

Note: We will need to obtain county, highway, and begin and end reference markers for each candidate project visited.)

APPENDIX B:
EXAMPLES OF CANDIDATE SITES FOR PM AND REHAB TREATMENT

The following categories have been used to identify the project treatment methods in the study:

Category 1: Strong PM candidate flexible pavement with higher end ADT.
Category 2: Strong PM candidate flexible pavement with lower end ADT.
Category 3: Strong PM candidate rigid pavement.
Category 4: Strong rehab candidate flexible pavement with higher end ADT.
Category 5: Strong rehab candidate flexible pavement with lower end ADT.
Category 6: Strong rehab candidate rigid pavement.
Category 7: One or two pavements that straddle PM and rehab warrants and could go either way.

Abilene District

Category 1: IH 20 from 0.35 miles West of Wells Lane to Shirly Road

Category 2: FM 600 from IH 20 to FM 3034

Category 4: FM 2833 from SH 351 to Jones county line

Category 5: US 83 frontage road from Ambler Ave to N 1st

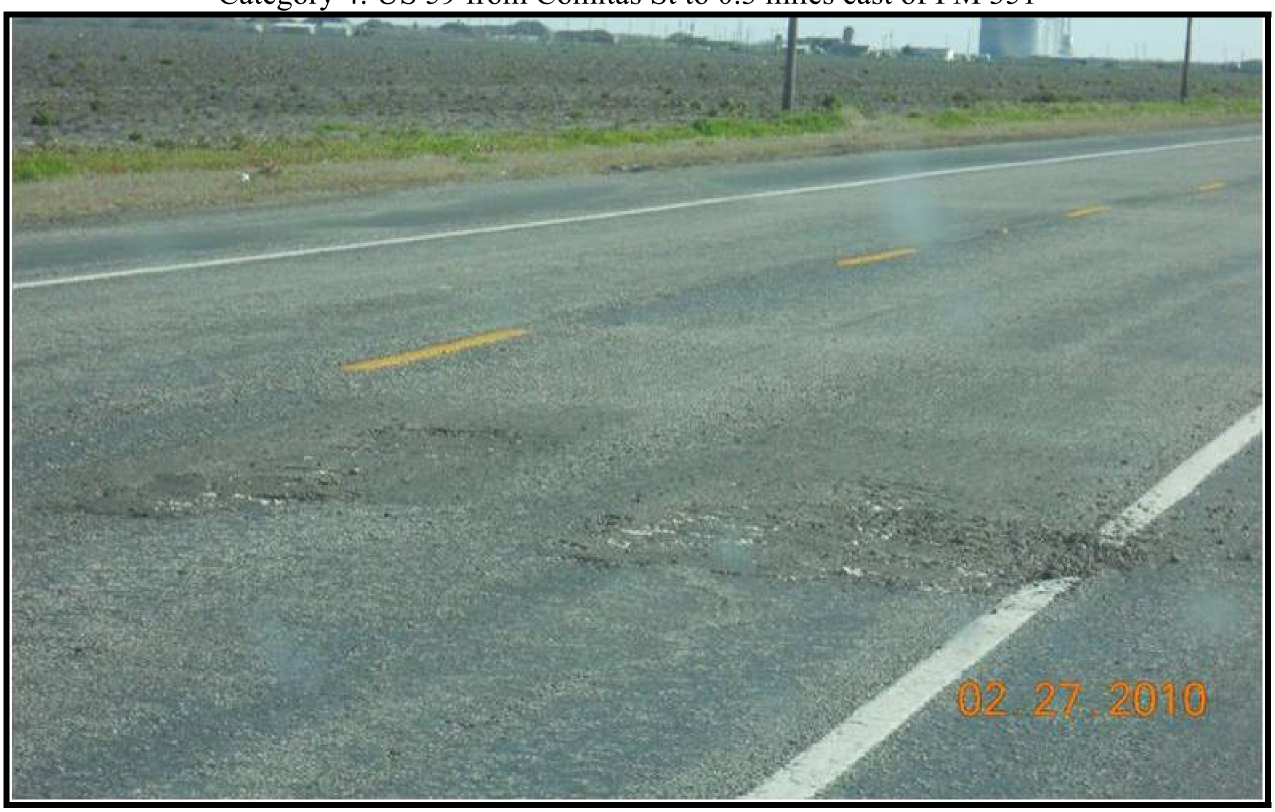
Category 7: US 83 from FM 2404 to Jones county line

Corpus Christi

Category 1: FM 43 from SH 358 to SH 357

Category 2: FM 624 from FM 70 to SH 359

Category 4: US 59 from Comitas St to 0.3 miles east of FM 351



Category 5: FM 2444 from FM 43 to East of CR 57

Category 7: FM 624 from SH 359 to US 281 (Edge failure)

El Paso District

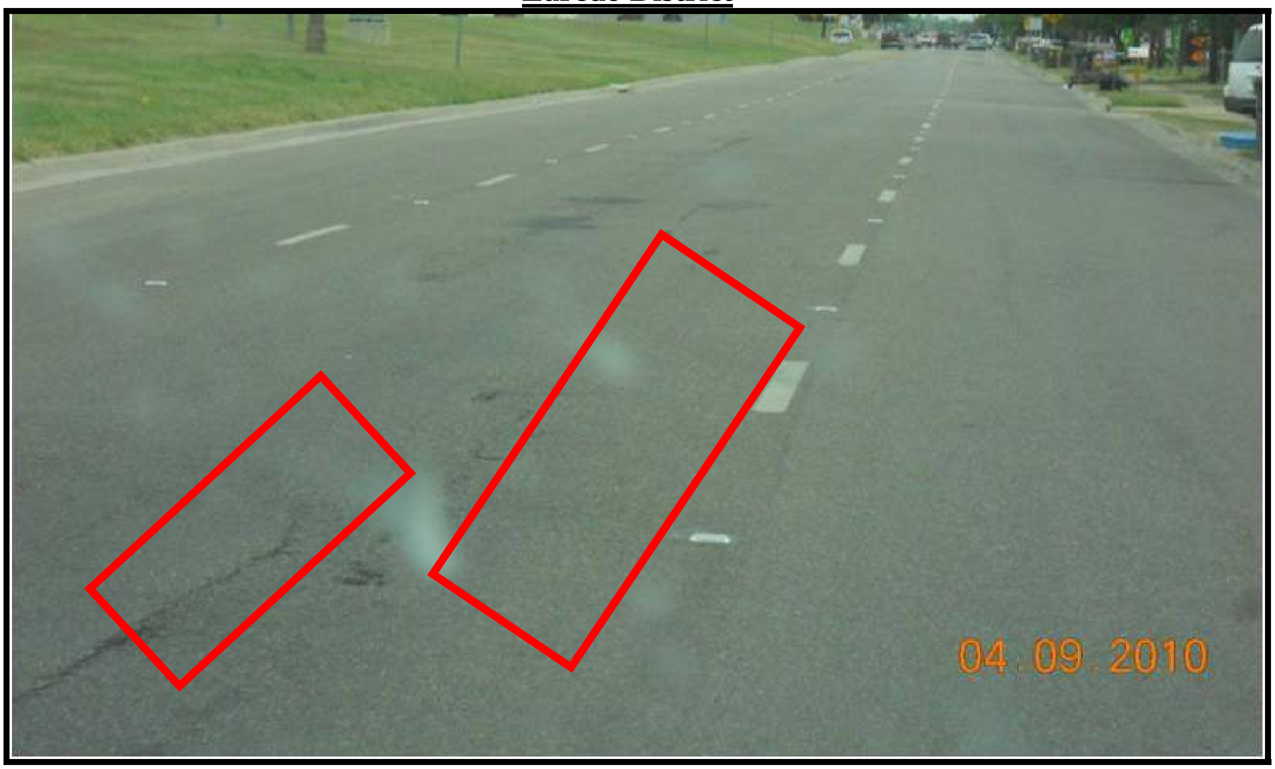
Category 1: IH 10 frontage road

Category 2: FM 1109

Category 4: FM 1281 from 0.3 miles E of IH 10 to 3.3 miles E of IH 10

Category 6: IH 10 from downtown El Paso to US 54

Laredo District



Category 1: IH 35 from Scott St to Delmar Blvd (cracking and rutting in the wheel path)

Category 2: FM 3338 from FM 1472 to SH 255

Category 4: FM 1472 from 0.5 miles N of Interamerica Blvd to 0.5 miles S of Interamerica Blvd

Category 7: US 83 from Palo Blanco to 1.7 miles South of Palo Blanco

Lufkin District

Category 1: Northbound US 59 from San Jacinto county line to FM 3460

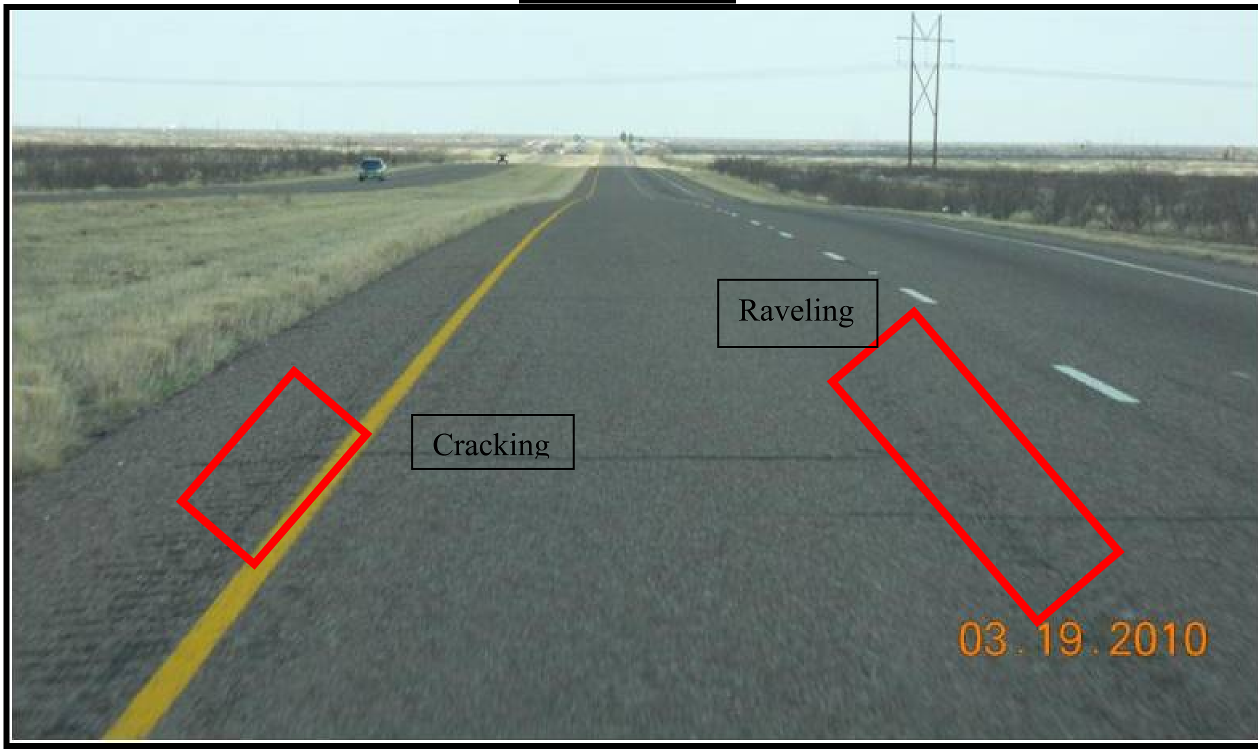
Category 2: FM 2109 from FM 1669 to SH 147 (Skid problem)

Category 4: Southbound US 59 (Livingston city limits) (reflective cracking)

Category 5: FM 95 from US 59 to SH 21

Category 7: US 69 from SL 287 to FM 326

Odessa District



Category 1: US 385 from SH 176 to Ector county boundary line

Category 2: SH 349 from SH 176 to Midland county boundary line (Raveling)

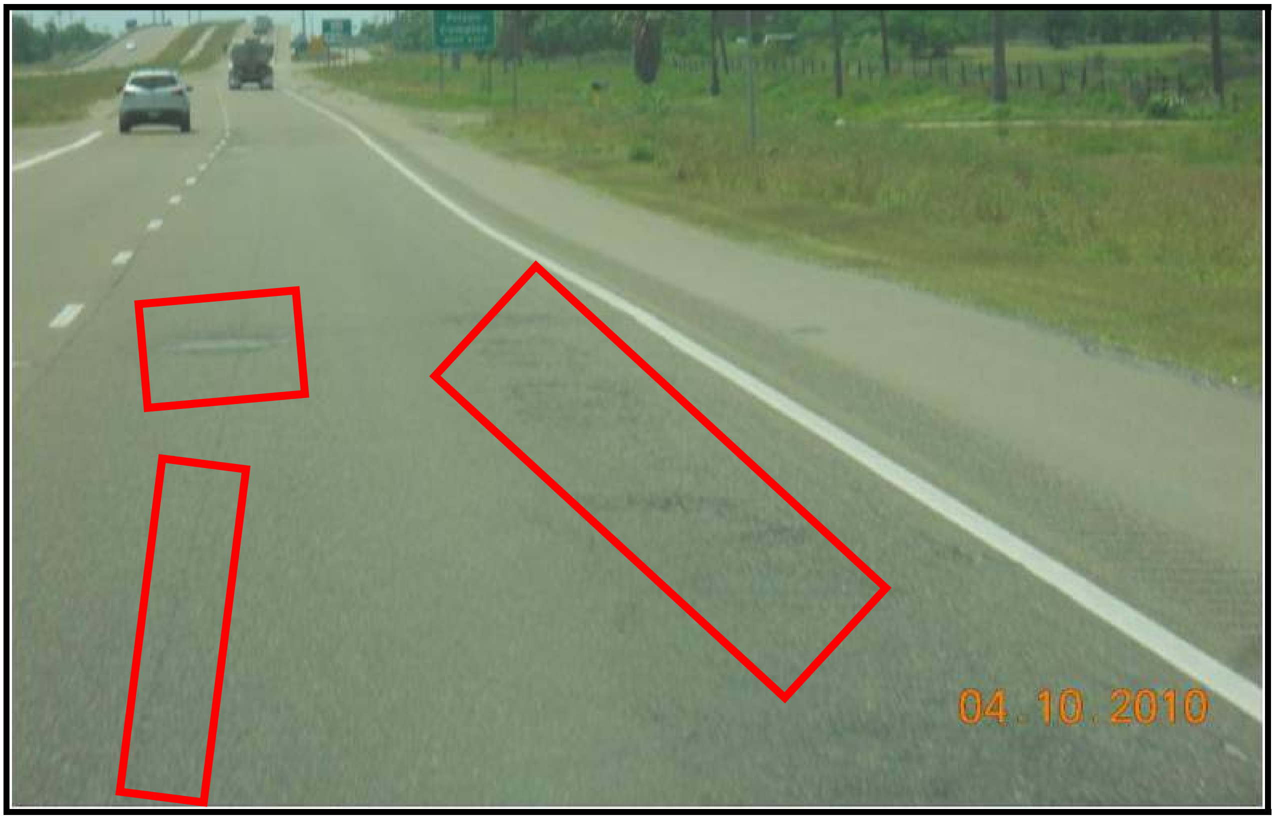
Category 4: SL 250 from BI 20 to SH 349

Category 5: BI 20 from SL 250 to SL 338 (wheel path rutting)

Pharr District

Category 1: US 83 from FM 494 to FM 1016

Category 2: FM 907 from SH 107 to FM 1925 (long. and trans. cracking)



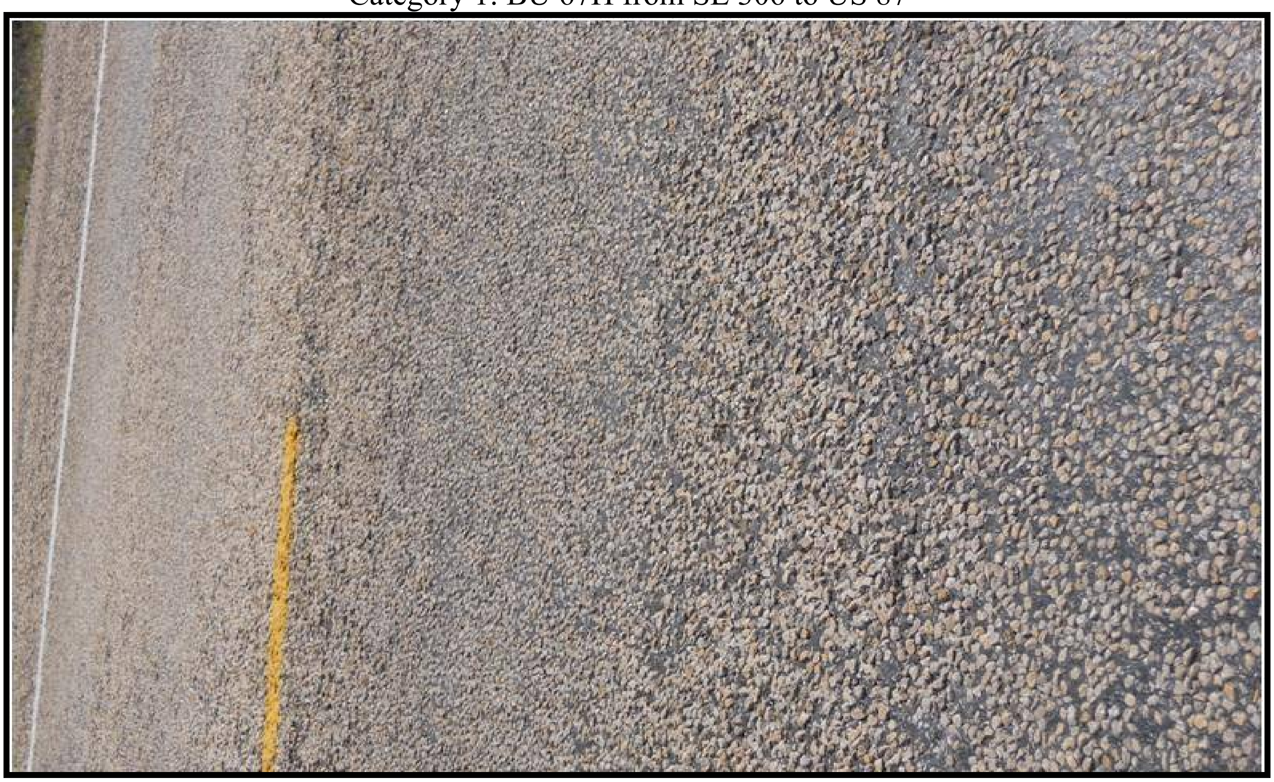
Category 4: US 281 from FM 2812 to FM 490 (potholes and long cracking)

Category 5: FM 2557 from BU 83 to US 281

Category 7: FM 2220 from SH 107 to FM 1924 (wheel path rutting)

San Angelo District

Category 1: BU 67H from SL 306 to US 87



Category 2: SH 163 from Crockett county line to 2.5 miles north of US 190

Category 5: RM 853 from Irion County line to US 67

San Antonio District

Category 1: US 90 from west of SL 1604 to Bexar county line (long. cracking and poor ride)

Category 2: FM 1535 (wheel path rutting)

Category 4: IH 410 SB+NB FR from FM 78 to Rittiman (potholes and long. and trans. cracking)


Category 5: FM 758 from 2.7 miles East of SH 46 to SH 123 (base repair and poor ride)

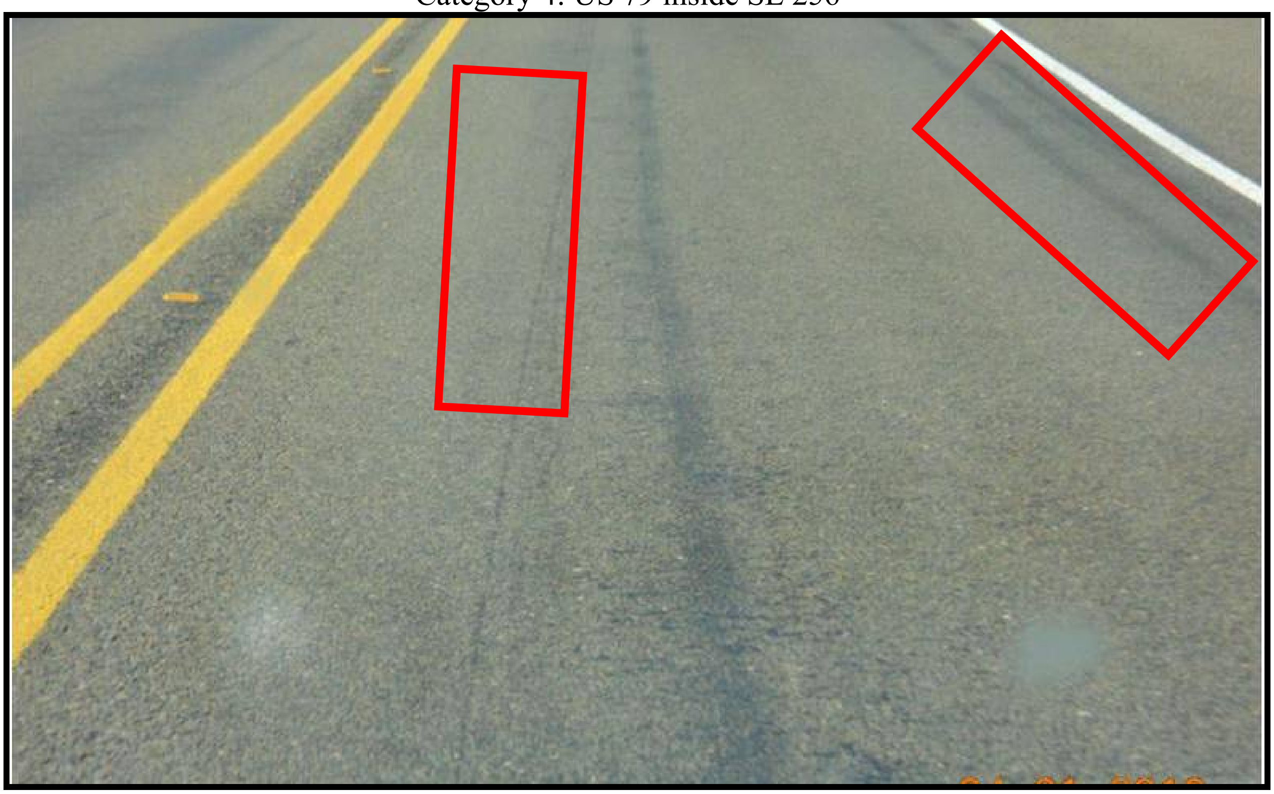
Category 7: FM 758 from Guadalupe county line to FM 78 (long. cracking and raveling)

Tyler District

Category 1: FM 2493 from US 69 to SL 323

Category 2: FM 322 from SL 256 to SH 294 (shallow rutting and raveling)

Category 4: US 79 inside SL 256


Category 5: US 287 from SH 294 to FM 2419 (raveling and poor ride)

Category 7: SH 294 from FM 322 to US 287

APPENDIX C:
TABLE FORMS OF QUESTIONNAIRE RESPONSES

SECTION I: RESPONDER(S) INFORMATION

1. What is your current position in the district? How long have you been working for TxDOT? Do you also have non-TxDOT experience?

District	Position	Years of Experience	Non-TxDOT Experience
Abilene	PE	10	NA
Corpus	DoM, ME, and Planner	3-26	NA
El-Paso	PE	20	4
Laredo	Advanced project development engineer and PE	11 and 7	0 and 1.5
Lubbock	DoC, DTO, DoM, DEs, AEs	14-32	NA
Lufkin	ME and DoM	35 and 22	NA
Odessa	DoO	25	NA
Pharr	DoM	15	NA
San Angelo	DoO	30	NA
San Antonio	DoM	22	NA
Tyler	DoO	25	0.5
Yoakum	DoM	36	NA
Waco	DoM	38	NA
Brownwood	DoO	29	NA
Amarillo	Design engineer and AEs	18-22	NA
Atlanta	NA	NA	NA
Fort Worth	DoM	20	5.5
Houston	Program administrator and DoM	18 and 25	NA
Austin	DoM	27	NA
Dallas	DoM and DoO	25 and 3	1 and NA
Childress	DoO	22	NA
Wichita Falls	DoO	27	NA

DoC: Director of Construction, DoT: Director of TP&D, DoM: Director of Maintenance, DoO; Director of Operation, MS: Maintenance Supervisor, MR: Maintenance Representative, ME: Maintenance Engineer, AE: Area Engineer, PE: Pavement Engineer, DE: District Engineer

SECTION II: DISTRICT USE OF PM AND REHAB PAVEMENT TREATMENTS

How would you describe your district's use level of each of the listed treatment methods?

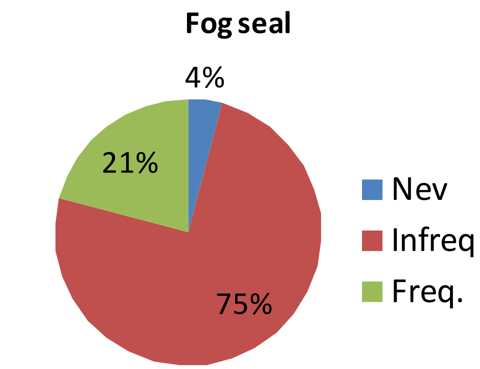
Table C.1. Breakdown for PM Treatments Use in Flexible Pavement/Rigid Pavement per District.

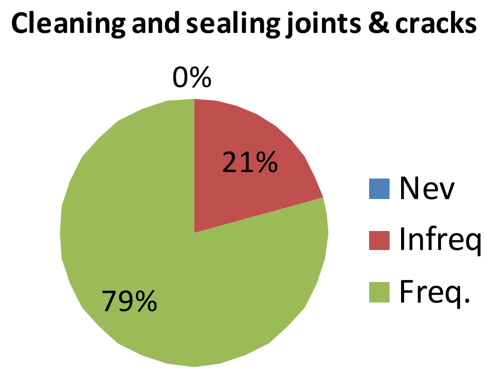
District	Fog Seal	Cleaning and sealing joints & cracks	Seal coat/ chip seal	Multi-ple course seal coat	Rubber seal coat	Perm. friction course over-lay	Surface treatment (Nova-chip)	Wheel path micro-surfacing	Full-width micro surfacing	Multi-ple micro surfa-cing	Slurry seal	Planning and texturing	Planning & texturing rigid	Others for rigid or flexible pavements
Abilene	Infreq	Freq	Freq	Infreq	Freq	Freq	Nev	Infreq	Freq	Freq	Nev	Infreq	Nev	Nev
Corpus	Infreq	Freq	Freq	Freq	Infreq	Infreq	Infreq	Nev	Infreq	Nev	Nev	Freq	Nev	Nev
El Paso	Infreq	Freq	Freq	Freq	Freq	Nev	Nev	Nev	Infreq	Nev	Nev	Infreq	Infreq	Nev
Laredo	Infreq	Infreq	Freq	Freq	Freq	Nev	Infreq	Nev	Infreq	Nev	Nev	Freq	Nev	Nev
Lubbock	Infreq	Freq	Freq	Nev	Infreq	Infreq	Infreq	Nev	Infreq	Infreq	Nev	Infreq	Nev	Infreq
Lufkin	Infreq	Freq	Freq	Infreq	Infreq	Freq	Nev	Freq	Freq	Freq	Infreq	Freq	Nev	Nev
Odessa	Infreq	Freq	Freq	Freq	Freq	Infreq	Infreq	Infreq	Infreq	Nev	Infreq	Freq	Nev	Nev
Pharr	Freq.	Freq	Freq	Infreq	Infreq	Infreq	Infreq	Infreq	Infreq	Infreq	Freq	Freq	Infreq	Freq
San Angelo	Nev	Infreq	Freq	Nev	Nev	Infreq	Nev	Nev	Infreq	Infreq	Nev	Freq	Nev	Freq
San Antonio	Infreq	Freq	Freq	Freq	Freq	Freq	Freq	Nev	Infreq	Nev	Nev	Freq	Nev	Freq
Tyler	Freq.	Infreq	Freq	Infreq	Infreq	Infreq	Infreq	Nev	Nev	Nev	Nev	Freq	Nev	Freq
Yoakum	Infreq	Infreq	Freq	Freq	Infreq	Infreq	Nev	Nev	Infreq	Infreq	Nev	Freq	Infreq	Nev
Waco	Infreq	Infreq	Freq	Freq	Nev	Nev	Infreq	Infreq	Infreq	Nev	Nev	Infreq	Nev	Nev
Brownwood	Infreq	Infreq	Nev	Nev	Infreq	Nev	Nev	Infreq	Nev	Nev	Nev	Infreq	Nev	Nev
Amarillo	Infreq	Freq	Freq	Nev	Infreq	Infreq	Infreq	Infreq	Infreq	Infreq	Nev	Infreq	Nev	Infreq
Atlanta	Infreq	Infreq	Freq	Freq	Infreq	Nev	Freq	Freq	Freq	Infreq	Infreq	Infreq	Infreq	Freq
Fort Worth	Infreq	Infreq	Freq	-	Nev	Nev	Nev	Infreq	Infreq	Infreq	Nev	Nev	Infreq	Freq
Houston	Infreq	Infreq	Infreq	Infreq	Freq	Freq	Infreq	Infreq	Infreq	Nev	Nev	Freq	Infreq	Freq
Austin	Infreq	Freq	Freq	Infreq	Nev	Freq	Freq	Infreq	Infreq	Nev	Infreq	Freq	Nev	Freq
Dallas	Freq.	Freq	Freq	Nev	Infreq	Freq	Freq	Infreq	Freq	Infreq	Nev	Infreq	Infreq	Nev
Childress	Freq.	Freq	Freq	Nev	Infreq	Nev	Infreq	Infreq	Infreq	Infreq	Nev	Infreq	Infreq	Nev
Wichita Falls	Infreq	Freq	Freq	Nev	Freq	Freq	Freq	Infreq	Infreq	Infreq	Nev	Infreq	Infreq	Infreq
Beaumont	Infreq	Infreq	Infreq	Freq	Freq	Nev	Infreq	Freq	Infreq	Infreq	Nev	Nev	Infreq	Freq
Bryan	Infreq	Freq	Freq	Freq	Infreq	Infreq	Freq	Nev	Nev	Infreq	Infreq	Nev	Infreq	Nev
Paris	No data available													

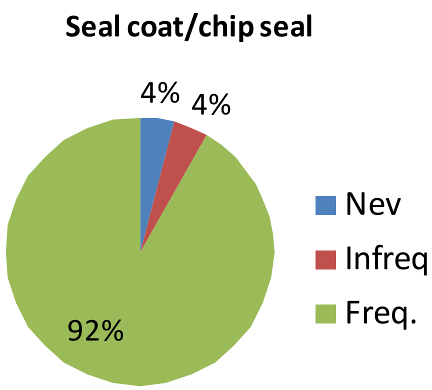
Table C.1. Breakdown for Rehab Treatments Used in Flexible Pavement/Rigid Pavement per District.

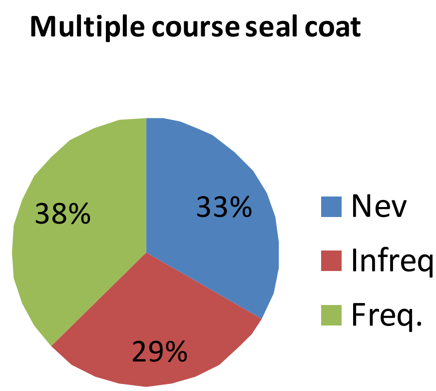
District	Fabric underseal & thin HMAC overlay (< 2″)	Seal coat & thin HMAC overlay (< 2″)	Thin HMAC overlay (< 2″)	Ultra-thin bituminous overlay (< ¾ inch)	Hot in-place recycling & thin overlay	Hot in-place recyc-ling	Cold in-place recycling & seal coat	Cold milling & bituminous overlay (<1 ½″)	Repair of localized sections of flexible pavement	Full-depth repair of concrete pavement	Bituminous shoulder (remove & replace shoulder)	Others for rigid or flexible pavements
Abilene	Infreq	Freq	Freq	Infreq	Nev	Nev	Nev	Freq	Freq	Nev	Nev	Freq
Corpus	Nev	Freq	Freq	Infreq	Infreq	Freq	Infreq	Infreq	Freq	Nev	Nev	Freq
El-Paso	Nev	Infreq	Freq	Nev	Infreq	Nev	Nev	Nev	Freq	Freq	Infreq	Nev
Laredo	Nev	Infreq	Freq	Nev	Nev	Nev	Nev	Freq	Freq	Nev	Nev	Nev
Lubbock	Infreq	Freq	Nev	Nev	Nev	Nev	Nev	Freq	Freq	Freq	Infreq	Freq
Lufkin	Nev	Freq	Freq	Freq	Infreq	Infreq	Infreq	Freq	Freq	Freq	Nev	Freq
Odessa	Infreq	Freq	Freq	Nev	Nev	Nev	Nev	Infreq	Freq	Infreq	Infreq	Freq
Pharr	Infreq	Freq	Freq	Nev	Infreq	Infreq	Infreq	Freq	Freq	Nev	Infreq	Freq
San Angelo	Freq	Freq	Infreq	Nev	Nev	Nev	Nev	Nev	Nev	Nev	Infreq	Freq
San Antonio	Nev	Freq	Infreq	Nev	Nev	Nev	Nev	Freq	Freq	Infreq	Infreq	Freq
Tyler	Nev	Freq	Freq	Nev	Infreq	Infreq	Nev	Freq	Freq	Infreq	Infreq	Nev
Yoakum	Infreq	Freq	Freq	Nev	Infreq	Infreq	Nev	Freq	Freq	Freq	Infreq	Nev
Waco	Nev	Freq	Freq	Freq	Nev	Nev	Nev	Freq	Freq	Infreq	Infreq	Infreq
Brownwood	Nev	Freq	Freq	Nev	Nev	Nev	Nev	Infreq	Freq	Nev	Freq	Infreq
Amarillo	Nev	Infreq	Freq	Infreq	Infreq	Nev	Infreq	Freq	Freq	Infreq	Infreq	Nev
Atlanta	Infreq	Infreq	Freq	Infreq	Infreq	Infreq	Infreq	Infreq	Freq	Freq	Infreq	Freq
Fort Worth	Infreq	Infreq	Infreq	Nev	Nev	Nev	Nev	Infreq	Freq	Freq	Infreq	Freq
Houston	Infreq	Freq	Infreq	Infreq	Nev	Freq	Freq	Freq	Freq	Freq	Freq	Nev
Austin	Infreq	Freq	Infreq	Infreq	Infreq	Infreq	Nev	Freq	Freq	Freq	Nev	Nev
Dallas	Infreq	Freq	Infreq	Nev	Infreq	Infreq	Nev	Nev	Freq	Freq	Freq	Freq
Childress	Infreq	Freq	Freq	Infreq	Nev	Nev	Nev	Freq	Freq	Infreq	Freq	Infreq
Wichita Falls	Infreq	Infreq	Freq	Nev	Infreq	Nev	Infreq	Freq	Freq	Infreq	Infreq	Nev
Beaumont	Nev	Freq	Infreq	Infreq	Nev	Nev	Freq	Nev	Freq	Freq	Infreq	Freq
Bryan	Nev	Freq	Freq	Nev	Freq	Nev	Nev	Freq	Freq	Freq	Infreq	Nev
Paris	No data available											

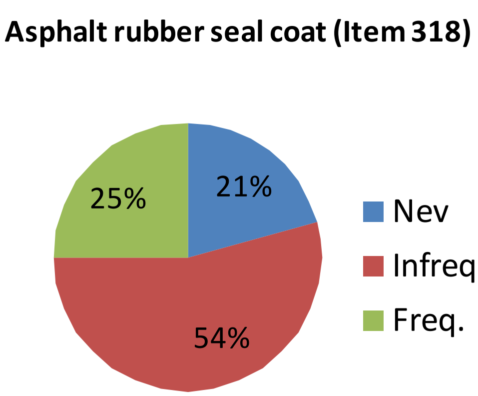
Summary of PM treatments frequently used in the districts

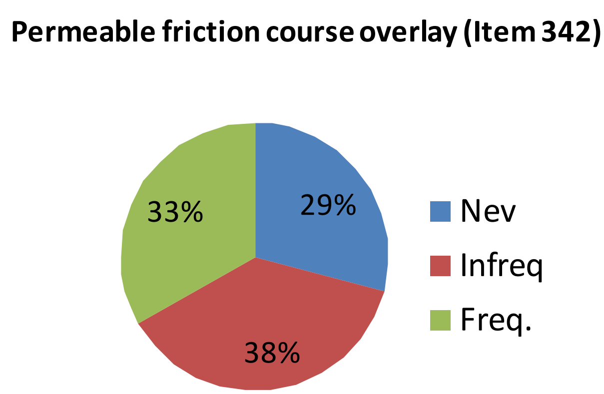




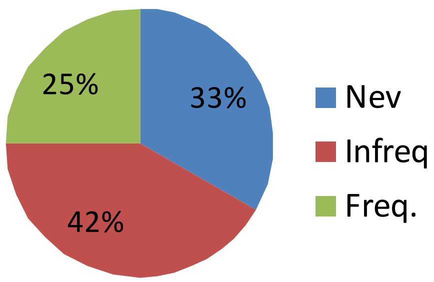




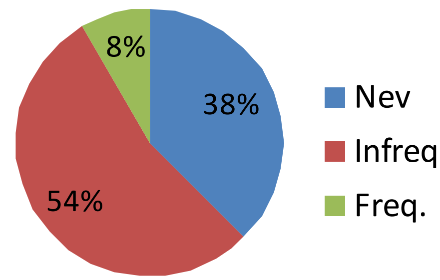




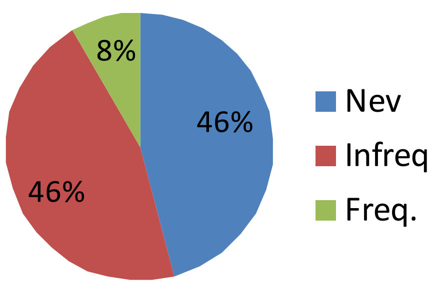
Paver-laid surface treatment (Novachip)



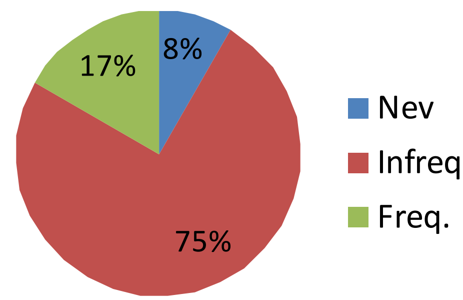
Wheel path microsurfacing (Item 350)



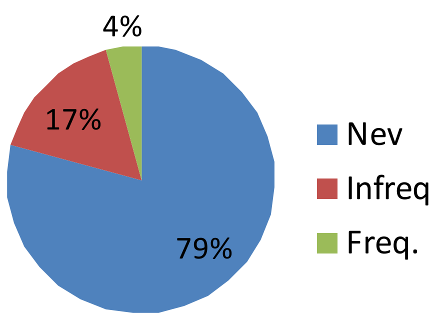
Multiple course microsurfacing (Item 350)



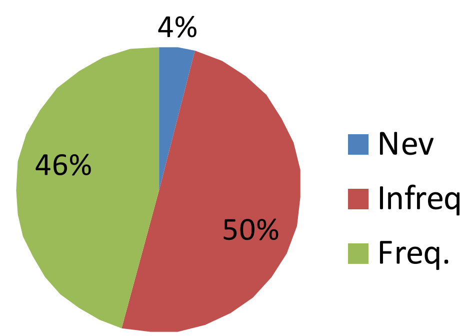
Full-width microsurfacing (Item 350)



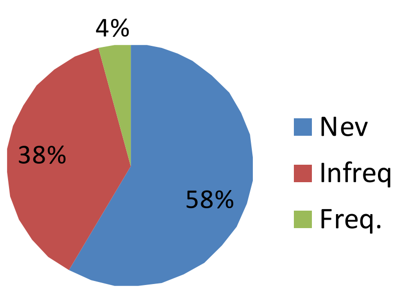
Slurry seal



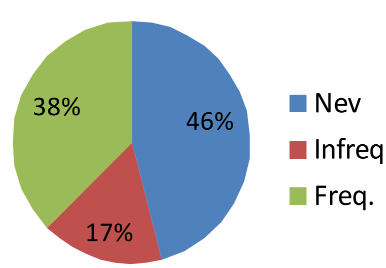
Planing and texturing flexible pavements



Planing and texturing rigid pavements

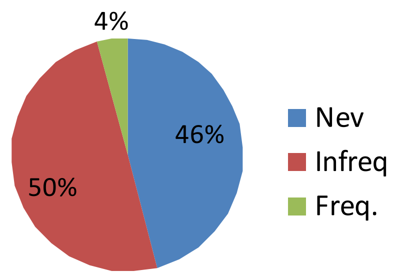


Others for rigid or flexible pavements:

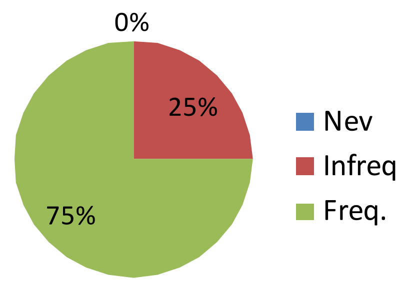


Summary of Rehab treatments frequently used in the districts

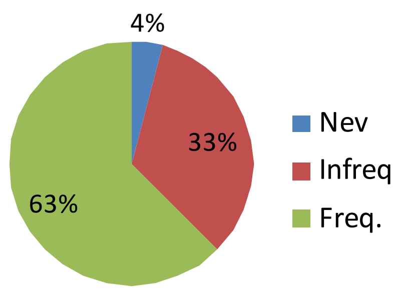
Fabric underseal & thin HMA overlay (< 2")



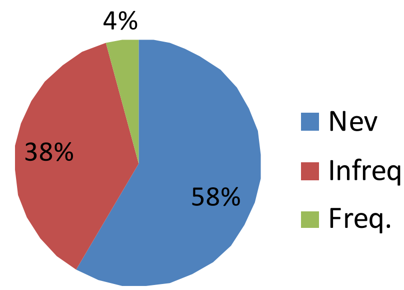
Seal coat & thin HMA overlay (< 2")



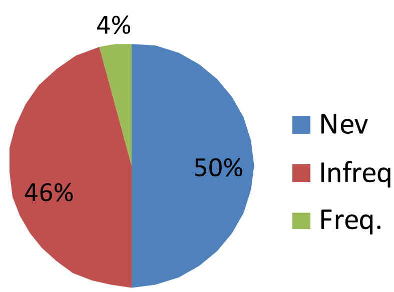
Thin HMA overlay (< 2")



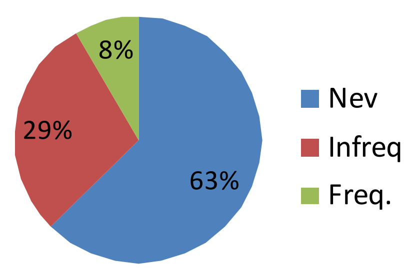
Ultra-thin bituminous overlay (< ¾")



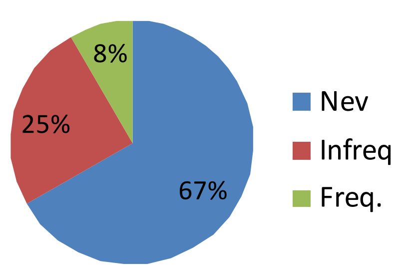
Hot in-place recycling & thin HMA overlay



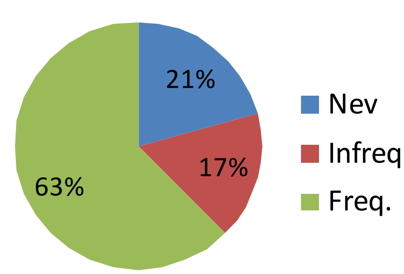
Hot in-place recycling



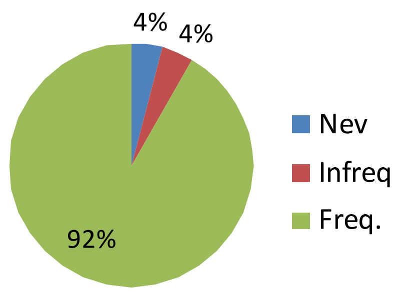
Cold in-place recycling & seal coat



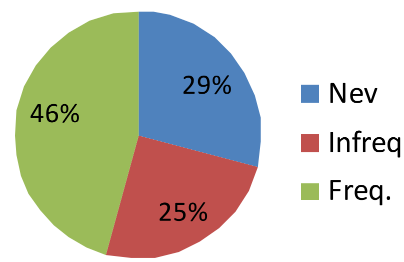
Cold milling & bituminous overlay (< 1 ½")



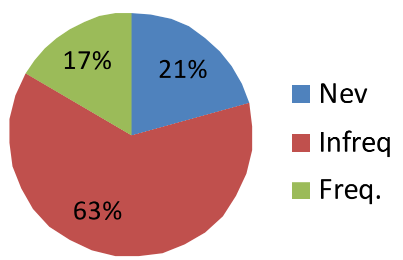
Repair of localized sections of flexible pavement



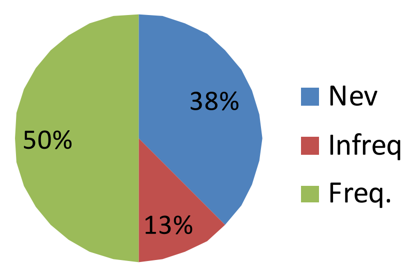
Full-depth repair of concrete pavement



Bituminous shoulder (remove & replace shoulder)



Others for rigid or flexible pavements:



SECTION III: GENERAL QUESTIONS ABOUT THE DISTRICT'S PM/REHAB PROJECT SELECTION PROCESSES

1. When do the PM and rehab project selection processes generally begin each year, and who initiates the processes in your district?

District	Process starting time	Personnel
Abilene	January–March	DoM
Corpus	January–February	DoT
El Paso	February–March	PE
Laredo	February–March	PE and Maint. Supervisor
Lubbock	December–January	DoT
Lufkin	January	DoM
Odessa	December	MS
Pharr	March	DoM
San Angelo	March–April	District Design office
San Antonio	January	DOT and DoM
Tyler	February	DoO and DoT
Yoakum	January	Maintenance Office
Waco	November-December	MS (PM) & AE (RH)
Brownwood	--	DoT or PE
Amarillo	February–March	--
Atlanta	November	AE
Fort Worth	February	DoM
Houston	February–April	DoM and DOT
Austin	March	DoM
Dallas	--	AE
Childress	February–March	DoO and DoT
Wichita Falls	March	AE
Beaumont	December–January	MS
Bryan	January	AE
Paris	--	--

DoC: Director of Construction, DoT: Director of TP&D, DoM: Director of Maintenance, DoO; Director of Operation, MS: Maintenance Supervisor, MR: Maintenance Representative, ME: Maintenance Engineer, AE: Area Engineer, PE: Pavement Engineer, DE: District Engineer

2. Are PM and Rehab project selection decisions made simultaneously and by the same group of decision-makers in your district?

3. Do you split the pavement budget into PM and Rehab from the outset?

4. Does the PM budget include any non-pavement items (e.g., grass cutting?)

District	Que. 2	Que. 3	Que. 4
Abilene	Yes	Yes	Yes
Corpus	Yes	Yes	No
El Paso	Yes	Yes	Yes
Laredo	Yes	Yes	No
Lubbock	Yes	Yes	No
Lufkin	Yes	Yes	No
Odessa	No	Yes	No
Pharr	Yes	Yes	No
San Angelo	Yes	Yes	No
San Antonio	No	Yes	No
Tyler	No	No	No
Yoakum	Yes	Yes	No
Waco	No	Yes	No
Brownwood	Yes	Yes	No
Amarillo	Yes	Yes	No
Atlanta	Yes	Yes	No
Fort Worth	No	Yes	No
Houston	Yes	Yes	Yes
Austin	Yes	Yes	No
Dallas	Yes	Yes	No
Childress	Yes	Yes	No
Wichita Falls	Yes	Yes	No
Beaumont			
Bryan			
Paris			

5. What levels of the district organization and offices are involved, from putting together initial project nominations to final project selections, for both PM and rehabilitation projects?

District	PM	Rehab
Abilene	MS, AE, DoC, DoM, DoT & DE	MS, AE, DoC, DoM, DoT & DE
Corpus	MS, AE, District Design Engineer and DE	MS, AE, District Design Engineer and DE
El Paso	MR, AE, MS, and PE	MR, AE, MS, and PE
Laredo	PE, MS, AE, DoM, DoO, DoC and DoT	PE, MS, AE, DoM, DoO, DoC and DoT
Lubbock	AE, MS and Design office	AE, DoT, ME, CE and DE
Lufkin	MS, AE and DoM	MS, AE and DoM
Odessa	MS, PE, ME, DoT and DoO	MS, PE, ME, DoT and DoO
Pharr	MS, MR, DoM, DoT, DE and staff	MS, MR, DoM, DoT, DE and staff
San Angelo	AE, DoO, DoT and DE	AE, DoO, DoT and DE
San Antonio	AE, DoT and MS	AE, DoT and MS
Tyler	MS, DoO, DoT, DoC, Deputy DE and DE	MS, AE, DoO, DoT, DoC, Deputy DE and DE
Yoakum	MS, AE, DoM, DoC, DoT and DE	MS, AE, DoM, DoC, DoT and DE
Waco	Maintenance superintendent, MS, DoM and DE	AE, DoT and DE
Brownwood	MS, AE, District staff and DE	MS, AE, District staff and DE
Amarillo	MS, AE, District Design Engineer and DE	MS, AE, District Design Engineer and DE
Atlanta	AE, DoO, District lab engineer, Advance project development engineer and District design engineer	AE, DoO, District lab engineer, Advance project development engineer, District design engineer
Fort Worth	DoM, DoC, DoT, PE, AE, MS and seal coat coordinator	DoM, DoC, DoT, DoT, PE, AE, MS and seal coat coordinator
Houston	ME, Area offices, Design, Maintenance, and DoT	ME, Area offices, Design, Maintenance, and DoT
Austin	MS, AE, DoC, DoM, DoT, PE and DE	MS, AE, DoC, DoM, DoT, PE and DE
Dallas	MS, AE, DoO	MS, AE, DoO
Childress	MS, District Maintenance Administrator, AE, DoO and DoT	MS, District Maintenance Administrator, AE, DoO and DoT
Wichita Falls	MS, AE, DoT, DoO and DE	MS, AE, DoT, DoO and DE
Beaumont	MS, AE, DoM, DoC, DoT, PE and DoO	MS, AE, DoM, DoC, DoT, PE and DoO
Bryan	Transportation Engineer Supervisor, DoC, DoO, DoT, and District Design Engineer	Transportation Engineer Supervisor, DoC, DoO, DoT, District Design Engineer and PE
Paris	MS, AE, PE, DoM and DoO	--

6. At what organization level does consideration of whether PM or rehab funding is most appropriate begin? At what level is the final decision made?

District	Organization level	Final Decision
Abilene	AE	DE
Corpus	AE	AE, District Design Engineer and DE
El Paso	District material and pavement engineer	DoC
Laredo	MS and PE's	DE
Lubbock	Area office	District office
Lufkin	DoM, DoM	DE
Odessa	District staff and AE	DE
Pharr	DoM and AE	DE
San Angelo	AE, Maintenance foreman level	DE
San Antonio	MS and AE	DoT and DoM
Tyler	AE, DoO, DoT, DoC, Deputy DE and DE	DE
Yoakum	DoM and DoT	DE
Waco	AE	DE
Brownwood	DoT, PE and DoO	DE
Amarillo	AE	AE, District Design Engineer and DE
Atlanta	Collective decision of planning committee	DE
Fort Worth	MS and AE	DoM and DoT
Houston	--	DoT, District program administrator and DoM
Austin	--	DE
Dallas	--	DoO and DoT
Childress	--	DoT and DE
Wichita Falls	MS	DE
Beaumont	DoM and DoC	DE
Bryan	--	DE and remaining Directors

SECTION IV: TOOLS CURRENTLY USED BY YOUR DISTRICT IN SELECTING PAVEMENTS FOR TREATMENT AND IN DECIDING BETWEEN PM AND REHAB PAVEMENT TREATMENTS

1. Which of the following tools does your district use for deciding a PM or Rehab action in your district? Is this approach somehow documented?

District	Needs assessment report	Condition score	District developed approach			Approach documented
			PMIS data (1)	Site visual inspection (2)	Combination (1) & (2)	
Abilene	√	√			√	No
Corpus		√			√	No
El-Paso		√			√	No
Laredo					√	Yes
Lubbock	√	√				No
Lufkin		√			√	No
Odessa		√			√	No
Pharr		√			√	No
San Angelo		√		√	√	Yes
San Antonio	√	√	√	√	√	No
Tyler		√	√	√	√	No
Yoakum	√	√	√	√	√	No
Waco		√			√	Yes
Brownwood					√	Yes
Amarillo		√			√	Yes
Atlanta		√			√	Yes
Fort Worth		√			√	No
Houston		√			√	No
Austin	√	√	√	√	√	Yes
Dallas	√	√	√	√	√	Yes
Childress	√	√	√	√	√	No
Wichita Falls	√	√	√	√	√	Yes
Beaumont	√	√	√	√	√	No
Bryan		√	√	√	√	Yes
Paris		√	√	√	√	yes

2. (2a-2f) If your district uses own approach, does it consider the following factors/threshold:

District	ADT	SI	FN	Age	IRI
Abilene	√		√		√ (IRI>180 M&I.ADT >10,000)
Corpus	√		√ (only for PM)	√ (SC-7 years)	
El Paso	√ (ADT<5000-SC. ADT>5000-SC or OL)			√ (8 years)	
Laredo	√ (ADT<1000-Inhouse. ADT-3000-Comb of Inhouse with RMC. ADT-10,000-RMC)	√	√	√	
Lubbock	√	√			
Lufkin	√		√ (<20 strong PM)		√
Odessa	√ (500-1250)	√	√ for PM.		√ for PM. X for rehab
Pharr	√ (ADT<5000-SC. ADT>10000-OL)	√	√	√ (7 years-SC)	√(< 2 from PMIS -Milling or OL)
San Angelo	√		√		
San Antonio	√	√ (IH/ADT-10000:OL. Others ADT<25000-SC. Others ADT> 25000-OL)	√		√ IH high speed, high ADT
Tyler	√ (ADT>5000:SC)	√	√		√
Yoakum	√	√ for Rehabs		√ for repairs	
Waco	√	√	√	√ (6years-SC)	√
Brownwood			√		
Amarillo					
Atlanta	√	√	√	√ (15 years-SC)	√ (200-Rehab)
Fort Worth					
Houston		√			√
Austin	√	√	√ (<20 strong PM)		
Dallas	√		√	√ (5years-SC)	
Childress					
Wichita Falls	√				
Beaumont	√				
Bryan	√	√			
Paris	√				

ADT: Average Daily Traffic, SI: Structural Index, FN: Functional Cclass Number, IRI: International Roughness Index, SC-Seal Coat, OL-Overlay

g) Does your district's approach include threshold values for any individual distress types which necessitate treatment? If so, indicate the probable treatment corresponding to the distress level below.

Flexible Pavement

District	Shallow Rutting	Deep Rutting	Patching	Failures	Block	Cracking Allig.	Long.	Trans.	Raveling	Flush-ing
Abilene	PM	RH	PM	PM/RH	PM	RH	<50% PM	<50% PM.	PM	PM
Corpus	PM	RH	-	RH	PM	-	PM	PM	PM	PM
El Paso	PM	RH	PM	RH	PM	PM	PM	PM	PM	PM
Laredo	Mill	Level up or RH	PM	Spot repair or RH	Spot repair or RH	Spot repair or RH	PM(SC)	PM or M&I	PM(SC)	Mill or SC
Lubbock	PM	RH (Mill)				PM-RH				Strip seal or LRH
Lufkin	PM	PM	PM	RH			PM	PM	PM-RH	PM-RH
Odessa		PM								
Pharr	PM	PM /RH	PM	RH	RH	RH	PM-1/2''	PM-1/2''	PM	PM
San Angelo	PM	PM	PM	PM	PM	PM	PM	PM	NA	NA
San Antonio	PM<0.5''									
Tyler	PM	RH	PM	RH	PM/RH	PM or RH	PM	PM	PM	PM
Yoakum				RH		RH	RH	RH	PM	PM
Waco	PM	PM-RH	PM/RH	PM/RH	PM/RH	PM/RH	PM/RH		PM	PM
Brownwood	Micro surf.									
Amarillo		PM/RH		RH			PM		PM(fog or SC)	
Atlanta	PM	RH								PM
Fort Worth	PM	PM	PM	PM		PM or RH	PM	PM	PM	
Houston	PM/RH		Patching	Patching (>0)		RH-20%)	PM (>50ft of 100ft)	PM (.2 ft)		
Austin										
Dallas	PM	RH	PM	PM	PM	RH	PM	PM		
Childress	RH	RH	PM	RH	PM	RH	PM	PM		
Wichita Falls	PM	RH	PM	RH	PM	PM	PM	PM	PM	
Beaumont		RH		RH		RH				
Bryan	PM		RH	RH						
Paris										

SC: Seal coat, M&I: Mill and Inlay

Rigid Pavement

District	Spalled Cracks	Punchouts	Asphalt Patches	Concrete Patches	Avg. Transv. Crack Spacing	Failed Joints/ Cracks
Abilene	No rigid pavements					
Corpus	No rigid pavements					
El Paso	PM/RH	RH	--	Full depth RH	--	PM/RH
Laredo	spot repairs	spot repairs	--	--	--	--
Lubbock	--	Full depth repair	--	Full depth repair	--	--
Lufkin	None	RH	PFC		--	--
Odessa	No rigid pavements					
Pharr	--	--	--	--	--	--
San Angelo	--	--	--	--	--	--
San Antonio	Combined with other factors					
Tyler	PM	Rare	Rare	Rare	PM	PM
Yoakum	--	--	--	--	--	--
Waco	Fiber screed or elastomeric concrete	RH (Full depth repair)	--	--	RH (Fiberscreed, elastomeric or Portland patch)	Fiber screed elastomeric concrete
Brownwood	--	--	--	--	--	--
Amarillo	--	--	--	--	--	asphalt patch
Atlanta	Reconstruction	Reconstruction	Reconstruction	Reconstruction	--	--
Fort Worth	PM (Flex crete)	PM(Overlay)	--	PM(SC)	--	NA
Houston	Partial depth patch or spall repair (10 or 20 per 100ft generates PM)	Full depth patch (10 per 100 ft)	--	--		PM(>5 in 100 ft-PM)
Austin	--	--	--	--	--	--
Dallas	PM (Flexcrete)	RH (Full depth repair)	--	PM	PM	PM
Childress	Patching	--	--	--	--	--
Wichita Falls	--	PM/RH	PM	PM	--	--
Beaumont	--	--	--	--	--	--
Bryan	--	--	--	--	--	--
Paris	--	--	--	--	--	--

h) What other considerations impact selections of projects for specific PM or rehabilitation techniques?

District	Position
Abilene	Budget, accident reports, Commercial activities, windmills construction
Corpus	Accident history
El-Paso	Budget
Laredo	Budget, urgency of projects, public, political and safety concerns, infrastructure, material availability, evacuation and military routes
Lubbock	Wind mills and dairy forms
Lufkin	Wet weather accidents
Odessa	Accident history and Safety
Pharr	Accident Reports, public and political concerns
San Angelo	Accidents, public concerns and complaints
San Antonio	
Tyler	Budget and accident reports
Yoakum	Pavement width
Waco	
Brownwood	
Amarillo	
Atlanta	Budget
Fort Worth	
Houston	
Austin	Public, political concerns and future development
Dallas	
Childress	Wind mills and oil wells
Wichita Falls	Wind mills and oil wells
Bryan	
Beaumont	
Paris	

i) When deciding which project or two gets the last funding available in each of the two funding categories, PM and rehab, what do you use as tie-breakers?

District	Tie-breaker
Abilene	Budget and work load
Corpus	Budget
El Paso	Age
Laredo	**ADT** and safety
Lubbock	**ADT**
Lufkin	**ADT**, skid and public concerns
Odessa	**ADT** and safety
Pharr	**ADT** and PMIS
San Angelo	Project time length
San Antonio	**ADT** and segment length
Tyler	**ADT**
Yoakum	**ADT**
Waco	Need and fair share to all counties
Brownwood	**ADT**, function class and safety
Amarillo	**ADT**, local economy and support
Atlanta	**ADT**
Fort Worth	**ADT**
Houston	**ADT** and PMIS
Austin	**ADT** and PMIS
Dallas	**ADT** and PMIS
Childress	**ADT**
Wichita Falls	**ADT**, PMIS scores, public concerns and future development
Bryan	**ADT** and politics
Beaumont	**ADT,** judgment and project time length
Paris	

j) Do PM or rehab needs for rigid pavements take some degree of preference over flexible pavement needs, or vice versa, when selecting projects for limited funding? If so, how?

District	
Abilene	No
Corpus	No
El Paso	Flexible over rigid
Laredo	No
Lubbock	Rigid over flexible
Lufkin	No
Odessa	No
Pharr	No
San Angelo	No
San Antonio	No
Tyler	No
Yoakum	Rigid over flexible
Waco	Rigid over flexible
Brownwood	No
Amarillo	No
Atlanta	No
Fort Worth	No
Houston	Flexible over rigid
Austin	No
Dallas	No
Childress	No
Wichita Falls	Flexible over rigid
Beaumont	
Bryan	
Paris	

SECTION V: CLOSING QUESTIONS

1. In your district, what type or types of distresses or other conditions most frequently warrant planning for rehabilitation instead of PM for a pavement under consideration?
2. Conversely, in your district, what type or types of distresses or other conditions most frequently warrant PM instead of rehabilitation for a pavement under consideration?
3. What would you say is the most important distress consideration when selecting the PM or rehab method for flexible pavements? For rigid pavements?

District	Que. 1	Que. 2	Que. 3
Abilene	**Failures**	**Cracking**	Cracking
Corpus	**Failures**, rutting, alligator cracking	**Cracking**, shallow rutting, skid and flushing	Cracking
El-Paso	**Failures** and deep rutting	**Cracking**	For flexible—**failures** and rutting. For rigid—punch outs
Laredo	Pavement **failures** and block cracking,	**Cracking** or PM Cycles	**Failures**, flushings, small ruttings and skid resistance
Lubbock	**Failures**	**Cracking**, wheel path flushing, skid	**Failures**
Lufkin	**Failures**	**Cracking** ,Skid	Surface cracking
Odessa	**Failures** and distress	**Cracking**, skid, age	**Failures**, rutting and skid
Pharr	Base **failures** and rutting	**Cracking**, flushing	Base **failures**
San Angelo	Extensive cracking, severe rutting and ride quality	**Cracking,** patches and shallow rutting	Cracking and rutting
San Antonio	Base **failures**, alligator cracking and deep rutting	PCR>70	Flexible—base **failures**, cracking, pumping fines. Rigid—Skid values, ride quality, punch outs and failures
Tyler	Multiple **failures** or severe rutting	Skid	Combination of age and distresses like rutting, cracking
Yoakum	Base f**ailures**, alligator cracking, longitudinal and transverse cracking	Rutting, raveling, and flushing	For flexible—Base **failures**. For rigid—Punch outs and patches
Waco	Structural issues	**Cracking**	For flexible—Base **failures**. For rigid—Punchouts
Brownwood	**Failures**	**Cracking**, flushing, rutting, hydroplaning, safety	**Failures**, Flushing, rutting, hydroplaning, cracking, and safety
Amarillo	**Failures**	**Cracking**, shallow rutting and raveling	**Failures**
Atlanta	Base **failures**, section loss and structural issues	**Cracking**, shelling, flushing	**Failures** and structural issues
Fort Worth	**Failures**	**Cracking**	Base **failures**
Houston	Rutting and Alligator cracking	**Cracking**	For flexible—longitudinal cracking, alligator cracking, and rutting
Austin	**Failures**	Condition	**Failures**
Dallas	**Failures** and fatigue cracking	**Cracking**, patches	Fatigue cracking and structural problems
Childress	**Failures**, Deep distresses, Alligator cracking	Cost cutting and regular seal coat program	**Failures**, deep distresses, and alligator cracking
Wichita Falls	Alligator cracking, Curb and gutter sections and bridge situation	**Cracking**, shallow rutting, and flushing	Alligator cracking
Beaumont			
Bryan			
Paris			

4. Does your district have a formal or informal method of evaluating and comparing performances of the various PM and rehab methods and materials you most frequently use? If so, please describe how this is done.

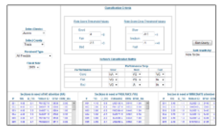
5. Has your district done informal experiments to determine when certain PM or rehab methods are most appropriate? If so, please describe what you did and learned.

District	Que. 4	Que. 5
Abilene	Informal	No
Corpus	Informal	No
El Paso	Informal	No
Laredo	Informal	No
Lubbock	Informal	No
Lufkin	Informal	No
Odessa	Informal	Yes
Pharr	Informal	No
San Angelo	Informal	No
San Antonio	Informal	Yes
Tyler	Informal	Yes
Yoakum	Informal	Yes
Waco	Informal	No
Brownwood	Formal	Yes
Amarillo	Informal	Yes
Atlanta	Informal	No
Fort Worth	Informal	No
Houston	Informal	Yes
Austin	Informal	No
Dallas	Informal	Yes
Childress	Informal	Yes
Wichita Falls	Informal	Yes
Beaumont		
Bryan		
Paris		

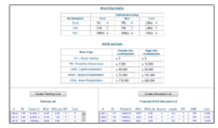
APPENDIX D:
EXAMPLE OF BEST PRACTICES FOR THE SELECTION OF REHAB AND PREVENTIVE MAINTENANCE PROJECTS IN AUSTIN DISTRICT

Austin District
Pavement Management Program Development Standard Operating Procedure

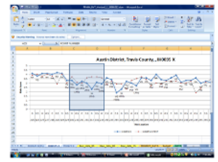
1



2



3, 4



Draft PM Work Program Development

1) PPMM Network Analysis (NN, VG, IA)
2) PPMM Budget analysis using estimated budget
3) Export PPMM data to Excel Sheet with Macros
4) Use Macros to create graphs, select potential projects with route, TRMs and treatment level indicated.

WWARP / CRIS Analysis

6) Evaluate WWARP/CRIS reports
7) Summarize reports from Maintenance Supervisor on crash incidents.
8) Prepare draft list of potential safety treatment projects

6

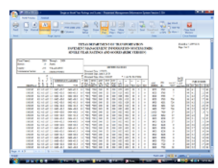
Develop Preliminary Work Program

9) Create preliminary draft program of work.
10) Identify projects that are listed in both the PPMM & WWARP programs (initial top priority)
11) Next tier are WWARP projects that are not PPMM
12) Next tier are PPMM projects that are not WWARP
13) Review preliminary program and add roadways not identified in analysis (if necessary)
14) Prepare preliminary site visit plan of action
15) Initiate office data collection process

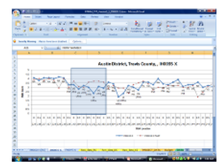
Office Data Collection

16) ADT, number of trucks (Truck ADT), project-level ESALs if available: or PMIS ESALs
17) Graphs / data summary showing current Ride, Distress & Condition and rate-of-loss and project limits (format for easy review during field evaluation)
18) Finalize site visit plan of action (schedule meetings with AEs or Maintenance Supervisors)
19) Email Schedules to AEs / Maintenance Supervisors and staff

16

17

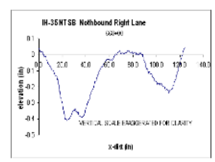


1

Site visit to each potential project

20) Bring laptop with PPMM PDP program, Digital camera
21) Ride / Walk project with AE staff / Maint Supvr.
22) Photograph distresses, accident sites, safety issues, drainage conditions, etc.
23) Document input from AEs and Maintenance Supervisors in PPMM PDP program
24) Upload photos to PPMM PDP program project file.
25) Repeat for each project

22



PPEI = f(WWARP; ADT; Truck ADT; Ride; Distress types / extent; Condition Drop; other factors?)

PPMM PDP Data Analysis

26) Based on PPMM, WWARP/CRIS, field data and office data analyze each project to determine overall ranking using PPEI index without SCI.

27) Based on data evaluation and initial PPEI rank. Identify projects for further NDT testing with FWD, GPR and coring.

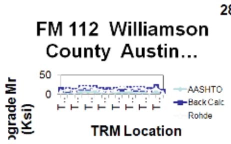
PPEI Index Analysis

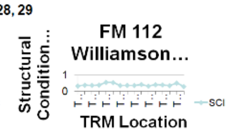
- Need to develop a PPEI Analysis Method to incorporate:
- Ride, Distress, condition, condition score drop
- ADT, truck ADT
- WWARP/CRIS
- Pavement Structural Condition Index (SCI)
- Treatment level and projected increase in pav't life
- Cost.

NDT data collection & Analysis

28) FWD data collection and SCI analysis
29) GPR data collection and analysis (sub-surface damage)
30) Cores as necessary.
31) Soil samples

28, 29





31

2

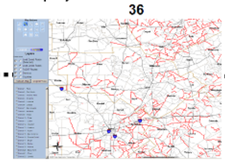
2[ND] Analysis with NDT data / SCI index

Re-compute PPEI and re-rank projects.

Final Proposed Program

32) PPEI index ranking for each project with SCI.
33) Rank order and initial program based on available funds
34) Graphs, charts, photos and supporting data for each project
35) Develop final estimated project costs (project delivery cost?)
36) GIS map showing project locations
37) Summary report with program list for presentation.

36



37

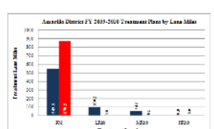
Consolidation of Project Data

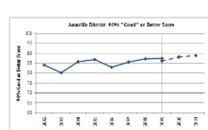
- Need standard format.
- Need to develop a catalogue of treatments for PM and Rehab based on data and SCI / PPEI index values.
- Summary report for each project / tablular list of all projecs

Presentation to AUS Admin

38) Power Point with proposed work program by county
39) Graphs, photos, WWARP/CRIS, SCI, PMIS, PPMM
40) Estimated budget per project / county / district
41) Map showing location of treatment projects
42) Projected change in District Condition Scores

42





3