REAL WORLD PAVEMENT PRESERVATION SOLUTIONS

Extending Pavement Life

Data Collection

Life Cycle Cost

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Prioritizing

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Cost Estimating

Activity Timing

Contracting Methods

INTRODUCTION

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Introduction

- **Do the Right Thing...**
- **Definitions**
- **Preventive Maintenance vs. Reactive Maintenance**
The right treatment, at the right time, on the right road!

But…
What kinds of treatments are available, and what pavement sections need them?

When is the best time to apply the treatment?

Where should the treatment be applied?

How will it be contracted, and how will I know the contractor will get it right?

How much will it cost?
INTRODUCTION

Do the Right Thing…

History shows that once a road has been constructed, it is more cost-effective to implement a preservation plan throughout the life of the pavement than to let it deteriorate and reconstruct it more often.

A pavement preservation plan should be able to identify pavement segments that need either preventive maintenance or other treatments.

The Federal Highway Association (FHWA), Minnesota Department of Transportation (MnDOT) and the National Center for Pavement Preservation (NCPP) define pavement preservation and maintenance as follows.
INTRODUCTION

Definitions

- Pavement Preservation
  - FHWA: “a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations”
  - NCPP: “pavement preservation is a cost-effective set of practices that extend pavement life and improve safety and motorist satisfaction while saving public tax dollars”

Sources: FHWA Pavement Preservation Expert Task Group; National Center for Pavement Preservation
Introducing

Definitions

- Preventive Maintenance
  - FHWA: “a 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 significantly increasing the structural capacity)”
  - MnDOT: “to improve or extend the functional life of a pavement. It is a strategy of surface treatments and operations intended to retard progressive failures and reduce the need for routine maintenance and service activities”

• Routine Maintenance
  ➢ “consists of work that is planned and performed on a routine basis to maintain and preserve the condition of the highway system or to respond to specific conditions and events that restore the highway system to an adequate level of service”

Definitions

• Minor Rehabilitation
  ➢ “consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develops in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation”

INTRODUCTION

Definitions

• Newly-Constructed Bituminous Pavement Surface

![Image of a newly-constructed bituminous pavement surface]
INTRODUCTION

Definitions

- Good candidate for pavement preservation activities.
Definitions

- Not a good candidate for pavement preservation.
Preventive Maintenance vs. Reactive Maintenance

**Preventive**

Preventive treatments are most often not specified as a result of an *observed* pavement distress. Without relying on distresses to guide pavement maintenance decisions, we rely on knowledge of pavement deterioration processes, engineering judgment, time, and traffic levels to determine the timing and type of preventive treatments.

In order to best accomplish this, good data is needed. As discussed in this guide, a well-managed Pavement Management System (PMS) enables the user to easily view and understand past information and make predictions on future performance.
Reactive Maintenance

Conditions often exist that are out of our control, requiring something to be done to maintain an acceptable level of performance. As distresses become manifest, the type and extent of treatment depends on many different variables – distress types, severity level, functional classification of the road, and traffic levels, for example.

Corrective or reactive treatments are applied as needed to minimize further deterioration. This could be a similar treatment as the preventive treatments, but in this case the timing can change the type of treatment.
Pavement Preservation: Extending Pavement Life

- **Realistic Expectations**
- **Estimating Beneficial Effects of Pavement Preservation**
- **PSI vs. PCI**
- **Theoretical vs. Actual**
- **Benefits of a Pavement Preservation Program**
Preventive maintenance should be able to restore the function of the existing pavement and extend its service life, but it is not intended to increase its structural capacity or strength. The project team met with many representatives from the agencies participating in the study during the winter and spring of 2011. A list of general questions was asked of the personnel interviewed and other topics were discussed. Many of these questions were developed by, or with the assistance of Mr. Tom Wood, of the MnDOT Office of Materials and Road Research. Below is a summary of questions asked, and some responses.
Realistic Expectations

- How long do you *expect* a particular treatment to last?

The primary activity for which the agencies have longevity expectations are seal coats or chip seals, overlays, and full-depth reclamation. The general consensus is that seal coats or chip seals should last about 7 years, and up to 9 years. In terms of extending the life of a pavement structure, overlays are expected to extend the life of the pavement about 8-10 years, and FDR should be a more permanent solution, lasting 20-25 years.
Realistic Expectations

- In general, how long does a particular treatment *actually* last?

When asked about the actual number of years that the various activities last, more activities were mentioned (primarily more differentiation in the overlay category). In the following list, the activity and general amount of time

- Chip seal: as little as 5 years, as long as 10 years, and average 7 years.
- Overlays
  - 1.5” blade level bituminous overlay: 7 years
  - 1.5” bituminous overlay: 7 yrs
  - 5” concrete overlay: 20+ yrs
- FDR: 15 years (limited responses)
This table shows the results of one research study, indicating the experience on the LTPP SPS-3 test sites.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Original Condition</th>
<th>6-Year Failure Probability</th>
<th>Average Median Survival Time</th>
<th>Average Benefit Compared to No Treatment (years)</th>
<th>Median Survival Time with No Treatment (Control Sections)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin Overlay</td>
<td>Good</td>
<td>25</td>
<td>7.5</td>
<td>2.2</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>30</td>
<td>7.3</td>
<td>4.8</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>100</td>
<td>2.2</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Slurry Seal</td>
<td>Good</td>
<td>48</td>
<td>6.5</td>
<td>2</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>57</td>
<td>5</td>
<td>3.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>100</td>
<td>2.5</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Crack Seal</td>
<td>Good</td>
<td>50</td>
<td>6.5</td>
<td>1</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>41</td>
<td>7.2</td>
<td>5.7</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>100</td>
<td>0.75</td>
<td>0.75</td>
<td>0</td>
</tr>
<tr>
<td>Chip Seal</td>
<td>Good</td>
<td>25</td>
<td>N/A</td>
<td>N/A</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>25</td>
<td>N/A</td>
<td>N/A</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>32</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
</tr>
</tbody>
</table>

1. Median survival time = Number of years until 50% of the sections to which the treatment is applied fail (i.e., 50% failure rate)
2. Median benefit compared to No Treatment = The number of years a treatment adds to the median survival time compared to no treatment

Source: Luhr, et al., 2010.
Realistic Expectations – Analysis of Performance Data

- Coefficients of Variation in the data on the previous page are as high as 35%.
- Performance determinations are often done by “human interpretation” which can introduce high levels of variability in estimates of extended pavement life.
- Variability in pavement structures and materials is compounded with variability in pavement maintenance construction and materials.

Source: Luhr, et al., 2010
Extending the pavement service life through a particular application requires quality materials and construction methods. A contractor may use the best materials available, but if their process and procedure is not consistent with the needs of the pavement, the results may not be what the design predicted.
Since true pavement preservation activities do not contribute to the structural capacity of the pavement, a direct effect of such activities would not be seen in a traditional Present Serviceability Index (PSI) curve, as shown on the next page, but may be evidenced in a Pavement Condition Index (PCI) curve.

What is expected in a PSI curve when preservation activities are performed is not direct increases in PSI, but a flattening of the slope as the pavement structure deteriorates with time and traffic. A PCI curve, conversely, might reflect the immediate visual effects of a chip seal (e.g. cracks aren’t counted because they aren’t seen) resulting in an increased PCI, but as cracks reflect and reappear, the PCI will gradually return to a lower value.
Present Serviceability Index (PSI) with Structural Fixes only

Pavement Age, years

Present Serviceability Index

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
0 10 20 30 40 50 60

PSI vs. PCI
The discussion in this section should not diminish the overall benefit realized by the application of the preservation treatment.

While it is more difficult to observe and quantify the benefits on paper, it is possible, and the benefits are real in the sense that the pavement structure is protected and its life is prolonged.

The PSI curves on the next page show an example of the potential difference in serviceability when preservation activities are used in connection with activities that also add to the structural capacity of the pavement.
EXTENDING PAVEMENT LIFE

PSI vs. PCI

Present Serviceability Index (PSI) with Structural and Preservation Activities

Present Serviceability Index

Pavement Age, years
The information presented on the previous pages is similar to that in NCHRP Report 523 on optimizing the timing of preventive maintenance activities. This is compared to an actual case from a county road in Minnesota, on the next page.

Source: Peshkin et al., 2004.
Theoretical vs. Actual

The graph below shows actual PCI data compared with maintenance records for rehabilitation and preservation activities.
Research has shown that pavements in Minnesota with preventive maintenance activities have higher Surface Ratings over time.

Source: Wood et al., 2009
Another way of looking at the benefits of pavement preservation activities is from a performance perspective. In the example given in the previous pages (here and here) the cumulative performance provided by a pavement structure over its life can be computed as the accumulated area under the pavement condition curve (in this case Present Serviceability Index is used).

The performance is indicated by the units “PSI-years.” As can be seen in the figure on the next page, the pavement which has had preservation activities to extend the life of the structure has performed better over its life than a pavement where preservation activities have not been applied.
Benefits of a Preservation Program

This graph shows the difference in cumulative performance over time for a pavement receiving structural treatments only compared with a pavement receiving structural AND preventive treatments.

- With Structural Activities Only
- With Preservation Activities

Almost 20% improvement
When combined with construction cost data, the information on the previous page can be presented as $/PSI-year or, since construction costs are often considered on a per-mile basis, this could be presented as $/PSI-year per mile, or $/PSI-year/mile.
Benefits of a Preservation Program

As an example, a basic life-cycle cost analysis should be conducted, considering the preservation and rehabilitation activities after the initial construction (assuming that the initial construction will be the same, independent of the preservation plan).

Then the total PSI-years are computed for each plan (with and without preservation activities, or when deciding on a specific activity or its timing).

Finally, a comparison is made between the $/PSI-year/mile for each plan to determine its effectiveness.

This example is demonstrated more fully using sample data on the next pages.
In this analysis, Initial Construction and Reconstruction costs are ignored, as they are likely to be similar in both cases.

<table>
<thead>
<tr>
<th>Year</th>
<th>Plan 1 – Overlays at 10-year Intervals</th>
<th>Plan 2 – Chip Seal with Overlays at 15-yr intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Activity</td>
<td>Cost, $/mi</td>
</tr>
<tr>
<td>1</td>
<td>Initial Construction</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Chip Seal</td>
<td>20,000</td>
</tr>
<tr>
<td>7</td>
<td>Chip Seal</td>
<td>20,000</td>
</tr>
<tr>
<td>10</td>
<td>Mill &amp; Overlay</td>
<td>125,000</td>
</tr>
<tr>
<td>12</td>
<td>Chip Seal</td>
<td>20,000</td>
</tr>
<tr>
<td>15</td>
<td>Mill &amp; Overlay</td>
<td>125,000</td>
</tr>
<tr>
<td>16</td>
<td>Chip Seal</td>
<td>20,000</td>
</tr>
<tr>
<td>20</td>
<td>Mill &amp; Overlay</td>
<td>125,000</td>
</tr>
<tr>
<td>21</td>
<td>Chip Seal</td>
<td>20,000</td>
</tr>
<tr>
<td>26</td>
<td>Chip Seal</td>
<td>20,000</td>
</tr>
<tr>
<td>30</td>
<td>Reconstruct</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Step 1: **Conduct Life-Cycle Cost Analysis**

A basic LCCA, using a 1% discount rate, results in the following total present values:

- **Plan 1 (Rehabilitation only):** $215,600 / mile
- **Plan 2 (Preservation):** $212,400 / mile

The cost of adding several chip seals and only one overlay over the life of the pavement may be similar to applying two Mill & Overlay operations over the same life span. If the preservation activities serve the purpose of extending the life of the pavement structure, such a relative comparison is reasonable.

**While the overall costs may be similar, the next page shows the potential difference in pavement performance over time.**
Benefits of a Preservation Program

**Step 2: Determine Total Pavement Performance Value**

From the condition index data in the curves shown in the figure below and on the next page, the overall PSI-years may be computed, by accumulating the area under the curves for the respective plans. In this case, with the terminal serviceability set at 1.5, the area between the PSI curves and the terminal value is computed.

By the end of the planned life in the example, the “Rehabilitation Only” plan is estimated to provide a performance value of about 49 PSI-years. The Preservation plan provides about 62 PSI-years. This step of the analysis can also be conducted in terms of PCI rather than AASHTO’s PSI definition.
EXTENDING PAVEMENT LIFE

Benefits of a Preservation Program

Step 2: Determine Total Pavement Performance Value

The graph shows the present serviceability index over pavement age, comparing the performance with and without preservation activities. The graph illustrates that preservation activities can significantly extend the serviceability of a pavement, as indicated by the higher serviceability index over a longer period compared to structural activities alone.
Benefits of a Preservation Program

Step 2: Determine Total Pavement Performance Value

- Cumulative Performance (PSI-years) vs. Pavement Age, years

Graph showing the difference in cumulative performance between pavement with structural activities only and pavement with preservation activities.
Step 3: Compute Cost per Performance Unit

The third step is to divide the total life-cycle cost by the overall performance provided by the pavement.

For the Rehabilitation Only plan, this is

\[
\frac{\$215,600/\text{mile}}{49 \text{ PSI-Years}} = \$4,400 \text{ mile/PSI-Year}
\]

For the Preservation plan, the cost is:

\[
\frac{\$212,400/\text{mile}}{62 \text{ PSI-Years}} = \$3,430 \text{ mile/PSI-Year}
\]
Step 3: Other Questions and Concerns
Questions that cannot be answered in this analysis, but that must be discussed and resolved by the local agency, include the following.

• Are the additional time and expense involved in extra chip seals and other preventive activities worth the increased pavement performance?

• Are the additional user costs (disruptions to traffic, etc.) worth the increased pavement performance?

• How closely can costs and performance be estimated? How much will a difference in future prices affect the analysis?

• Will delaying preservation activities cause a pavement to deteriorate beyond the point where additional preservation would be useful?
Data Collection for Pavement Management

- **What?**
- **When?**
- **How?**
- **Why?**
- **More Specifics**

Effective pavement preservation begins with a pavement inventory, which is used by a pavement management system to identify needs, prioritize funding, and maintain the pavement condition of the overall system.
During the process of selecting a treatment for pavement preservation, it is important to understand what has been done, and the conditions to which it has been subjected in the past.

This can be accomplished by gathering and managing useful data on past, present and predictable future conditions.

A practical Pavement Management System (PMS) assists an agency in making sound engineering judgments in the decision making process.
Pavement Condition Data

Pavement condition rating:

Data collected should represent

what you see

not

what you want to see
Basic types of data are necessary. These include Inventory, Construction, Condition, and other information such as traffic levels.

1. Basic inventory
   a. Segment location (county, roadway designation, termini)
   b. Segment length and width

2. Construction
   a. Date of last reconstruction / major rehabilitation
   b. Reason for reconstruction / major rehabilitation (i.e., scheduled, emergency, or other)
   c. Dates and types of maintenance and rehabilitation activities
   d. Quantities of maintenance and rehabilitation materials
   e. Unit (or total) cost of construction, maintenance and rehabilitation activities

3. Condition and traffic
   a. Periodic surface rating index values (IRI, SR, PQI, etc.)
   b. Estimated traffic (ADT, vehicle classification, etc.)
   c. Current condition
Basic types of data are necessary. These include Inventory, Construction, Condition, and other information such as traffic levels.

Current Condition
Using Distress Identification manuals (MnDOT, FHWA, or others)
- Cracking (transverse, longitudinal, block, alligator)
- Joint deterioration
- Rutting
- Raveling & Weathering
- Patching
Other Items
- Oxidation
- Bleeding
In order to manage this information for roadways, an inventory must be taken of what is considered part of the system. The agency then formulates and assigns a method of rating the roadways. Often, agencies will divide the network of roadways into sections than can be covered annually.

For example, if a network is divided into thirds, all the roadways will be assessed every three years. Ultimately, an agency’s budget will govern how much and how often the roadways can be evaluated.

The more frequent they are rated, the better the information will be to determine what and where treatments are needed.
How?

Visual inspection, falling-weight deflectometer and ground penetrating radar are common ways of assessing a pavement’s condition.

These non-destructive test methods have proven very effective and safe ways to evaluate the roadways. Visual inspection can be both qualitative (counting cracks per mile) and qualitative (assessing severity) and can therefore have the potential to be inconsistent from person to person.
One concern is that often agencies use the collected data to find the “worst condition” pavement. The temptation is to assign the highest priority to this segment, which inevitably uses the allotted funding much sooner since the required treatment for severely deteriorated pavements is often much more costly.

One way of determining the best candidate for maintenance funding is the “Remaining Service Life” (RSL) approach. This approach uses data already collected by the PMS and assigns a value to the remaining life a segment of pavement has before it needs total reconstruction. By managing the remaining life of the segments, it is possible to find a balanced approach to preserving pavements before they need more major treatments while still addressing pavements in worse conditions.

It is a more “top down” approach rather than a “bottom up” approach.

A good PMS has the capability, if enough data has been collected, to be used to make general models of how pavements will perform and predictions of where certain roadways may require upcoming pavement preservation treatments.

This of course takes some time to collect enough data. However, generic models can be used in cases where enough data is not available. These models can be incorporated into the selection process of which pavements receive treatments and when, until adequate specific data is collected.
Data often collected and that is most useful to pavement preservation and pavement management engineers include:

- Street/Roadway with termini or mile-post references
- Segment length
- Segment width
- Existing layer types and thicknesses
- Material types
- Historical condition index values and the dates they were collected
- Traffic counts and the year they were counted or estimated
  - ADT, AADT, HCADT, % trucks, etc.
- Dates and types of construction, rehabilitation, maintenance, and preservation activities
- Other information relevant to construction dates and cost
More Specifics – Pavement Condition Rating

**MnDOT Pavement Distress Identification Manual**

**SHRP Distress Identification Manual**
Seven Deadly Sins of Pavement Management

1. People forget the purpose of the system
2. Nobody understands how you reached your conclusions
3. Nobody understands what you are talking about
4. Too much effort for a conceptually straightforward business decision
5. Has little impact on the overall business
6. Drowning in a sea of data
7. Funding is to improve road infrastructure, not to make decisions

Source: Parkman and Bennett, 2011.
Life-Cycle Cost Analysis

- Equivalent Uniform Annual Cost Comparison
- Cost for Performance
- Comparing Alternatives
Life-cycle cost analysis should look at the specific benefits expected from specific activities related to pavement preservation.

Example:

A pavement section receives an overlay as a major rehabilitation project, with a cost of $250,000 per mile. The expected service life is 15 years. At a 3% discount rate, the equivalent uniform annual cost (EUAC) for this project is $20,900 per mile per year.

If a preservation treatment is applied at year 2, which extends the life of the pavement 3 years, and costs $20,000 per mile, the new EUAC is $19,500 per mile per year.

Savings of $1,400 per mile per year!
LIFE-CYCLE COST ANALYSIS

Equivalent Uniform Annual Cost Comparison

Without Preservation Activity
EUAC = $20,900 per mile per year

With Preservation Activity
EUAC = $19,500 per mile per year

Minimum Allowable Pavement Condition

Years since Construction

Years since Construction

M&O: $250,000/mi
Chip Seal
$25,000/mi

End of Service Life

End of Service Life

Data Collection
Activity Timing
Contracting Methods
Life Cycle Cost
Sources of Information
Extending Pavement Life
Preservation Activities
Prioritizing
Home
Without Preservation Activity
Performance = 863 “PCI-years”

With Preservation Activity
Performance = 946 “PCI-years”

M&O: $250,000/mi

Minimum Allowable Pavement Condition
Comparison of Cost and Performance

Example:

Without the preservation activity
EUAC = $20,900 / mile / year
Performance = 863 PCI-years
Cost of Performance = $24.22 / mile / PCI-year

With the preservation activity
EUAC = $19,500 / mile / year [6.7% Savings]
Performance = 946 PCI-years [9.6% Improvement]
Cost of Performance = $20.61 / mile / PCI-year [14.9% Savings]
Sources of Additional Information

- Pavement Preservation – General
- Pavement Management Systems
- Data Collection
- Life-Cycle Cost Analysis
- Preservation Activities
- Timing and Prioritization
- Cost Estimating and Contracting
- References
Sources of Additional Information

General Pavement Preservation

National Center for Pavement Preservation
www.pavementpreservation.org

What We Don’t Know About Pavement Preservation
www.techtransfer.berkeley.edu/icpp/papers/22_2010.pdf

MnDOT Pavement Preservation Research
www.dot.state.mn.us/materials/pavementpreservation.html

FHWA: General Pavement Preservation Information
www.fhwa.dot.gov/pavement/pres.cfm

Preservation Approaches for High-Traffic-Volume Roadways
onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-R26-RR-1.pdf
SOURCES OF ADDITIONAL INFORMATION

Pavement Management Systems

Implementing Pavement Management Systems
www.dot.state.il.us/blr/P052.pdf

Implementation of Pavement Management in Minnesota

LRRB Video – Pavement Management: Better Data, Better Decisions, Better Roads at the Right Time
www.lrrb.org/media/reports/Pavement_Management.wmv

Transportation Research Board Committee on Pavement Management Systems
www.pavementmanagement.org

Pavement Management Systems Overview
www.state.nj.us/transportation/eng/pavement/pdf/PMSOverviews0709.pdf
Definition of the “Cradle-to-Grave” Pavement Management Process

www.utexas.edu/research/ctr/pdf_reports/0_4186_P1.pdf
Sources of Additional Information

Commercially Available Pavement Management Systems

Dynatest

New York Bituminous Products Corporation (NYBIT)
www.nybit.com/ppmp-overview.html

StreetSaver
www.mtcpms.org/products/index.html

ICON
Commercially Available Pavement Management Systems

PavePRO Manager
www.ims-rst.com/pavepro.shtml

VIM Road Pavement Management System

MicroPAVER
www2.apwa.net/bookstore/detail.asp?PC=SPR.PAVER

AgileAssets Pavement Analyst
www.agileassets.com/products/pavement-analyst/
Sources of Additional Information

Data Collection

MnDOT Distress Identification Manual

SHRP Distress Identification Manual

EXTENDING PAVEMENT LIFE

DATA COLLECTION

LIFE CYCLE COST

PRESERVATION ACTIVITIES

COST ESTIMATING

PRIORITIZING

SOURCES OF ADDITIONAL INFORMATION

Life-Cycle Cost

MnDOT Life Cycle Cost Analysis Method
www.dot.state.mn.us/materials/pvmtdesign/lcca.html

Life-cycle cost analysis system for pavement management at the project level

Developing a Robust Pavement Life Cycle Cost Analysis
www.cptechcenter.org/ncc/F2013Presentations/T2%20Mack%20LCCA.pdf

Evaluation of Life Cycle Cost Benefits of Some Pavement Preservation Strategies Using Caltrans PMS Data
www.techtransfer.berkeley.edu/pavementpres09downloads/harvey_thurs_prelim-lcca.pdf
Preservation Activities

Minnesota Seal Coat Handbook 2006
www.mrr.dot.state.mn.us/research/pdf/200634.pdf

Chip Seal FAQ
www.dot.state.mn.us/materials/PDF/chip%20seal%20FAQ.docx

Preventive Maintenance Best Management Practices of Hot Mix Asphalt Pavements
www.lrrb.org/media/reports/200918.pdf

Crack Sealing 101: Hot Mixed Asphalt Pavements
www.mrr.dot.state.mn.us/research/pdf/2010MRRDOC010.pdf

Recommended Practices for Crack Sealing HMA Pavement
www.mrr.dot.state.mn.us/research/pdf/2008MRRDOC021.pdf
Preventive Maintenance Fog Sealing of HMA Cul-de-Sacs

www.mrr.dot.state.mn.us/research/pdf/2008MRRDOC021.pdf
Preservation Activities

Edge-Joint Sealing as a Preventive Maintenance Practice
www.mrr.dot.state.mn.us/research/pdf/200326.pdf

Micro surfacing: NCHRP Synthesis 411
onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_411.pdf

Perpetual pavement design for flexible pavements in the US
www.tandfonline.com/doi/pdf/10.1080/10298430600619182

Review of Best Practices for the Selection of Rehab and Preventive Maintenance Projects
tti.tamu.edu/documents/0-6586-1.pdf
Sources of Additional Information

A Quick Check of Your Highway Network Health
www.fhwa.dot.gov/pavement/preservation/if07006.pdf

Reformulated Pavement Remaining Service Life Framework

Pavement Remaining Service Interval Implementation Guidelines

Pavement Rehabilitation Selection
www.lrrb.org/media/reports/200806.pdf
Repair Priorities: Transportation spending strategies to save taxpayer dollars and improve roads

Optimum time for application of slurry seal to asphalt concrete pavements
paramountasphalt.com/resources/Optimum-Time-for-Application-of-Slurry-Seal.pdf

Optimization of Pavement Preservation Activities

Optimal Timing of Pavement Preventive Maintenance Treatment Applications
onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_523.pdf
Sources of Additional Information

Cost Estimating and Contracting

MnDOT Average Bid Prices
www.dot.state.mn.us/bidlet/avgPrice.html

MnDOT Construction Cost Index
www.dot.state.mn.us/bidlet/costIndex.html

MnDOT Abstracts for Awarded Jobs
www.dot.state.mn.us/bidlet/abstract.html
Sources of Additional Information

References


Parkman, C.C., and C.R. Bennett, The Seven Deadly Sins of Pavement Management, 8th International Conference on Managing Pavement Assets, November 15-19, 2011, Santiago, Chile.


Shah, H. K., Y. Yoon, M. Hastak, and J. Lee, Benefits and Assessment of Annual Budget Requirements for Pavement Preservation, Publication FHWA/IN/JTRP-2011/06, Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2011.

References


Pavement Preservation Activities

- Guidelines
- Definitions
- Preventive Maintenance Activities
- Routine Maintenance Activities
- Minor Rehabilitation
### Pavement Preservation Guidelines

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Increase Capacity</th>
<th>Increase Strength</th>
<th>Reduce Aging</th>
<th>Restore Serviceability</th>
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<td>Major (Heavy) Rehabilitation</td>
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<td>Structural Overlay</td>
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<td>Minor (Light) Rehabilitation</td>
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<td>Preventive Maintenance</td>
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<td>Routine Maintenance</td>
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<tr>
<td>Corrective (Reactive) Maintenance</td>
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<tr>
<td>Catastrophic Maintenance</td>
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</table>

Source: Gieger, 2005.
• Routine Maintenance
  ➢ “consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develops in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation”

Source: AASHTO Highway Subcommittee on Maintenance
Common preservation treatments for **flexible** pavements include
- Crack sealing
- Seal coat or chip sealing
- Slurry or micro surfacing
- Ultrathin bonded wearing course (Paver placed surface seal, or NovaChip)
- Thin and ultrathin hot-mix asphalt overlay

Common preservation treatments for **rigid** pavements include
- Joint sealing
- Diamond grinding
- Dowel-bar retrofit
- Partial- or full-depth repair
### Preventive Maintenance Activities

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Expected Performance</th>
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<tr>
<td></td>
<td>Treatment Life, yrs</td>
<td>Pavement Life Extension, yrs</td>
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<td><strong>Flexible Pavement</strong></td>
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<td>Crack Fill</td>
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<td>Slurry Seal</td>
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<td>Microsurfacing</td>
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<td>Chip Seal – Single</td>
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<tr>
<td>Chip Seal - Double</td>
<td>5-10</td>
<td>8-10</td>
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<tr>
<td>Ultra-thin Bonded Wearing Course, or NovaChip</td>
<td>7-12</td>
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<tr>
<td>Thin HMA Overlay – Dense Graded</td>
<td>5-12</td>
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<tr>
<td>Thin HMA Overlay – Open Graded</td>
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<td><strong>Rigid Pavement</strong></td>
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<tr>
<td>Joint Resealing</td>
<td>2-8</td>
<td>5-6</td>
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<tr>
<td>Crack Sealing</td>
<td>4-7</td>
<td>---</td>
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<tr>
<td>Diamond Grinding</td>
<td>8-15</td>
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<tr>
<td>Partial-depth Patching</td>
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<td>---</td>
</tr>
<tr>
<td>Full-Depth Patching</td>
<td>5-15</td>
<td>---</td>
</tr>
</tbody>
</table>

Adapted from Peshkin, et al., 2011.
Crack Sealing

**Do**
- Seal cracks as soon as possible
Crack Sealing

Do

➢ Use recommended sealant for the activity
  • 3719 (crumb rubber) Clean & fill
  • 3723 (low modulus) Clean & fill, rout & seal
  • 3725 (extra low modulus) Rout & seal
CRACK SEALING

**Do**
- Clean cracks
- Dry cracks
- Neat and clean application
Crack Sealing

Don’t
- Fill wet cracks
- Overheat sealant
- Make wide over bands
Chip seals are constructed by spraying one or more layers of polymer-modified asphalt emulsion binder on a roadway and embedding finely graded aggregate into it. Once the aggregate is evenly dispersed the pavement is then rolled.

Chip seals are used to provide a new wearing surface on roadways that is intended to eliminate raveling, retard oxidation, reduce the intrusion of water, improve skid resistance and seal cracks. They can last on average about 7 years and are typically applied on low volume roads.
Chip Seal

Do

- Chip seal pavement *early in life* (<4 years old)
- Only on structurally sound roadways
- Sweep as soon as possible
- Fog seal all rural chip seal
Chip Seal

**Do**

- Design the application rate for the need
  - Apply proper amount of aggregate
- Follow MnDOT’s recommendation
  - 2356 specification
  - Seal Coat Handbook ([LRRB Report 2006-34](#))
Don’t
- Chip seal in September or later
- Leave extra rock on roadway more than 1 day
- Use chip seal to try to hold a deteriorated pavement together
Micro Surfacing / Slurry Seal

Micro surfacing is a cold-applied paving mixture composed of polymer-modified asphalt emulsion, crushed aggregate, mineral filler, water and a hardening-controlling additive. No rolling is required and the finished surface can generally be opened to traffic soon after placement.

Like a chip seal, micro surfacing can be used as a blanket cover on pavements suffering from loss of skid resistance, oxidation, raveling and surface permeability. In addition, micro surfacing can be used to fill ruts and improve rideability by removing minor surface irregularities. This treatment can last on average 8 to 9 years. It is also suitable for all traffic levels.
Micro Surfacing / Slurry Seal

Don’t

- Work too late in fall
- Apply slurry seal more than one rock thick
- Allow careless application
Thin Bonded Wearing Course or NovaChip

**Do**
- Use as wearing course on higher volume roadways
  - Combination of wearing course and preventive maintenance treatment in one
- Use proper application of bonding emulsion
- Seal HMA as soon as possible
**Routine Maintenance Activities**

“consists of work that is planned and performed on a routine basis to maintain and preserve the condition of the highway system or to respond to specific conditions and events that restore the highway system to an adequate level of service”

- Clean and fill cracks
- Pavement patching
- Other
 Minor Rehabilitation

“consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develops in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation”

- Grinding (to repair surface roughness)
- Spall repair
- Small areas of full-depth repair
A survey of users was conducted to assess the pavement preservation activities most often used in local street networks in Minnesota. The following were characteristics of the street networks for which the agencies that responded are responsible.

- ADT
  - as little as 85 vpd; as high has 17,000 vpd
- Current Pavement Condition Index
  - as low as 4; as high as 100
- Segment Length
  - as short as 75 feet; as long as 5 miles
Survey of Pavement Management System Users

This figure gives an idea of the distribution of PCI values in the street networks surveyed.
Timing of Pavement Preservation Activities

- Initial Construction and Preservation Planning
- Subsequent Preservation Activities
- Pavement Management System Benefits
- Preservation Timing “Triggers”
- Preservation Timing “Classification”
- The Mile-Year Concept
- Research
- Case Study
When a road is first built it should be as close to “perfect condition” as it will ever be. Typically, a pavement preservation plan is used to schedule the necessary treatments over the life of the pavement. The primary factors contributing to deterioration are weather, water and traffic.

Usually, the only one we can control is the water. A well-constructed road will have the proper geometrics and drainage characteristics to drain much of the surface water away from the road. However, seasonal variations in temperature often cause cracking in bituminous pavements which create ways for water to enter the system.
Some agencies have a standard policy to apply a chip seal on a new pavement the first year following construction. Crack sealing is a regular maintenance treatment, which is often followed up with a chip seal for added protection.

Often agencies use their pavement management system to dictate when to apply treatments based on criteria it uses.

Research has shown that it is often better to apply the first treatment sooner rather than later. That first treatment will allow the pavement system to wear and function the way it was designed.
As time progresses and after the road has had the initial treatment, it is important to continue tracking its performance and condition. Many agencies track condition and performance in different ways. One of the questions asked during the interviews with local agencies was “How (or when) do you determine which roadways receive which treatments?”

The primary responses to this question related to the frequency with which agencies conduct condition surveys, and how they interpret the data. Some agencies conduct condition surveys every year, observing 1/3 of the system’s miles each year. Other agencies conduct a full condition survey once every 3 years, collecting data on 100% of the system’s miles during that year.
Subsequent Preservation Activities

Regarding the data reduction and decisions on which roadway receives which treatment, the prevalent response is that the road in “the worst condition, with the most traffic” receives attention. In addition, some agencies mentioned a long-range plan where future needs are anticipated and budgets are estimated.

Through these processes the agencies attempt to maintain their goals for system wide pavement PCI values, with the constraints of budget, time, and traffic.

However the data is collected and analyzed, it should be incorporated into a comprehensive pavement management system that can subjectively track, record and may even be able to predict values if given enough information.
One benefit to using computerized pavement management systems is that over time, the system will begin to use the actual condition survey data entered by the agency in the analysis. For each roadway maintained by an agency, the system will develop customized deterioration curves based on that data, rather than the default curves supplied by the software. Thus, a more relevant analysis can be conducted that will more closely optimize the use of pavement preservation, maintenance, and rehabilitation funding for an agency.
Specific “triggers” are developed by agencies to identify when pavement sections are in need of some type of maintenance or rehabilitation. Two examples of these are given below.

<table>
<thead>
<tr>
<th>Example #1</th>
<th>Example #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI</td>
<td>Planned Activity</td>
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<tr>
<td>71-100</td>
<td>Chip seal</td>
</tr>
<tr>
<td>41-70</td>
<td>Overlay</td>
</tr>
<tr>
<td>26-40</td>
<td>Localized subgrade corrections and reconstruction</td>
</tr>
<tr>
<td>0-25</td>
<td>Total reconstruction</td>
</tr>
<tr>
<td>66-100</td>
<td>Chip seal</td>
</tr>
<tr>
<td>36-65</td>
<td>Overlay</td>
</tr>
<tr>
<td>0-35</td>
<td>Reconstruction</td>
</tr>
</tbody>
</table>
Other agencies use PCI simply as a classification system for their pavement network, as follows.

86-100  Excellent
71-85   Good
51-70   Adequate
36-50   Marginal
0-35    Poor

Agencies attempt to keep the average roadway PCI value to a certain level, as an indicator of the overall quality of their roadway network. One Minnesota agency reported a desire to maintain this average PCI above 80, while another attempts to maintain an average “in the upper 70s”. Overall, most reported a slight decline in average PCI over the past decade.
Another method of analyzing performance and function is by using what is called, “lane mile-years”. Larry Galehouse, Director National Center for Pavement Preservation and Jim Sorenson, Team Leader FHWA Office of Asset Management, published an article explaining the concept of mile-years. They explain that it is a “top-down” approach, using historic estimates to manage entire road networks instead of breaking them up into smaller systems (i.e. projects, subdivisions, etc.)

The concept of lane mile-years assumes that every lane-mile segment of a road network is rated by the number of years remaining until the end of its life as a terminal condition. The terminal condition represents the level of minimal operating condition for that road or network. If nothing was improved during the year, the mile-years remaining will decrease by one.

### Lane Mile-Years in a Network

A given network has a total number of lane-miles. This amount is the amount of lane-miles per year that need to be improved in order to maintain the same level of performance as the previous year.

An example is a network of 500 lane-miles. If no improvement is made in the following year the system will lose 500 lane-mile-years per year. If more than 500 lane-miles are improved in the following year the overall system will be improving. If only 500 lane-miles are improved (to increase service life by at least one year each, on average), there would be no change in the overall system.
Findings from the MN TH 56 research

- Sealing improves resistance to aging (cracking)
- Sealing sooner is better
  - Waiting 3 or more years after construction produced similar results in terms of fracture energy, which leads to cracking
  - Sealing 1-2 years after construction showed improvement in resistance to aging in terms of cracking
- Fracture Energy (shown on next page) is highest when chip seal is applied 1-2 years after construction. (Higher fracture energy is better). The control section did not receive a chip seal. The figure indicates that waiting more than about two years for the first chip seal is almost equivalent to not applying a chip seal at all.

Source: Ongoing MnDOT research.
Minnesota TH 56

Fracture Energy, J/m²

<table>
<thead>
<tr>
<th>Chip Seal Time, years after construction</th>
<th>Fracture Energy</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
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<tr>
<td>1</td>
<td>300</td>
</tr>
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<td>2</td>
<td>250</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
</tr>
</tbody>
</table>

Source: Ongoing MnDOT research.
Research

Years of life extension needed for a pavement treatment to be cost effective

Source: Ongoing MnDOT research.
Many agencies conduct preservation and structural activities with less frequency than they would like. This is related to budgetary constraints and other issues, and is not a new problem. Prioritizing and executing a pavement maintenance and rehabilitation plan is discussed in the Prioritizing section.

One example of a “designed” vs. “actual” set of pavement maintenance and rehabilitation strategies follows. In this example, the agency plans to conduct the following pavement preservation and rehabilitation activities according to a specific schedule.
TIMING OF PRESERVATION ACTIVITIES

Case Study

Year 1: Initial Construction
Years 2 – 21: Chip Seal every 2-3 years
Years 22 – 60: Overlay every 8 years, with seal coats at 3 and 6 years after each overlay.

Such a plan is often not based on performance or condition triggers such as PCI or SR, but rather on time alone. This method makes the timing easier, but also presents the possibility that some activities will be done earlier or later than are needed.

Another method that can be implemented with this type of plan is to use time as a pseudo-trigger, or a time at which the roadway segment is evaluated for the need to perform the activity or not.
The figure below shows this plan graphically, indicating the treatment applied and the year in which the activity is scheduled to take place. The overlay and two subsequent chip seals over an eight-year period is repeated until about year 60, at which time the agency intends to reconstruct the roadway.

Years Since Initial Construction

Repeat Until Year 60
While the schedule shown in the previous figure is the agency’s plan for newly-constructed roadways, the figure below shows a typical roadway and the activities that have actually been implemented since its construction 41 years earlier.
As can be seen, chip seals have been applied less often than desired in the plan, and an overlay was applied many years earlier than would be expected under the plan. One pattern that is apparent in the data on the previous page is that a chip seal or overlay was applied approximately every 7-10 years (8 and 9 years for the first chip seal and overlay, respectively, 7, 10, and 8 years for the next three chip seals, and 7 more years for the second overlay).

The timeline and plot in the figure on the next page are an expansion beyond year 16 shown in the previous figure, with the pavement condition index values measured approximately every three years. The general decline of PCI values is evident, with a dramatic increase after the overlay in year 39 was applied. It appears that the chip seals, even if applied every 8-10 years, extended the life (in terms of keeping the PCI above 60) until an overlay was constructed.
Case Study

TIMING OF PRESERVATION ACTIVITIES

Activity Timing

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timing</th>
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</thead>
<tbody>
<tr>
<td>Chip Seal</td>
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<td>Chip Seal</td>
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<tr>
<td>Chip Seal</td>
<td>41</td>
</tr>
<tr>
<td>Overlay</td>
<td>15</td>
</tr>
</tbody>
</table>

Years Since Initial Construction
This figure shows similar information for another roadway from the same agency. One overlay, placed at year 20 did not receive another treatment until 8 years later. The PCI of that roadway was maintained above 60 for about 9 years after the chip seal, but then decreased dramatically during the three years between two PCI measurements in years 34 and 37. Unfortunately, after the significant decrease was noticed, it took five more years before an overlay was placed.
The previous pages are examples of similar cases occurring on pavements in many networks, demonstrating the benefits of:

- Regular pavement preservation activities
- Proper timing of rehabilitation activities
- Regular condition surveys
- Development of a pavement preservation plan, based on condition and performance triggers, and following it as closely as possible.
Contracting Methods to Ensure Quality Construction

- **Bid Items**
- **Specifications**

This section gives guidelines for contracting methods to improve the probability of quality construction and long-lasting pavement structures.
## Contracting Methods

### Bid Items

**Crack Seal**
- By road station
  - Average crack spacing
  - Assume cracks are full-width)

**Chip Seal**
- By square yard
  - Include aggregate and all operations except emulsion
  - Eliminates overruns
  - Encourages proper application rate to cover aggregate

**Emulsion for Chip Seal**
- By the gallon or by the ton

**Fog Seal**
- By the gallon or by the ton
Other Specifications

Crack Seal
- Seal every crack
- Don’t pay for overruns
- Crack sealing should be easy to inspect

Chip Seal
- Every roadway needs a different application rate
- Require the chip seal to be designed, including application rate
Prioritizing Preservation Activities

- Many Questions…
- Decision Trees
- Ranking
PRIORITIZING PRESERVATION ACTIVITIES

Many Questions…

Prioritizing among a network of roadway segments can be challenging, and presents several unique questions:

- When is the appropriate time for a particular preservation activity?
- Will the additional costs now result in savings later?
- How long is too long to delay?
- How will I know if it is too long?
- What should I do if I wait too long?
- Which of the many roadway segments in the system deserve attention now?
From a network perspective, one of the tools used most often is the decision tree. The decision tree is intended primarily for assigning pavement maintenance or rehabilitation activities based on a common set of criteria that can be applied uniformly across the network. The decision tree does not provide a prioritized list of roadway segments, but allows an agency to develop a program of maintenance and rehabilitation based on the collected project-level needs throughout the network.

Two examples of decision trees are shown in the next pages – a simple type of decision tree and one that takes many more conditions into account.
REAL WORLD PAVEMENT PRESERVATION SOLUTIONS

Prioritizing Preservation Activities

Decision Trees

Asphalt Pavement

- Pavement Condition Index > 4
  - Preventive Maintenance

- Pavement Condition Index ≤ 4
  - Load-Associated Structural Deterioration
    - Present
      - Load-Associated Structural Overlay
    - Not Present
      - Functional Overlay

### Prioritizing Preservation Activities


#### Decision Trees

**Start here**
- Too much load related distress?
  - PSR <> Trigger
    - Too many cracks or PSR ≥ 2.5
      - Any prior thin overlays?
        - Curb?
          - Not eligible for P.M.
          - Medium Mill & Overlay
        - Do nothing
    - Thin Mill & Overlay
      - Thin Overlay
      - Thin Mill & Overlay
      - Micro Surf (rut fill)
        - Crack fill
        - Crack seal
        - Micro Surf
        - Chip Seal
        - Do nothing
  - Last rehab = rut
    - Good for crack seal?
      - Good for crack fill?
        - Age ≥ 7 years and last rehab <> Surface Treatment
          - AADT > 10,000
            - Micro Surf
            - Chip Seal
            - Do nothing
          - AADT > 10,000
            - Micro Surf
            - Chip Seal
            - Do nothing
While a decision tree can help determine the best course of action on a single roadway segment, there are several methods for taking those recommendations and developing a prioritized pavement maintenance and rehabilitation program.

- Sort by predicted $/mile/PSI-year value.
- Ensure that good pavements do not fall below a threshold value where preservation activities would no longer be effective.
- Use engineering judgment to make determinations on borderline cases. Treatments used in borderline situations are more likely not to be cost-effective.
- Coordinate with other nearby roadways to gain economic benefits of larger construction activities.
Some of the decision making can be delegated to a computerized algorithm, but final decisions and prioritizations should be done with human interaction and engineering judgment, assisted by computer analysis.

For example, a medium-sized city street network with 2,000 segments could be evaluated by algorithm and engineering judgment using the following steps.
1. Computerized decision tree to identify first set of activity assignments. These could be divided by PCI value, time since last reconstruction, time since last activity, etc.
   - Do Nothing
   - Preservation Activity (crack seal, patching, surface treatment)
   - Rehabilitation Activity (major or minor)
   - Reconstruction
2. For the do-nothing recommendations, check to make sure the marginal segments are truly in a condition to endure another 2-3 years without any treatment.
3. For the preservation and rehabilitation recommendations, conduct a cost analysis with predicted performance to prioritize roadway segments with the best potential to provide extended life and need less rehabilitation activity in the next 7-10 years.
### Ranking

4. For the reconstruction recommendations, check for segments that could wait another 2-3 years before becoming absolutely too rough or structurally deficient to continue.

5. Develop a cost analysis for the set of final recommendations and compare to available budget.

6. If prioritized needs exceed available budget, make appropriate adjustments to the prioritized recommendations – delaying needed activity, adjusting cutoff points, and moving more segments to the “do-nothing” option for that year.
There are more sophisticated methods for optimizing and prioritizing the recommendations developed by a decision tree. These are described in the [Timing and Prioritization references](#) and often require additional pavement condition data, historical data (from which computer software develops deterioration prediction curves), and other requirements.
Peshkin et al. introduced an Effectiveness Index to optimize the timing of specific treatments. The effectiveness index compares the benefit/cost ratio of each possible scenario with the maximum individual B/C ratio ($\text{B/C}_{\text{max}}$). In computing the B/C ratios for individual treatments, the authors utilize a method similar to that described in this report – comparing the area under performance curves for the “do-nothing” and the individual treatment predictions.

Source: Peshkin et al., 2004.
Shah et al. recommend life cycle cost analysis methods as well as parameters called “Lane-mile years” and “Highway Health Index” to help quantify the benefits of pavement preservation.

Source: Shah et al., 2011.
Cost Estimating

- **Introduction**
- **Bid Tabulations**
- **Bid Abstracts**
An analysis of historical bid tabulations and/or actual contractor bids for specific projects can provide a basic understanding of the probable cost of a certain maintenance or rehabilitation activity. It is important to consider the size of the projects that are reported in the bid tabs and actual bids.

Contractors working on smaller projects often incur fixed costs that amount to a larger proportion of the overall project than on larger projects. These costs such as for mobilization, may be the same regardless of the project size, and thus are divided over smaller quantities, resulting in larger unit costs.

Other factors to consider are the units within which the materials and construction activities are bid, layer thickness, material type, and the project location – all of which can affect the quantities and/or cost estimates.
It is not the intent of this report to provide actual costs or even bids within a certain time frame, but to provide adequate information for individual agencies to develop their own estimates for specific projects.

As an example of a bid tabulation document, the table on the next page provides a sample of asphalt wearing course bids tabulated over a one-month time span. This type of information can be found on the MnDOT web site, at http://www.dot.state.mn.us/bidlet/avgPrice.html.
### Bid Tabulations

Sample bid tabulation data from August 2013.

<table>
<thead>
<tr>
<th>Item Group</th>
<th>Item Number</th>
<th>Item Description</th>
<th>Units</th>
<th>Quantity</th>
<th>Dollars (000s)</th>
<th>Average Price</th>
<th>Contract Occurr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2360</td>
<td>2360.501/12200</td>
<td>TYPE SP 9.5 WEARING COURSE MIX</td>
<td>TON</td>
<td>16,675</td>
<td>$852</td>
<td>$51.10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2360.501/22200</td>
<td>TYPE SP 12.5 WEARING COURSE MIX</td>
<td>TON</td>
<td>166,144</td>
<td>$7,476</td>
<td>$45.00</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>2360.501/23200</td>
<td>TYPE SP 12.5 WEARING COURSE MIX</td>
<td>TON</td>
<td>1,041,536</td>
<td>$48,785</td>
<td>$46.84</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>2360.501/25500</td>
<td>TYPE SP 12.5 WEARING COURSE MIX</td>
<td>TON</td>
<td>248,378</td>
<td>$13,287</td>
<td>$53.50</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2360.503/22215</td>
<td>TYPE SP 12.5 WEAR CRS MIX 1.5&quot; THICK</td>
<td>SY</td>
<td>1,853</td>
<td>$18</td>
<td>$9.75</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2360.503/22220</td>
<td>TYPE SP 12.5 WEAR CRS MIX 2.0&quot; THICK</td>
<td>SY</td>
<td>1,853</td>
<td>$23</td>
<td>$12.50</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2360.503/23220</td>
<td>TYPE SP 12.5 WEAR CRS MIX 2.0&quot; THICK</td>
<td>SY</td>
<td>816,277</td>
<td>$5,574</td>
<td>$6.83</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: MnDOT Bid Letting web pages.
Several items are of interest in this extracted table.

1. All items fall under the same Item Group (2360).
2. There are only two different primary Item Numbers in this table of seven items, but each item has a unique secondary number.
3. Three different “TYPE SP 12.5 WEARING COURSE MIX” items show different quantities and average prices. While there may be some differences in the exact material or mix design, these are essentially utilized for the same purpose.
4. The Quantity is not necessarily correlated with the Average Price. This means that quantity alone is not responsible for changes in unit prices. In this example, of the three items wear courses mentioned above, the cheapest unit price is for an item with about 1/5 the quantity of the next lowest unit price.
5. Similar materials can be bid with different units – TON and SY. The units must be considered accordingly in such cases.

In order to estimate a project’s cost successfully, all relevant bid items must be considered. It is most often beneficial to consult bid abstracts of previously let projects. These can be found at the MnDOT bid letting web site. The next page contains a list of all items included in a typical micro surfacing pavement preservation project on a CSAH roadway in central Minnesota.

The total cost for this project (approximately 10 miles long) was estimated at about $450,000. The low bid for the project was just over $475,000. Other important information to consider on this project is its size (number of miles, square yards, linear feet, etc.), its location, the amount of other work the agency and other agencies are putting out for bid, and other parameters.
Bid Abstracts

- MOBILIZATION
- REMOVALS
  - PAVEMENT MARKING REMOVAL
  - PAVEMENT MARKING REMOVAL
- BITUMINOUS MATERIALS
  - BITUMINOUS MATERIAL FOR FOG SEAL
  - BITUMINOUS MATERIAL FOR MICRO-SURFACING
  - MICRO-SURFACING SCRATCH COURSE
  - MICRO-SURFACING SURFACE COURSE
  - BITUMINOUS MATERIAL FOR TACK COAT
- TRAFFIC CONTROL
  - TRAFFIC CONTROL
  - PORTABLE CHANGEABLE MESSAGE SIGN
  - TRAFFIC CONTROL SUPERVISOR
  - WORK ZONE SPEED LIMIT
  - INTERIM PAVEMENT MARKING
  - PAVEMENT MESSAGE (LEFT ARROW) PAINT
  - PAVEMENT MESSAGE (RIGHT ARROW) PAINT
  - 24" SOLID LINE WHITE-PAINT
  - 24" STOP LINE WHITE-PAINT
  - 24" SOLID LINE YELLOW-PAINT
  - 4" SOLID LINE WHITE-EPOXY
  - 8" SOLID LINE WHITE-EPOXY
  - 4" BROKEN LINE WHITE-EPOXY
  - 4" SOLID LINE YELLOW-EPOXY
  - CROSSWALK MARKING-PAINT
  - 4" SOLID LINE WHITE-PAINT (WR)
  - 4" BROKEN LINE WHITE-PAINT (WR)
  - 4" SOLID LINE YELLOW-PAINT (WR)
  - 4" BROKEN LINE YELLOW-PAINT (WR)
  - 4" DOUBLE SOLID LINE YELLOW-PAINT (WR)

Source: MnDOT Bid Letting web pages.
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