

# Pavement Preservation in the State of California-Protecting Our Investment

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**ABSTRACT:** The California Department of Transportation (Caltrans) is a recognized leader in the field of pavement preservation. Over the past 10 years, Caltrans has established permanent funding for pavement preservation treatments, a partnership with industry called the Pavement Preservation Task Group (PPTG), secured the support of upper management, and established the California Pavement Preservation (CP2) Center at the California State University, Chico. The paper will discuss some of the pavement preservation activities in California including the following: a) concept of Pavement Preservation in California and the important benefits derived from this program, including economic and environmental, b) development of the Maintenance Technical Advisory Guide (MTAG) for pavement preservation which include the maintenance treatments for both flexible and rigid pavements, c) the Innovation Program, which is funded at \$5 million per year. This consists of surface recycling, use of warm mix technology with thin HMA overlays, and a variety of new and innovation surface seals, and d) the challenges facing those trying to implement a pavement preservation program.

**KEY WORDS:** Pavement preservation, Pavement maintenance

## 1.0 INTRODUCTION

### 1.1 Background

The California Department of Transportation has 50,000 lane miles of state highway to maintain and rehabilitate. In the early 90's, its primary focus was on the rehabilitation of pavements, with maintenance handling primarily reactive treatments. Currently, the program has grown to about \$250 million per year devoted to preservation treatments.

The process used to gain acceptance for pavement preservation had its roots in the 1990's. The state maintenance engineers used the results of its pavement management system to show that the condition of the pavements was dropping and the number of roads in poor condition was increasing. Caltrans also began to look into long-life pavements to minimize future maintenance and rehabilitation as well as increasing the number of maintenance strategies that could be used to preserve the fair to good pavements in good condition. The concept of pavement preservation used by Caltrans to help increase their funding for pavement preservation is shown in Figure 1.

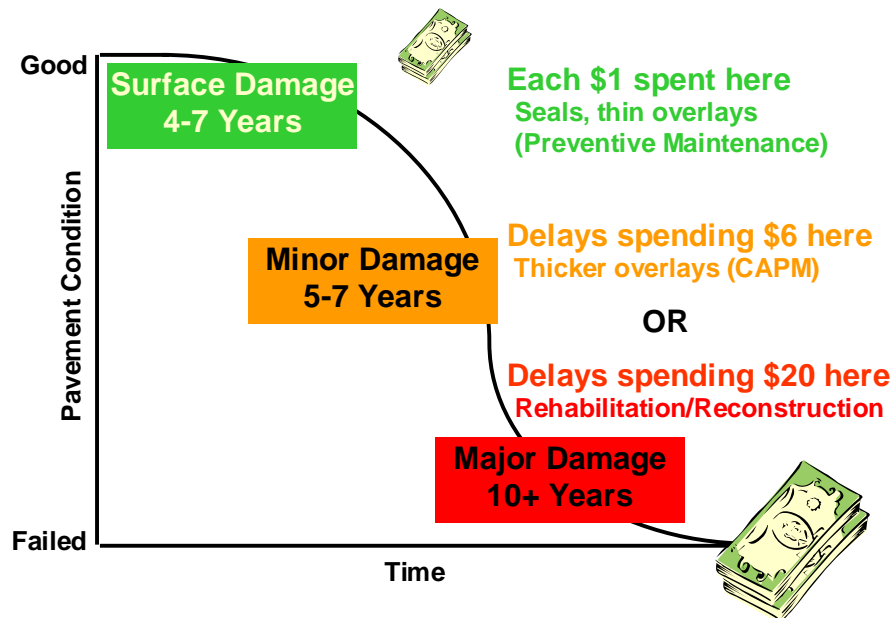


Figure 1: Pavement preservation concept used by Caltrans

## 1.2 Objectives of the Paper

The objectives of this paper are to illustrate what has been accomplished by Caltrans in terms of preservation including the following:

- Concept of Pavement Preservation in California and the important benefits derived from this program
- Development of the Maintenance Technical Advisory Guides (MTAGs) for pavement preservation which include the maintenance treatments for both flexible and rigid pavements
- Innovation Program, which is funded at \$5 million per year to encourage the use of new treatments. The types of projects constructed and monitored as a part of the program consist of surface recycling, use of warm mix technology with thin HMA overlays, and a variety of new and innovative surface seals.
- Challenges facing those trying to implement a pavement preservation program, including the incorporation of a pavement management system to monitor the lives of preservation treatments.

## 2.0 PAVEMENT PRESERVATION

### 2.1 Concept

Pavement preservation is similar to maintaining an automobile or a house. The concept of paying for minor work now to prevent major work in the future is an important concept of pavement preservation. Caltrans has been describing the benefit of pavement preservation to that of pavement rehabilitation using a 6 to 1 ratio, meaning that the cost of pavement preservation treatments are about 1/6 of that for pavement rehabilitation (Caltrans, 2007). This approach unfortunately does not consider the lives of the treatments, the life extension of the existing pavement associated with the treatments, and the other costs such as user and safety costs.

### 2.2 Benefits

Caltrans has identified several potential benefits associated with implementing a pavement preservation program including the following:

- Life extension of the existing pavements (delay in pavement rehabilitation). This is an important benefit of pavement preservation. If timely low cost treatments can defer pavement rehabilitation or reconstruction, they will preserve funds now for use on other more urgent or needed activities (see Figure 2).
- Lower treatment costs. Pavement preservation treatments typically cost from \$1-6/sq.yd while the cost to rehabilitation roads can be 6 to 10 times more expensive and the cost to reconstruct roads can be 15 to 30 times more expensive (Caltrans, 2007).
- Reduced user costs. Keeping good roads in good condition has been shown to reduce annual user costs by as much as \$500-700 per vehicle per year. This means the roads are smoother with fewer potholes to cause damage to vehicles (TRIP, 2009).
- Improved safety (to the public and the workforce). Pavement preservation treatments usually take less time to complete, therefore, the contractor can get in and get out faster minimizing the chances for work accidents during long work periods. Better roads surfaces also provide for good drainage and skid resistance which improves safety to road users.
- Improved overall network health. Some agencies have shown the overall network health can be improved by keeping good roads in good condition and finding ways to plan repairs for pavements in need of rehabilitation and reconstruction.
- Environmental benefits. Pavement preservation treatments also reduce air pollution, noise and the like because of typically short construction periods. Less equipment used for shorter periods of time reduces fossil fuel demand and vehicle emissions.
- Pavement preservation treatments are “Green”. Many of the treatments produce fewer emissions that potential effect global warming and reduce the energy needed to produce materials.

To realize the above benefits, Caltrans and others needed better information to convince the transportation commission and the legislature (or the other decisions makers) to provide more dedicated funding for pavement preservation while at the same time finding additional funds to repair pavements beyond the preservation stage. Work that has been accomplished at the CP2 Center (in cooperation with MACTEC and UC Davis) was designed to provide better information on the economic benefits of pavement preservation (Lee et al, 2007; Zhou and Barrantes, 2008). Work is also underway at the Center to document the energy and

environmental benefits of pavement preservation (Stroup-Gardiner, 2008).

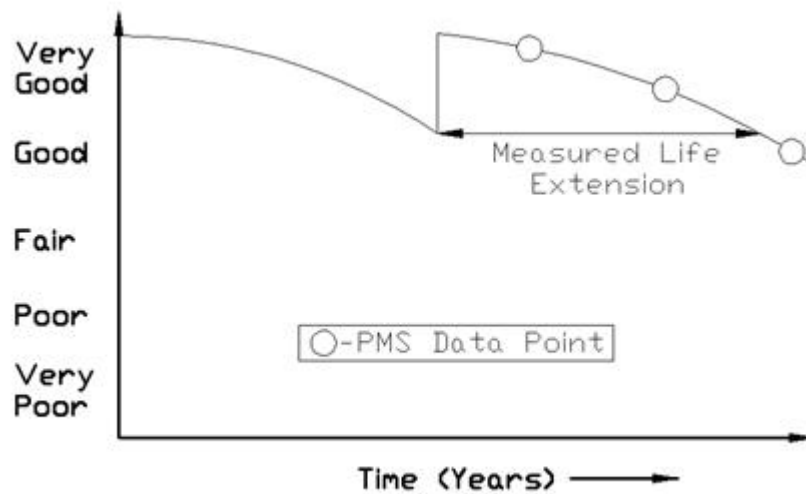


Figure 2: Schematic of life extension of pavements

### 2.3 Summary of Caltrans studies

Caltrans embarked on various efforts to determine the economic benefits of pavement preservation. The objective of these efforts was to evaluate the cost effectiveness of a proactive pavement preservation program as compared with the rehabilitation strategies currently employed by state and local agencies. The FHWA RealCost program was used to determine the life cycle cost savings associated with the use of a proactive pavement preservation program (Caltrans, 2006). Cost data used in the analysis came from the State of the Pavement Report (Caltrans, 2005) for the Caltrans analysis and from the Metropolitan Transportation Commission for the local agencies studies.

#### *COST ANALYSIS APPROACHES AND ASSUMPTIONS*

Agencies have historically used some form of LCCA to assist in the evaluation of alternative pavement design strategies. FHWA policy indicates that LCCA is a decision support tool. As a result, FHWA encourages the use of LCCA in analyzing all investment decisions. The life cycle cost approach used by Caltrans is the FHWA RealCost model (Caltrans, 2006). The program provides both a deterministic and probabilistic approach to determining the most cost effective strategies.

The work done by UC Davis using Caltrans data addressed the following questions:

- Is it more beneficial to apply pavement preservation treatments compared to applying no maintenance?
- Should pavement preservation treatments be applied at an earlier or later stage of cracking?
- How do the life cycle costs of different pavement treatment combinations compare?

The UC Davis study made use of the data extracted from the Caltrans pavement management database. However, it should be mentioned that most of the scenarios contained in the database did not include proactive pavement preservation scenarios. Most of the treatments were placed on pavements when the cracking was between 10-25%.

The studies conducted by the MACTEC and the CP2 Center investigated scenarios common to local agencies in California; scenarios representing pavements that received planned preventive maintenance and scenarios representing pavements that received only major rehabilitation treatments (with some minor maintenance). A discount rate of 4% and analysis periods of 35 years were used in the LCCA. Salvage values (SV) of the treatments were considered and prorated during the analysis. Even though the traffic loading and repetitions for local agencies can be different than for state agencies, the results of this analysis were expected to yield useful information.

### *RESULTS*

The results of the studies indicated the following:

- For local agencies data, the life cycle cost savings with the proactive pavement preservation program compared to the traditional rehabilitation program could save up to 20 % over the analysis period.
- For the Caltrans data, the life cycle cost savings when using pavement preservation varied from 20 to nearly 50%. Additionally, applying preservation treatments at later stage of cracking results in life-cycle costs up to 14% higher than if treatments are placed at an earlier stage of cracking.
- Life extension is a function of the pavement condition, traffic, and climate.

These studies for local agencies considered including the use of user costs, but the effect was not that significant. Studies by others for higher volume roads would suggest that the savings can be higher if users' costs are considered.

### *RETURN ON INVESTMENT USING PAVEMENT PRESERVATION*

The current pavement preservation budget for Caltrans is \$206 million per year; however, it only treats 2,700 lane miles per year. This is not yet a pro-active pavement preservation program. The State Highway Operation and Protection Program (SHOPP) is normally about \$4-5 billion per year. An annual savings of 20 to 50% or more could result from a proactive pavement preservation program. Table 1 summarizes the return on investment of a proactive pavement preservation program.

Table 1: Cost savings from pavement preservation treatments

For rehabilitation - 6 to 10:1 based on first costs only; for reconstruction - 20 to 50:1 or more based on first costs.
Over the life cycle - 20 to 50 % from the traditional way where the typical life cycle is 30 years. This assumes a proactive pavement preservation program.
For Caltrans SHOPP budget for 30 years (average of \$5 billion per year) or \$150 billion, savings would be 20-50% of \$150 billion or \$30 to 75 billion.

The following can be concluded based on above analysis:

- Caltrans currently treats about 2700 lane miles per year with pavement preservation treatments (\$206 million)

- Caltrans should be treating about 7000 lane miles per year to have a proactive pavement preservation program
- This means the preservation budget should be increased about 2.6 times
- By doing this, Caltrans could save 50% or more in its annual SHOPP budget over the next 30 years
- The remaining funds could be used to reconstruct the badly distress roads or to improve the overall network condition

Based on this study, Caltrans has requested an increase in the permanent annual pavement preservation funding.

### 3.0 MAINTENANCE TECHNICAL ADVISORY GUIDE

#### 3.1 Concept

The Caltrans Maintenance Technical Advisory Guide (MTAG), first developed in 2002, is a technical manual that covers pavement preservation and maintenance principles, materials used in maintenance treatments, treatment selection and individual chapters on the main strategies used by Caltrans (Caltrans, 2003).

Caltrans developed MTAG to provide vital information for maintenance personnel to aide in making better and more informed decisions in selecting and applying maintenance treatments for their highways. It is a reference guide that will be used by all types of Caltrans personnel when selecting a maintenance treatment and understanding how it needs to be applied. The MTAG was designed for several types of uses ranging from general instruction to specific work practice descriptions. It has been used especially by Maintenance Managers, Supervisors, and Superintendents. Construction personnel and designers have also found considerable use for this publication.

In 2006, Caltrans initiated development the MTAG for rigid pavement (Caltrans, 2006). It followed the same format as for the flexible pavement MTAG. It covered not only the chapters on materials and treatments, but also one on surface characteristics as requested by industry. In 2007, the flexible pavement MTAG was revised and expanded to include additional flexible pavement treatments, including recycling and interlayers.

#### 3.2 Organization of the MTAG

The MTAG is presented in two volumes. Volume I covers flexible pavement preservation while Volume II deals with rigid pavement preservation. Table 2 shows the chapters for each of the volumes.

The first three chapters of each volume of the MTAG are devoted to general issues that affect the use of any and all the pavement preservation techniques. They provide background on the pavement preservation concept, pavement distress, materials and strategy selection.

The remaining chapters of both volumes of the MTAG each address one of the treatment techniques commonly used by Caltrans. This section of the paper provides a short description of the type of information that the MTAG presents in the chapters for the treatment topics. For full length copies of this and other pavement preservation treatment chapters, the reader should go to the Caltrans website at the following websites:

Flexible: [http://www.dot.ca.gov/hq/maint/MTA\\_GuideVolume1Flexible.html](http://www.dot.ca.gov/hq/maint/MTA_GuideVolume1Flexible.html)

Rigid: [http://www.dot.ca.gov/hq/maint/MTA\\_GuideVolume2Ridgid.html](http://www.dot.ca.gov/hq/maint/MTA_GuideVolume2Ridgid.html)

A typical pavement preservation treatment chapter in the MTAG presents a description of the effectiveness and limitations of these techniques, as well as material selection, design considerations, and construction procedures. Also included are a troubleshooting guide and a list of important factors to be considered during design and construction of the treatment.

Table 2: MTAG Volumes and Chapters

<b><i>MAINTENANCE TECHNICAL ADVISORY GUIDE</i></b>	
<b>Flexible Chapters</b>	<b>Rigid Chapters</b>
1. Introduction	1. Introduction
2. Materials	2. Surface Characteristics
3. Treatment Selection	3. Treatment Selection
4. Crack Sealing	4. Joint Resealing & Crack Sealing
5. Patching & Edge Repair	5. Diamond Grinding & Grooving
6. Fog & Rejuvenating Seals	6. Dowel Bar Retrofit
7. Chip Seals	7. Isolated Partial Depth Concrete Repair
8. Slurry Seals	8. Full Depth Concrete Repair
9. Microsurfacing	
10. Thin Maintenance Overlays	
11. Bonded Wearing Course	
12. Interlayers	
13. In-place Recycling	

### 3.3 Benefits of the Guides

The MTAG was created as a resource of pavement preservation information for district engineers. To determine the value that the MTAG provides to them, Caltrans staff conducted an informal survey recently. The results indicate that all the respondents are familiar with the MTAG and that two-thirds of them use it either occasionally or quite often. Also, two-thirds found sufficient information within the MTAG to answer their pavement preservation questions quite often or most of the time. Half of the respondents credit information contained in the MTAG for enabling them to use a pavement preservation treatment that they would not have otherwise tried. The following are some of the comments that the respondents had sent regarding what is most valuable to them about the MTAG:

- “Up-to-date information and available online”,
- “It is a good reference for designers to get info on maintenance strategies”
- “I use it to justify strategies”
- “It seems to discuss all important aspects of the treatment or process”.
- “Sometimes I really like the amount of technical detail that it goes into on a particular subject”.

## 3.0 INNOVATION PROGRAM

### 3.1 Background

An innovation can be a product, a process, or an idea which can be used in a preservation strategy that results in a benefit or improvement over existing procedures used by Caltrans. Caltrans wants to utilize the latest techniques and research results in the area of pavement

preservation to improve the overall performance of the State’s roadway network. A \$5 million funding level per year has been allocated to run the innovation program.

The objectives of establishing the innovation program are to implement innovation and new products in the areas of pavement preservation and to encourage technical transfer, and to eventually improve the performance and status of pavements in California.

### 3.2 Treatments Evaluated

Table 3 lists innovations that have been constructed by Caltrans. Caltrans is evaluating the performance of these constructed innovation projects:

Table 3: Pavement preservation innovations by Caltrans

<b>Innovation Title</b>	<b>Locations</b>	<b>Construction Date</b>
<i>Cold in Place Recycling</i>	City of Chino	June and July, 2008
<i>Fog and Rejuvenating Seals</i>	Districts 9, 1, and 2	2008, 2009
<i>Hot in Place Recycling</i>	Districts 2 and 8	2008
<i>Interlayers</i>	District 2	2008
<i>Polymer or Tire Rubber Modified Asphalt Chip Seals</i>	District 11	2007, 2008
<i>Rubberized Emulsion Aggregate Slurry</i>	Districts 7 and 11	2009, 2010
<i>RAC-O-HB</i>	Various locations	2000-2005
<i>Warm Mix Asphalt</i>	Districts 3, 4, 6, and 11	2007- 2009

Some other innovations such as double chip seals over fabrics and quiet pavement are in the proposal stage and will be evaluated later.

### 3.3 Innovation Database

To support management of innovation and new products in the areas of pavement preservation and to encourage technical transfer through dissemination of information through a web site, an online innovation database has been developed by the PPTG innovation subgroup and the CP2 Center (Cheng et al., 2008). There are five different groups of users for the database.

- General Public - This group was created to help disseminate innovation. They can log in using “guest” for both username and password. After login, they can browse, view innovations, and search innovations by keywords, but they cannot comment, edit, or submit proposals.
- Champions or Innovators - This user group can submit new proposals and view others’ innovations. They can also submit two files with their proposals. For security reasons, they can edit their own innovations, but they can not edit proposals submitted by other champions or innovators.
- Innovation Committee or Reviewers - This user group can review and comment on the innovations submitted. They can also see the comments created by themselves or others, but they cannot edit any innovation submitted.
- CP2 Center Staff - This user group can add or edit new users to the database in addition to having all the functions of innovation committee members
- PPTG Chair - This user group can approve innovation status to pre-proposal, proposal, and final report besides the functions of innovation committee members.



The innovation database promotes innovations. All Caltrans innovations can be submitted and stored on one site. People can have access to all innovation projects. And it is a good way to manage innovation through online program. The website for the database is: [http://www.ecst.csuchico.edu/cp2c/innovation\\_database/](http://www.ecst.csuchico.edu/cp2c/innovation_database/).

### 3.4 Benefits of the Program

There are many benefits of the establishing the innovation program. The innovation program helps implementing new technologies and products that are more cost effective than conventional ones. The innovation program accelerates the rate of technique transfer and can quickly use innovation to improve California roadway pavement performance. The developed innovation database can help Caltrans effectively manage pavement preservation innovations and can keep track of innovations for long term performance evaluation (Cheng et al., 2009).

## 4.0 CHALLENGES FACING PRESERVATION PROGRAMS

Several challenges have been identified from the agency point of view. Some of these are discussed below:

- Dealing with the paradigm shifting from fixing worst-pavements first to fixing good-pavements first. One of the biggest obstacles to overcome is to convince agency personnel to move from the conventional worst-first practice of fixing pavement problems to fixing good pavements first while letting the bad ones continue to deteriorate.
- Need for top management commitment. Pavement preservation programs will not succeed without top management commitment. This includes getting a commitment for dedicated funding and for resources needed to collect information on the effectiveness of preventive maintenance treatments.
- Recognizing the importance of pavement preservation. Pavement preservation projects should also warrant ribbon-cutting ceremonies just like other major rehabilitation or reconstruction projects.
- Identify a champion for the program. Pavement preservation programs need a champion for them to be effective.
- Need to show early benefits. It is important to show the early benefits of the pavement preservation program including treatment life extensions, reduced life cycle cost, and the like.
- Selecting the right treatment for the right pavement at the right time. Preventive maintenance treatments can be ineffective if the correct treatments are not used. It is important that the right treatment be used on the pavement and that it is applied in a timely manner.

## 5.0 SUMMARY

Caltrans has been very successful in implementing a pavement preservation programs, but there is still more to do. This section summarizes the major accomplishments during the past decade:

- Developed and implemented a pavement preservation program with top management support. This includes a permanent fund for pavement preservation which is currently funded at \$206 million per year which should be increased to \$800 million per year in

order to treat 7,000 lane miles per year. By doing this, we can save 50 % or more of the State Highway Operation and Protection Program (SHOPP) budget each year, allowing the savings to help reconstruct some of the more distressed roads.

- Developed the MTAGs for flexible and rigid pavements. These have assisted the districts as well as local agencies to become more aware of the available techniques and how and when to apply them
- Developed an innovation program of \$5 million per year to place new preservation techniques. The projects are monitored by the CP2 Center using a database that can be accessed by agencies or industry to help with this effort.

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