Integrating Preventive Maintenance and Pavement Management Practices

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ABSTRACT

Managing a pavement network has become more complex as the competition for pavement preservation funds has grown and the need to justify decisions has increased. As a result, tools that can help an agency collect, analyze, and summarize data have become increasingly important. As a result, asset management tools, such as pavement management systems, have become a necessary component of today's transportation agencies. Coupled with a change in agency focus from expansion to preservation, pavement management systems are now being used to support the use of cost-effective preservation strategies such as preventive maintenance.

However, the use of pavement management tools to support preventive maintenance programs is impacted by the degree to which preventive maintenance treatments are integrated into a pavement management system. Agencies that have successfully integrated their preventive maintenance treatments into their pavement management system have been able to demonstrate the benefits of their preventive maintenance programs to upper management. For the most part, these analyses have focused on the comparison of worst-first strategies to strategies that incorporate preventive maintenance treatments or illustrations of the cost-effectiveness of preventive maintenance treatments.

To fully support a preventive maintenance program, the preventive maintenance treatments must be fully integrated into the pavement management models. This requires a concentrated effort on the part of the transportation agency to re-evaluate its pavement management analysis models to ensure that preventive maintenance treatments and timings are incorporated into the pavement management analysis.

The technical issues that must be addressed to successfully integrate preventive maintenance treatments into an agency's pavement management activities are discussed further in this paper. Examples from transportation agencies that have addressed the integration issues are provided to illustrate possible approaches that may be used.

Key words: pavement management—pavement preservation—preventive maintenance

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INTRODUCTION

As the management of transportation networks has become increasingly complex, and the competition for pavement preservation funds has grown, tools that can help an agency collect, analyze, and summarize data have become increasingly important. Nationally, the emphasis on the use of these tools has resulted in the development of a Strategic Plan for the Task Force on Transportation Asset Management that emphasizes the importance of promoting the development of asset management tools and analysis methods, and communicates to states how to better utilize and implement these concepts (*1*). As a result, asset management tools, including the use of pavement management systems, have become a necessary component of today's transportation agencies. Coupled with a change in agency focus from expansion to preservation, pavement management systems are now being used to support the application of cost-effective preservation strategies such as preventive maintenance.

One of the factors that has driven the need for asset management tools is the change in focus in transportation agencies from new construction to preservation. Coupled with changes in legislation that have simplified the use of federal funds for maintenance activities (such as TEA-21), new preservation strategies are being introduced in transportation agencies. Preventive maintenance programs are being developed and implemented as cost-effective strategies for accomplishing an agency's preservation goals.

Nationwide, the experience with pavement preservation programs in general, and preventive maintenance programs specifically, has been limited. Therefore, experience combining pavement preservation and pavement management is even more limited. Several agencies have successfully used their pavement management systems to demonstrate the benefits of preventive maintenance as they began to implement preventive maintenance programs. Michigan, New York, and California are all examples of states that have been able to use pavement management tools to jump-start their preventive maintenance programs and to bolster the amount of dedicated funding allocated to it. For the most part, these analyses have focused on the comparison of worst-first strategies to strategies that incorporate preventive maintenance treatments or illustrations of the cost-effectiveness of preventive maintenance treatments.

Although these communication efforts have proven successful in helping to promote preventive maintenance programs, the use of pavement management to illustrate the potential benefits to the agency is only one aspect of how pavement management can be used to support a preventive maintenance program. Another important component is fully integrating the preventive maintenance activities into the pavement management system models so that preventive maintenance treatments are incorporated into the pavement management recommendations provided from the optimization analysis. This second function is much more difficult than the first, as it often relies on "simulating" conditions. The integration of preventive maintenance into pavement management requires a concentrated effort on the part of the transportation agency to re-evaluate its data collection activities, performance modeling approach, and program development activities to ensure that preventive maintenance treatments, and their timings, can be identified by the pavement management system, and that the benefits realized from the application of the treatments can be accounted for in the optimization analysis. This paper introduces the preventive maintenance concept and outlines the considerations that must be made to integrate preventive maintenance into a pavement management system.

THE PREVENTIVE MAINTENANCE CONCEPT

As defined by the Federal Highway Administration (FHWA), pavement preservation involves a systematic approach to preserving the investment in existing roadways by improving pavement performance and extending pavement life in a cost-effective manner (*2*). It includes a variety of activities

that are undertaken to provide and maintain serviceable roadways, including corrective and preventive maintenance as well as minor rehabilitation activities.

An important part of a preservation program is the use of pavement preventive maintenance treatments to improve the functional condition of the network and retard the overall rate of deterioration. Since preventive maintenance treatments are relatively inexpensive in comparison to resurfacing or reconstruction projects, preventive maintenance programs have been found to be a cost-effective means of meeting pavement performance goals. The use of preventive maintenance treatments also slows the rate of pavement deterioration, thereby delaying the need for major rehabilitation by several years, as shown in Figure 1. The delay in rehabilitation needs is more than offset by the fairly low cost of preventive maintenance treatments, which results in a fairly dramatic cost savings in the total costs associated with preserving the pavement network.

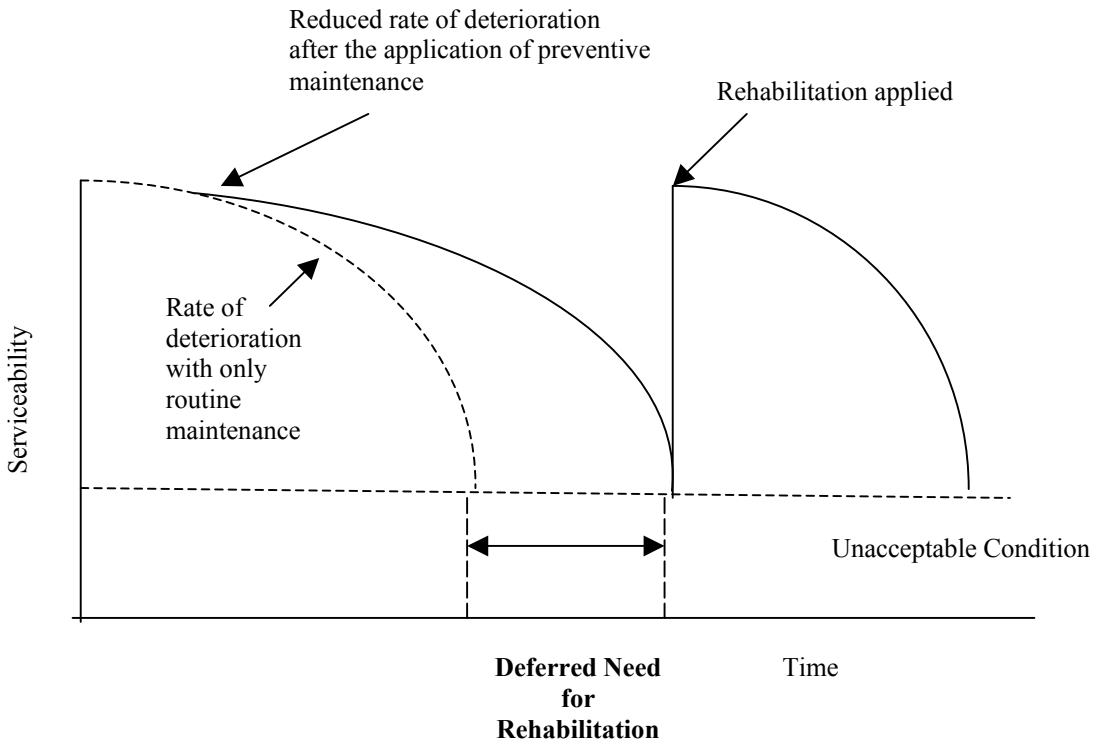

FIGURE 1. Deferred Need for Rehabilitation with the Use of Preventive Maintenance Treatments

There area other benefits that can be realized through the use of a pavement preventive maintenance program. Some of the benefits documented in the literature are listed below (*3*):

- Higher customer satisfaction with the road network.
- The ability to make better, more informed decisions on an objective basis.
- The more appropriate use of maintenance techniques.
- Improved pavement conditions over time.
- Increased safety.
- Reduced overall costs for maintaining the road network.

Despite the benefits that may be realized, many agencies have found it difficult to implement a preventive maintenance program because of the agency's resistance to apply preventive maintenance treatments to roads in good condition when a large part of the network is in poor condition. This is especially difficult when pressures from the public or politicians tend to support a "worst-first" strategy. To overcome this challenge, agencies must utilize their pavement management systems to demonstrate the benefits of a preventive maintenance strategy and support the agency's change in philosophy. However, since pavement management systems have primarily been relied on to serve as programs for identifying and prioritizing rehabilitation needs, integrating preventive maintenance and pavement management requires some modifications. Some of the approaches that are used to integrate preventive maintenance into pavement management and the specific technical areas that need to be addressed to successfully integrate these programs are discussed in the following sections of this paper.

APPROACHES TO INTEGRATION

There are three primary approaches that can be used to integrate preventive maintenance treatments into a pavement management system. The approach used by an agency is dependent on the availability of information in the pavement management system to support the development of the required models, the overall objectives for the analysis of the preventive maintenance treatments, and the sophistication of the pavement management system.

The simplest approach provides recommendations for preventive maintenance candidate sections as a default to the analysis of pavement rehabilitation and reconstruction needs. Using this type of approach, the pavement management system is used to analyze the rehabilitation and reconstruction needs of a network, and any pavement sections that are not candidates for these types of treatments are automatically considered to be candidates for preventive maintenance. Although this approach is easy to implement because it requires no changes to the pavement management models, it provides limited support for analyzing the impacts associated with the use of preventive maintenance treatments.

A slightly more sophisticated approach is to incorporate a single treatment into the pavement management analysis models that represents a variety of preventive maintenance treatments. For example, in addition to evaluating thin overlays, mill and fills, and structural overlays as treatment options, the pavement management analysis will also consider pavement sections for a treatment called preventive maintenance, which is generally applied to pavements in fairly good condition. Pavement sections that are recommended for preventive maintenance are then investigated in more detail to determine the specific type of preventive maintenance treatment that should be applied. This approach is relatively simple to implement and does not require very sophisticated analysis tools to use. However, the performance rules and cost models that are used to analyze the preventive maintenance treatment tend to be averages that represent a broad range of possible treatments. This approach is better than the first approach for analyzing the impacts of preventive maintenance, but does not provide a specific recommendation for the type of treatment that should be used.

The Metropolitan Transportation Commission (MTC) in the San Francisco Bay area uses this type of approach for its analysis of preventive maintenance treatments. Based upon a standard deterioration curve, treatment trigger levels are set to establish the condition level at which various treatments are considered. Figure 2 illustrates the standard deterioration of the Pavement Condition Index (PCI) over time and the progression of treatments that the MTC system utilizes to appropriate identify maintenance and rehabilitation activities. The trigger value between preventive maintenance and light to moderate rehabilitation occurs at a PCI of 70, the trigger value between light to moderate rehabilitation and heavy rehabilitation occurs at a PCI of 50, and the trigger value between heavy rehabilitation and reconstruction occurs at a PCI of 25 (*4*). These values can be modified in the program for various pavement categories,

or families. In addition to a treatment trigger, the MTC system has supplemental requirements that influence treatment selection. For example, in order for preventive maintenance to be selected, the pavement section must have a condition higher than 70 and the condition must be projected to remain above the trigger value for at least three years.

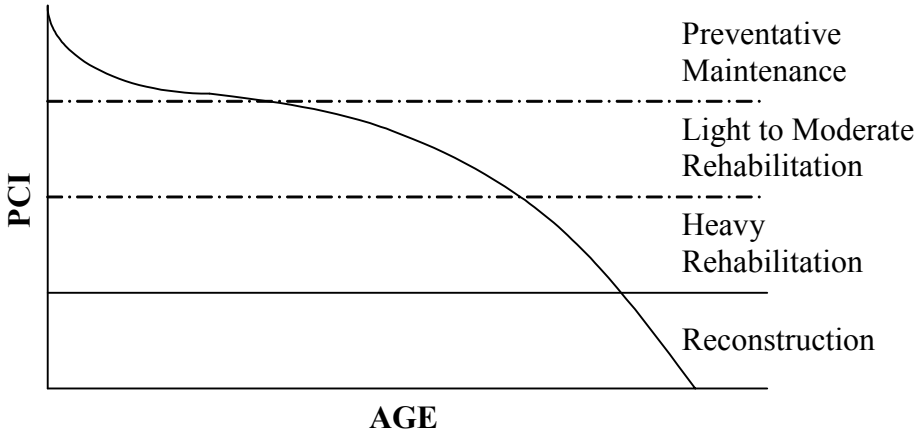

FIGURE 2. PCI Deterioration Curve and Default MTC Treatment Levels

The most sophisticated approach is to define specific preventive maintenance treatments into the pavement management system and to develop performance models, treatment rules, cost functions, and impact models for each treatment that is defined. This approach requires the most effort to establish, but provides the greatest level of support for the preventive maintenance program. An agency using this approach is best prepared to use its pavement management system to support the analysis of the benefits associated with a preventive maintenance program as well as to assist in the identification and prioritization of appropriate preventive maintenance treatments. The requirements to achieve this level of integration are further discussed in the next section of the paper.

INTEGRATING PREVENTIVE MAINTENANCE INTO PAVEMENT MANAGEMENT MODELS

To fully integrate preventive maintenance treatments into a pavement management system, all components of the pavement management system must be examined to determine whether changes are necessary to accommodate the consideration of maintenance treatments, as discussed in the following subsections.

Pavement Condition Assessment and Condition Indexes

Agencies that are taking steps to incorporate preventive maintenance treatments into a pavement management system should investigate several aspects of the pavement condition survey procedures. First, the agency should evaluate the types of distress that are collected during the survey to determine whether the factors that trigger the selection of preventive maintenance treatments are included. For example, some preventive maintenance treatments are triggered to address friction problems caused by excessive bleeding or raveling of the pavement surface. If the pavement condition survey procedures do not report the presence of bleeding or raveling, the system will not be able to recommend appropriate treatments.

Secondly, the agency must evaluate the procedures that are used to convert pavement distress information into pavement condition indexes. If all the distress information is compiled into one, single composite index, then the pavement management recommendations may not be specific enough to identify feasible treatment options. Alternatively, an agency that uses individual indexes for triggering treatments may be better prepared to identify treatments that address the primary cause of the deterioration. For example, if a friction index is available, it could be used to trigger preventive maintenance treatments designed to improve the safety of the facilities. A pavement management system that only uses an overall condition index would not provide enough of an indication of the type of deterioration present to effectively identify an appropriate action.

The agency should also review its survey frequency to determine whether it is sufficient for identifying the window of opportunity for preventive maintenance treatments. In many instances, there is a short window during which preventive maintenance treatments are appropriate. If pavement condition surveys are conducted outside of that window, the opportunity for applying effective preventive maintenance treatments may be lost.

Pavement Performance Models

Pavement performance models are used in a pavement management system to predict future conditions. The results are then used to determine future maintenance and rehabilitation needs and to report the future condition of the pavement network under various scenarios. Many transportation agencies use a "family" modeling approach that groups pavement sections with similar characteristics and uses regression techniques to determine the deterioration pattern that is reflective of the family performance data. In order to properly incorporate preventive maintenance treatments into the pavement performance models an agency must address the development of performance models for each of the preventive maintenance treatments included in the analysis and for each condition index that is used to trigger treatments. The development of performance models that show the change in pavement conditions with and without the application of the treatment provide the information necessary for the pavement management system to evaluate the additional performance that can be realized by the application of the treatment.

The pavement management database must be able to provide the information necessary to support the changes to the pavement performance models (*5*). For instance, if a chip seal curve is developed, chip seal treatments must be identified in the pavement management database. In many agencies, that means that maintenance treatment information has to find its way to pavement management and that the information reported is provided in a manner that is useful to the pavement management section. This requires that data are collected using a common reference system (or a compatible referencing system) to ensure compatibility.

Pavement Treatment Rules

In addition to defining pavement performance models for each treatment considered in the analysis, an agency must also develop treatment rules that indicate the conditions under which the treatment is considered feasible and the reset rules that define the conditions that exist after the treatment has been applied (*5*). In general, setting up treatment rules is not difficult. Many agencies use decision trees, such as the one illustrated in Figure 3, to define the set of conditions under which a preventive maintenance treatment is considered feasible. As with the development of performance models, the pavement management database must contain the information used in establishing the treatment rules.

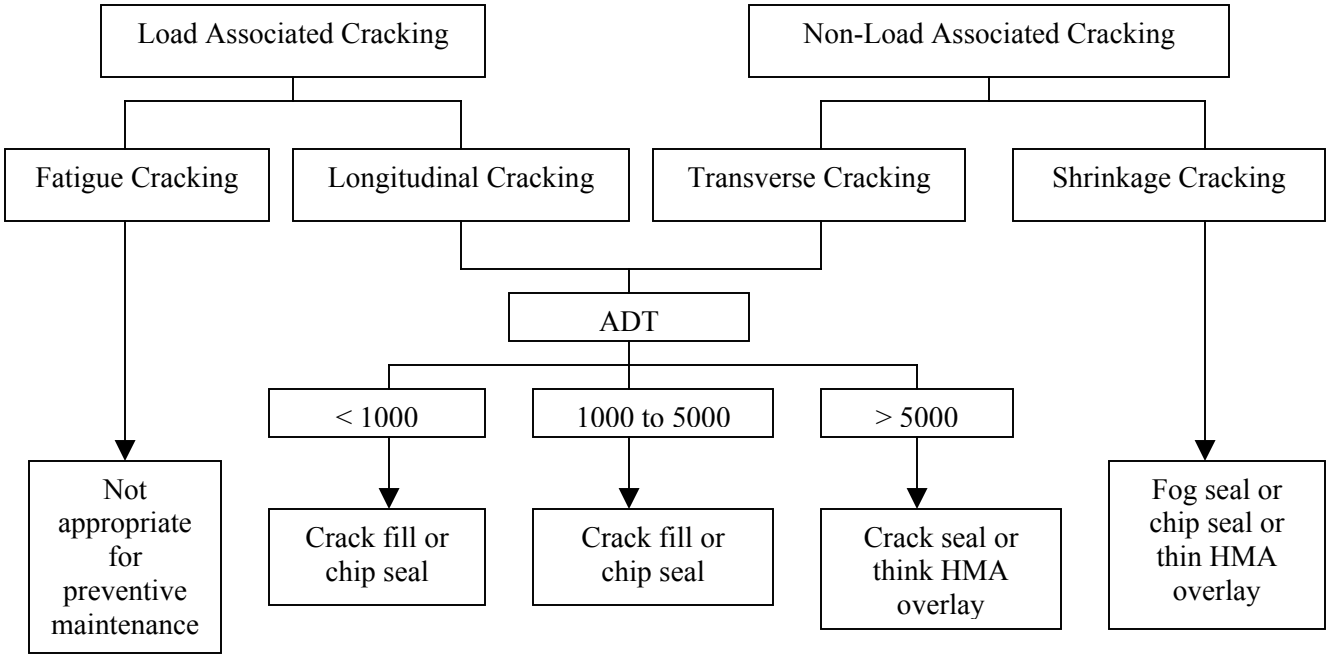

FIGURE 3. Sample Decision Tree for Cracking (*6*)

Treatment Impact Rules

More difficult than establishing the treatment rules for identifying feasible preventive maintenance treatments is defining the reset rules that the pavement management system uses to analyze the conditions that apply immediately after a preventive maintenance treatment is selected for a pavement section. This is more complicated for preventive maintenance treatments than it is for a rehabilitation or reconstruction treatment. For rehabilitation and reconstruction treatments, the condition indexes generally return to a perfect (or near perfect score) and existing pavement performance curves are used to reflect the new rate of deterioration. However, with preventive maintenance treatments this activity is somewhat more complex because the treatments do not necessarily return the pavements back to the highest rating (*5*). Instead, an incremental increase represented by a percentage improvement in condition or some other mathematical expression may be more appropriate. For example, an agency may set a rule that crack sealing provides a 10 percent improvement in pavement condition after its application and returns to the original performance curve within a 3-year window. Alternatively, the preventive maintenance treatment might provide an immediate improvement in pavement condition and follow a slower rate of deterioration after the application of the treatment. The agency's challenge is to define these rules for each treatment considered in the analysis. The issue is further complicated by the fact that not all pavement management systems allow for the use of these more complex reset rules and the performance of maintenance treatments is not well documented in most agencies.

USE OF PAVEMENT MANAGEMENT TO DEMONSTRATE COST-EFFECTIVENESS

The benefits associated with the use of preventive maintenance treatments as part of a pavement preservation program are numerous. When properly integrated into a pavement management system, the

pavement management system can be used to help demonstrate the benefits associated with the use of preventive maintenance treatments, including improved overall conditions or reduced preservation costs.

This concept is illustrated in Figure 4, which shows the dramatic difference that can occur in overall pavement conditions (as defined using a Pavement Condition Rating, or PCR) after several years of incorporating preventive maintenance treatments into a pavement preservation strategy. In this example, the agency compared the resulting conditions from two preservation strategies using the same level of funding for each. In the worst-first strategy, the pavements that were in the worst condition were addressed before any other pavements in the network. In the pavement preservation strategy, a preventive maintenance program was implemented in conjunction with traditional rehabilitation and reconstruction activities.

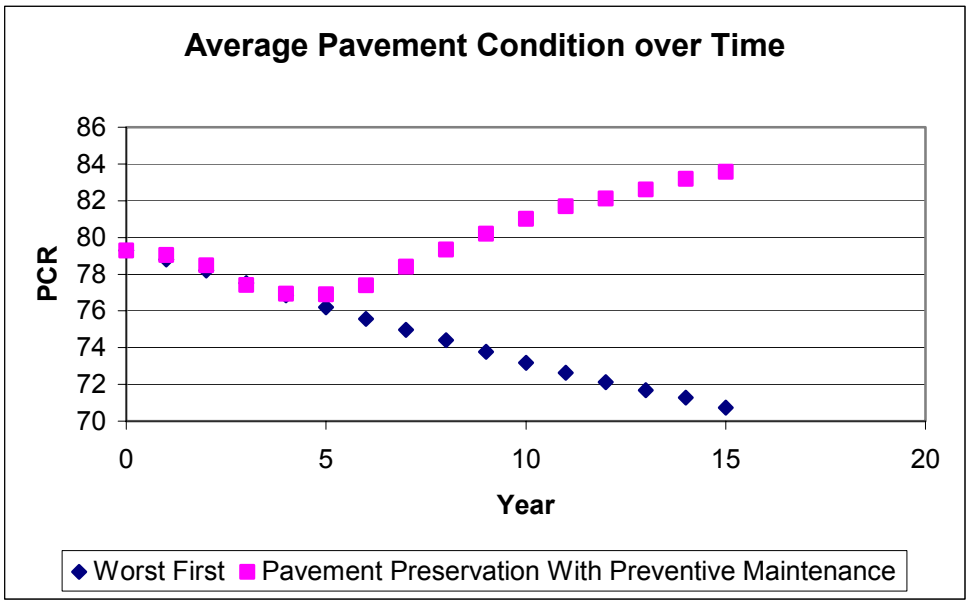

FIGURE 4. Benefits Associated with the Use of Preventive Maintenance Treatments as Part of a Pavement Preservation Strategy (North Carolina DOT, unpublished data)

CONCLUSIONS

A pavement management system can be used effectively to support the use of preventive maintenance treatments as part of a pavement preservation program. However, to successfully use the pavement management system in this manner, the preventive maintenance treatments must be integrated into the pavement management analysis models. This paper introduces three approaches that can be used to integrate preventive maintenance treatments into a pavement management system and the considerations that must be made to achieve the highest level of integration. The benefits that can be realized by integrating preventive maintenance treatments into a pavement management system include the ability to produce more coordinate work plans that demonstrate the cost-effectiveness associated with the use of sound pavement preservation principles.

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