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16. Abstract

This report provides the background for the development of a pavement management system for the paved roads of Virginia's secondary highway system. Included are descriptions of a study to develop an acceptable surface-condition rating system for surface-treated (chip-sealed) pavements, a pilot application of the system, and an assessment of the resources required to implement the system. The system developed includes a means to capture data for ordinary or routine maintenance needs. A further part of this study involved a comparative analysis of the allocation of resurfacing monies on the basis of (1) a historical 5-year program, (2) a 100 percent sampling approach, and (3) a 5 percent random sampling approach. Among the major recommendations are to proceed with full implementation of the system, including the provision of the needed resources; to use data from the system to determine the amount and allocation of the secondary resurfacing budget; and to capture data on ordinary maintenance needs for at least one cycle of pavement condition ratings.

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FINAL REPORT

MANAGEMENT OF PAVED SECONDARY ROADS

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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ABSTRACT

This report provides the background for the development of a pavement management system for the paved roads of Virginia's secondary highway system. Included are descriptions of a study to develop an acceptable surface-condition rating system for surface-treated (chip-sealed) pavements, a pilot application of the system, and an assessment of the resources required to implement the system. The system developed includes a means to capture data for ordinary or routine maintenance needs. A further part of this study involved a comparative analysis of the allocation of resurfacing monies on the basis of (1) a historical 5-year program, (2) a 100 percent sampling approach, and (3) a 5 percent random sampling approach. Among the major recommendations are to proceed with full implementation of the system, including the provision of the needed resources; to use data from the system to determine the amount and allocation of the secondary resurfacing budget; and to capture data on ordinary maintenance needs for at least one cycle of pavement condition ratings.

FINAL REPORT

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INTRODUCTION

The introduction of pavement management in the Virginia Department of Transportation (VDOT) in the early 1980s was an enormous step in the direction of providing objective management functions and activities in many areas. Although the earliest implementation of a pavement management system (PMS) was for the interstate highway system, a similar system was soon operative for the primary and arterial systems.[1] In the late 1980s, interest in bridge management began to develop and a fledgling objective system was implemented.

A formal PMS for VDOT's secondary system has been slow in developing, due to its large size. The 1988 *VDOT Mileage Tables*[2] show 44,994 miles of secondary roads—33,906 miles of which are paved. Functionally, the latter vary from well-constructed, multilane, dual-divided, plant-mixed surfaced highways that carry a high traffic volume and load to narrow surface-treated roads that merely evolved from trails and carry few vehicles. Because of the poor delineation of performance criteria for unpaved roads, such roads were not included in the present study. At the same time the primary PMS was implemented, a modest effort at managing paved secondary roads was begun. This effort was based on a 5 percent random sampling of the secondary roads, from which the condition and needs of each county were to be estimated. This approach yielded results of such poor reproducibility that its credibility was questionable and the results were not well accepted.

A major barrier to the early development and implementation of a secondary PMS has been an old, informal system of funding chip-seal resurfacings on a 5-year cycle. Although every pavement was not resurfaced every 5 years, the system was funded in such a way that the 5-year average accrued. Such a system was clearly easy to implement and required little if any management effort to conduct.

In 1987, however, the investigators had occasion to review a number of paved secondary roads in various parts of the state and discovered some remarkable differences in the levels of service provided across the state. In some areas, pavements scheduled for resurfacing in the current year appeared to have been resurfaced the previous year. In others, it was evident that either many years had passed since resurfacing had been provided or there were dramatic differences in the performance of these low-volume pavements from one part of the state to another. Not all apparent discrepancies, however, were geographically widespread—some occurred within a single maintenance area.

These observations coupled with a desire to fulfill earlier pavement management mandates prompted the investigators to seek management support to proceed with the development and implementation of a secondary PMS. To solicit that support, state maintenance engineer C. O. Leigh was taken on a tour of the areas the investigators had seen. After that tour, Leigh gave his support to the effort, which was soon endorsed by the Maintenance Research Advisory Committee and the Pavement Management Research Advisory Committee. A work plan[3] for the project was approved by the Federal Highway Administration for HP&R funding in April 1988.

PURPOSE AND SCOPE

The purpose of the study was to develop and implement a PMS for the state's system of paved secondary roads. A *paved surface* was defined as one wherein a liquid asphalt material serves as a binding agent for the road's other surfacing components. The *state's system of paved secondary roads* was defined as all roads, except interstate highways, coming under VDOT jurisdiction and having a route number of 600 or higher. It was anticipated that secondary roads with hot-mixed asphaltic concrete surfaces would be managed in a manner similar to primary and interstate pavements.

Among the more important objectives of the study were the following:

- to develop a pavement condition rating system
- to develop objective criteria for use in the resurfacing decision-making process
- to develop means of assessing the ordinary (routine) maintenance and the rehabilitation needs of paved secondary roads
- to assess the relative merits of three approaches to managing paved secondary roads:
  - —the present, or historical, approach where the funding level will support an annual resurfacing of one fifth (20%) of the pavements in a given area (5-year cycle)

—a needs-based approach where the conditions of all pavements in an area (100 percent sample) are evaluated using an objective rating system and resurfacing funds are allocated to all pavements (miles) below the preselected threshold

—an estimated-needs approach where a 5 percent random sample of pavements is evaluated using an objective rating system (In this approach, the sample characteristics are used to estimate the distribution of pavement conditions in an area [i.e., the pavement population characteristics]. From those statistics, the percentage of pavements [miles] below the threshold is estimated and the funds allocated accordingly.)

- to assess the resources (personnel and equipment) necessary to implement the PMS chosen.

METHODOLOGY

Steering Committee

Since it was evident from the early reaction to discussions of pavement management for the secondary system that the cooperation and support of field personnel would be essential to a successful program, the investigators acted prior to the beginning of the study to have a steering committee appointed made up of representatives of the group. The committee was composed of the district pavement management coordinator, one residency maintenance manager, and one area maintenance manager from each of the nine highway districts. Committee members were appointed with the assistance and concurrence of the district engineer and the state maintenance engineer. A list of the committee members is given in Appendix A.

The first meeting of the steering committee was held in Lynchburg in September 1987. As a part of the meeting, a number of surface-treated pavement sections in Campbell County were reviewed by all members of the committee. The purpose of these reviews was to attempt to arrive at consensus plans for rehabilitation, maintenance replacement, and ordinary maintenance activities of the pavements, depending on the condition of the pavements. Instead, the consensus was that the Campbell County sites did not represent a typical cross-section of distress types (the overwhelming distress in Campbell County was bleeding or excessive asphalt).

The second activity of the steering committee took place in Charlottesville in April 1988. At that time, the investigators had selected a spectrum of 13 pavements in Albemarle, Fluvanna, and Orange counties. These pavements were selected on the basis of observed distress and were intended to provide the steering committee with a full range of pavement conditions with which to conduct a rating exercise. This exercise, utilizing an early version of the rating system described later, was conducted on April 28, 1988. The exercise served to familiarize the steering committee members with the pavement management process, including an effort to collect data on ordinary maintenance needs. It was, however, clear that the small number of sections did not provide sufficient data on which to base a long-term program.

At the conclusion of the exercise, a lively discussion of the approach to managing secondary pavements led to a decision to conduct a pilot study composed of one maintenance area from each district. It was further decided that members of the steering committee would conduct the pilot study.

Pilot Study

The pilot study was conducted during calendar year 1988 and completed by early fall of that year.

Condition Rating Method

In order to characterize pavement condition properly and have a tool for use in priority programming, it is necessary to have an acceptable procedure for rating pavement conditions. As a first step toward providing such a method for paved secondary roads, the investigators considered the method applied to the higher classes of flexible pavements already included in VDOT's PMS. The method incorporates alligator and longitudinal cracking, rutting, pushing, raveling, and patching as the major distresses. A subjective ride quality evaluation is also included. Although designed for the higher classes of pavements, nearly all of which are paved with hot-mixed asphaltic concrete, the procedure has been used for several years as the rating method employed in the 5 percent random sampling approach for the secondary system. In early trials by the investigators and during discussions with the steering committee, however, it soon became apparent that different distresses occurred on the secondary system, where the predominant pavement surface is a chip seal or "surface treatment."

Therefore, prior to beginning the pilot study, the investigators, in cooperation with the steering committee, designed a new trial rating procedure incorporating the distresses considered by a consensus to be the most important. The group agreed that it is very difficult to separate various deformation types of distress (rutting, pushing, settling) on surface-treated pavements and agreed that one class called "distortions" would be used. The group also determined that bleeding, although not usually considered a pavement distress, is an important consideration in the decision to re-treat a surface-treated pavement. Finally, the group added edge cracking as a distress often observed on secondary pavements (probably because the pavements tend to be relatively narrow such that wheel loads reach the edges more often than is the case with the primary system). Only two distresses, cracking and patching, are considered in both the primary and the present rating systems.

The general rating procedure, given in Appendix B, is to drive on the pavement at 5 to 10 mph and note the major distresses present. Teams were asked to undertake a mental averaging of the frequency and severity of each distress as they traversed a section of pavement and provide a consensus rating at the end of the section. The definitions of severity for each distress are given in the instructions, and the frequencies are described in the rating factor matrix on the worksheet (see Appendix B). Using the matrix, raters were asked to assign a rating factor of from 0 to 9 to each distress. An exception to the rule occurs in the case of patching, where it has been a convention of long standing that patching has no variations in severity level. For rating purposes, patching is assigned a severity level of "not severe" and, therefore, receives rating factors of 0 to 3. Poorly constructed patches may be rough and, therefore, affect the ride rating (determined at normal traffic speeds) for a pavement.

The definition of *pavement sections to be managed* was left to the discretion of the teams.

Other Instructions

Other features of the worksheet, designed to provide additional information to management and facilitate the analysis of the data, are as follows:

1. Space is provided for the rating teams to incorporate information concerning the ordinary or routine maintenance activities they would apply to each section of pavement evaluated. This feature was incorporated in an effort to begin to identify the reasons for applying each activity as well as to provide a possible basis for the projection of future needs. The most commonly used codes were listed on the worksheet. The raters were asked to add any others as needed.

2. Space is provided for the rating teams to enter their assessment, on a scale of 0 to 10, of whether a given section of pavement should be programmed for a resurfacing. Although this entry caused some difficulty for the teams, they were asked to make a consensus evaluation, with 0 indicating no need for resurfacing and 10 indicating that an early resurfacing is essential. As will be seen later, this entry was critical to the statistical analysis of the pilot study data such that the relative weights of various distresses could be determined. At the inception of the pilot study, all distresses were considered to be of equal importance. The study team was well aware that in the real world there are large differences in the relative importance of those distresses.

The complete instructions for the rating procedure may be found in Appendix B. However, a general instruction worthy of special note was to ignore pavements surfaced with other than surface treatment, i.e., asphaltic concrete–surfaced and slurry-sealed pavements, even though located on the secondary system. As final instructions, not included on the worksheet, the rating teams were asked to keep careful records of the hours spent in travel, in rating, and in office work. They were also asked to record any other resources required, such as vehicles, computers, and office space.

The pavement sections and areas chosen for the pilot study were not randomly selected. Instead, rating teams were asked to choose an area where they would be likely to find approximately 100 different sections of surface-treated pavement to evaluate. This failure to sample randomly, although unavoidable in the context of the present study, places some limitations on the usefulness of the data. Some of these limitations are discussed later.

RESULTS AND DISCUSSION

Pilot Study

By the time all worksheets for the pilot study had been turned in, 960 pavement sections comprising 848 roadway miles were represented. From such a mass of data, the investigators were able to develop some very interesting results, discussed in the following sections. The reader is reminded, however, that the study described herein was a pilot study and data from even such a large nonrandom sample may be misleading for a system of highways as large as Virginia's secondary system. For that reason, the reader must be careful not to generalize about relative pavement conditions across the state from the data presented. The focus is on developing and implementing the process—not on the results of the sample.

In an effort to prevent possible misuse of the data, in the following discussions the investigators purposely use a random identification scheme so that the reader cannot easily determine the locations of the various areas discussed. The locations will be recognizable by the participants in the study and can be made available to others upon request. Data are discussed for only eight areas (A through H), although nine (one from each district) participated in the pilot study. The ninth area is from the Northern Virginia district where the nature of the pavements is such that the investigators did not consider the sample to be meaningful. Specifically, 52 sites rated comprised only about 18 miles of roadway, much shorter segments than in any other area of the state. As a result of this change, much of the following analysis and discussion is based on 908 roadway sections rather than the original 960.

Pavement Distress Summaries

Pavement distress summaries for all 960 sections are given in Table 1 for each rating team in the pilot study. These summaries show large variations in both pavement distress and in average surface ages from one part of the state to another. For example, in area E, 116 sections of pavement were evaluated. The surface age averaged 4.5 years, and more than 86 percent were cracked to an average un-

Table 1

PAVEMENT DISTRESS SUMMARIES

	AREA A Avg Age 2.5 Years Total Samples 231			AREA B Avg Age 3.4 Years Total Samples 59			AREA C Avg Age 2.8 Years Total Samples 83			AREA D Avg Age 3.3 Years Total Samples 64			AREA E Avg Age 4.5 Years Total Samples 116		
	N	%	Avg Deduct	N	%	Avg Deduct	N	%	Avg Deduct	N	%	Avg Deduct	N	%	Avg Deduct
Cracking	51	22.1	0.6	39	66.1	1.6	74	89.2	2.4	25	39.1	1.1	100	86.2	3.0
Bleeding	92	39.8	0.9	35	59.3	1.5	49	59.0	1.1	46	71.9	2.5	104	89.7	3.6
Edge Cracking	53	22.9	0.7	47	79.7	2.8	72	86.7	2.7	41	64.1	2.1	105	90.5	3.5
Distortions	53	22.9	0.5	41	69.5	1.7	75	90.4	2.2	53	82.8	2.4	98	84.5	2.1
Oxidation	1	0.4	0.0	13	22.0	1.5	24	28.9	1.2	40	62.5	2.2	6	5.2	0.1
Patching	81	35.1	0.4	46	78.0	0.9	64	77.1	1.0	26	40.6	0.6	76	65.5	1.0

	AREA F Avg Age 2.8 Years Total Samples 103			AREA G Avg Age 2.7 Years Total Samples 111			AREA H Avg Age 2.0 Years Total Samples 141			AREA I Avg Age 4.9 Years Total Samples 52			STATEWIDE Avg Age 3.0 Years Total Samples 960		
	N	%	Avg Deduct	N	%	Avg Deduct	N	%	Avg Deduct	N	%	Avg Deduct	N	%	Avg Deduct
Cracking	80	77.7	2.2	67	60.4	1.4	113	80.1	2.0	48	92.3	2.0	597	62.2	1.7
Bleeding	67	65.5	2.0	62	55.9	1.1	59	41.8	1.0	19	36.5	0.8	533	55.5	1.5
Edge Cracking	85	82.5	2.9	65	58.6	1.5	101	71.6	1.7	49	94.2	2.2	618	64.4	2.0
Distortions	97	94.2	3.1	73	65.8	1.9	128	90.8	2.5	18	34.6	0.6	636	66.3	1.8
Oxidation	49	47.6	1.7	7	6.3	0.1	3	2.1	0.0	11	21.2	0.6	154	16.0	0.6
Patching	27	26.2	0.3	56	50.5	0.8	65	46.1	0.6	39	75.0	0.9	480	50.0	0.7

weighted deduct of 3.0. (At this point, all distresses are considered to have equal weight.) The other extreme was represented by area A, where 231 sections averaged 2.5 years of age and 22 percent were cracked to an average deduct of 0.6. Generally, the distress summary data show that the most frequently observed distresses vary from area to area. In some, the most frequent distress is cracking; in others, it is bleeding, oxidation, or patching.

Need to Surface Treat

When the need to surface treat (ST) is rated on a 0 to 10 scale, the statewide average is 4.4 (Figure 1). The present funding level of programming 20 percent of the secondary system each year will support treatment of all pavements with a rating of 7.3 or higher. However, at that level, there will be large differences in needs, which may later translate into large differences in the allocation of funds from one area to another (Figure 2).

When all ratings for the pilot study are averaged, as shown in Appendix C, it is clear that the 0 to 10 ST rating is related to age and condition of pavement. What is not so evident, however, is the fact, derived from statistical analysis of the data, that age of the pavement surface soon becomes the determining factor in those areas where the pavement deteriorates slowly. Evidently, this is a mind set carried over from employing the historical 5-year resurfacing cycle.

Distress Weighting Factors

A major step in the analysis of pilot study data was the regression analysis of the ST data compared with the distress data. Before this analysis was conducted, however, the ST need rating was transformed from a 0 to 10 scale to an inverse scale of 0 to 100 and called a surface treatment rating (STR). This scale assumes that a newly surfaced pavement will have a rating of 100 and that deduct points will accrue from each distress represented. The scale was further constructed in such a way that a 75 STR would correspond to the historically maintained level of service; i.e., an STR of 75, when used as a threshold value for resurfacing, would accommodate 20 percent of the paved secondary system on a statewide basis. The reasons for this artificial structuring are twofold: (1) an earlier study of primary pavements[1] showed that low-traffic roads could reasonably be resurfaced at a distress maintenance rating (DMR) of 75 (in the interest of maintaining a simple data base, this criterion was never used) and (2) to maintain consistency with the other PMSs, where interstate pavements are treated at a DMR of 83 and the primary at 78, it appeared reasonable to treat secondary pavements at a slightly lower threshold.

The regression analysis involved the use of raw distress deduct points as the independent variables. The details of this analysis are given in Appendix D, where the regression equations for all areas are given. The regression coefficients determined in the statewide analysis (i.e., for 908 sections of roadway) became the distress weights as given in Table 2. The regression relationship shows that on a

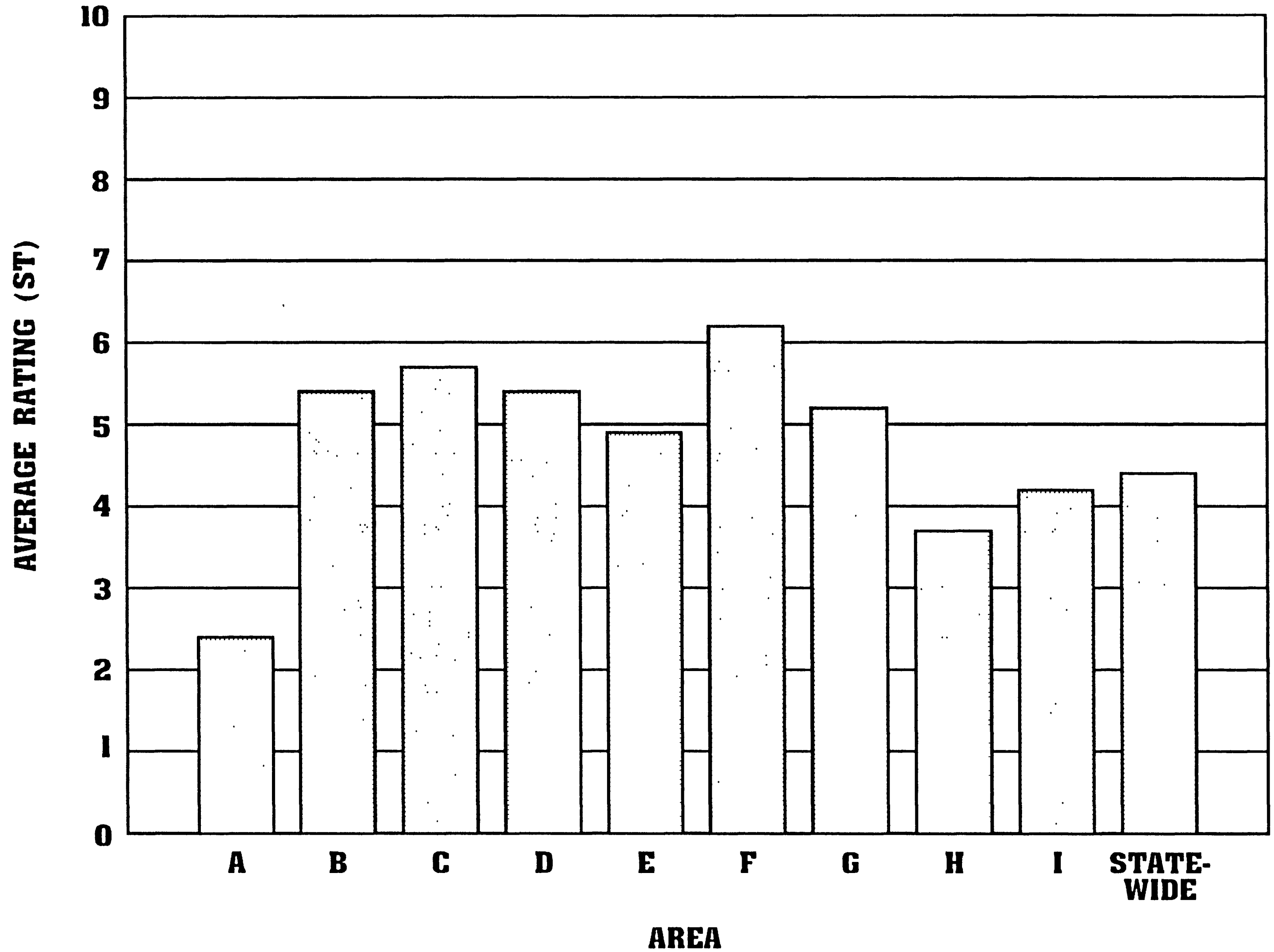

Figure 1. Average Need to Surface Treat (0 to 10 Scale).

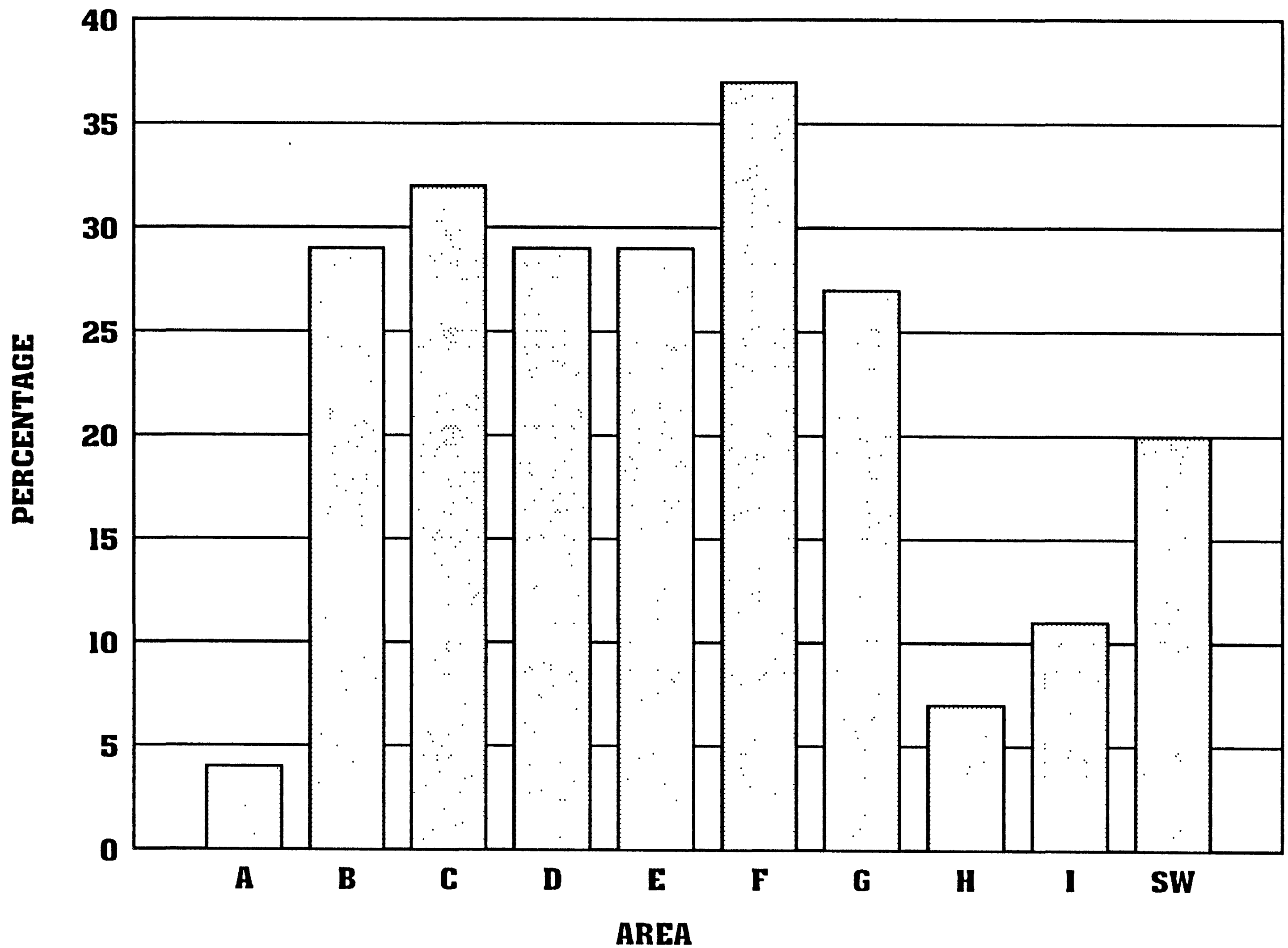

Figure 2. Percentage of Pavements With a Rating Over 7.3.

Table 2

Distress Weighting Factors

Distress	Asphaltic Concrete	Surface Treatment	Adj. Surface Treatment*
Cracking	2.4	2.1	2.2
Bleeding	—	1.1	0.8
Edge Cracking	—	0.9	1.4
Distortions	1.0	1.4	1.5
Raveling	0.9	—	—
Oxidation	—	2.4	—
Patching	2.3	4.1	4.2

*Adjusted after oxidation was removed as a distress to be considered.

statewide average basis the distresses used in the pilot study explain 80.3 percent of the variation in the need to surface treat a pavement. Slightly different distress weights would apply to each area. However, it was the judgment of the investigators that one system should be used statewide. Also, in Table 2, the distress weights for asphaltic concrete–surfaced roads determined in an earlier study[4] are given for comparison.

In both cases, cracking and patching are heavily weighted distresses. Further, in the initial analysis of the pilot study data, oxidation of surface-treated pavements received the heavy weight shown in Table 2. A more thorough study of the oxidation data in Appendix C, however, showed that, although it was very heavily weighed in some areas, it was almost nonexistent in others. The investigators, in cooperation with members of the steering committee, conducted a brief field study of the areas showing the highest oxidation ratings and those showing almost none. The consensus was that oxidation was very difficult to define and that it should not be used as a condition rating criterion.

The pilot study data were reanalyzed as shown in the last entry of Appendix D. The adjusted distress weighting factors given in the last column of Table 2 were the result. Thus, the regression relationship in Appendix D explains 76.0 percent of the variation in the ratings of the need to surface treat. Therefore, there are unidentified variables accounting for about 24 percent of the determination. Such a finding is not surprising in view of the acknowledged uncertainties in the rating system. In the interest of achieving rating consistency across the state, the adjusted weights are established for general use in the rating system for surface-treated pavements.

Comparison of Management Approaches in the Maintenance Replacement Budgeting Process

One of the objectives of the study was to assess the relative merits of three approaches to managing paved secondary roads. The results of this comparison are summarized in Table 3 and discussed below.

Table 3

Comparison of Approaches: Annual Miles Programmed

Area	5-Yr. Cycle	100% Sample	5% Sample
A	14.5	5.8	1.1
B	16.4	20.6	33.5
C	27.8	58.8	76.6
D	15.7	3.9	7.7
E	17.6	27.3	7.2
F	20.0	40.1	16.6
G	33.3	62.1	80.6
H	19.2	6.4	0.1
Total	164.5	225.0	223.4

1. *Present (historical) approach (5-year cycle).* Clearly, from one point of view, this method is attractive. The distribution of mileages to be treated is reasonably even across the eight areas. The approach is, therefore, less controversial than others might be. However, it does not address the real needs of the system.

2. *Needs-based approach (100 percent sample).* This approach shows large discrepancies between areas; this has been the case every time pavement condition data have been viewed from a statewide perspective.[1,5] As also shown in earlier studies,[1] this finding may reflect real differences in pavement performance from one part of the state to another. Again, the nature of the present sample is such that drawing conclusions concerning statewide differences in pavement condition would be dangerous. It is, however, clear that there are very real differences in need for the areas studied, whether from the way the sample was chosen or through chance. This approach provides a defensible means of determining the required budget size and how the budget should be distributed. (With this method, the field manager also has a prioritization tool that is not available with either of the other approaches.) In the present case, a needs-driven budget would address about 60 more miles of roadway in the current year than would a budget based on the historical approach.

3. *Estimated-needs approach (5 percent random sample).* With this approach, there are also large variations in condition among areas. The

similarities to the needs-based approach, however, are strong enough to show that the sampling process would work reasonably well if one wanted only to determine the total budget size. The needs-based and estimated-needs (5 percent sample) methods, in spite of large individual variations, result in nearly identical total mileages for the eight areas studied. This method would be less accurate in distributing the funds and would provide no means of prioritizing roadway sections.

Although it is evident that it would be highly desirable to apply a needs-based (100% sample) secondary PMS, it is recognized that resource limitations may preclude such action for some time. Until such resources are available, the estimated-needs approach would be far superior to the historical method of allocating funds on a 5-year cycle. Random sampling will at least provide a defensible means of allocating on a basis that approximates needs.

When roadway miles programmed are translated into funding allocations, the differences in the nature of proposed work is a major determinant. Although the major focus of this study was surface-treated roads, a substantial and growing proportion of secondary roads are surfaced with hot-mixed asphaltic concrete (plant mixed). Still another significant percentage is surfaced with a slurry seal. These various surface types may have different life cycles and different unit costs, all of which must be accommodated in the PMS. Those differences can be addressed only after several years of using the secondary PMS.

Ordinary Maintenance Data

The estimated ordinary maintenance needs for each pavement section are given in Appendix E, with units as defined in Appendix B. Although there were clear visual indications in the data that pavements in poorer general condition had greater ordinary maintenance needs than those in better general condition, the investigators were never able to show significant statistical relationships among the variables. For that reason, there is no objective support for an effort to continue to collect data on ordinary maintenance needs as a part of the rating procedure.

In spite of these findings, the maintenance personnel involved in the rating process were almost unanimous in their statements that the ordinary maintenance data would be useful planning information. The consensus was that the data were difficult to relate directly to pavement condition because of the inexperience of the raters in making the kinds of estimates required in the present study. The feeling generally expressed was that even the maintenance personnel had trouble making the unaccustomed judgments but that they could learn to do so in time.

It is the conviction of the investigators that a provision to collect data on ordinary maintenance needs should remain a part of the rating procedure for at least one round of statewide ratings.

Rehabilitation Needs

Although one of the objectives of the study was to develop a means of identifying sections of roadway that should be programmed for rehabilitation or reconstruction, it was found that accomplishing the task with the established resources and within the established time frame would not be practical. This realization has occurred as VDOT has developed more experience with other PMSs and has found that a principal indicator of needed major rehabilitation is the time rate of change in pavement condition. That is, other factors being equal, when a pavement deteriorates more rapidly than is the norm, it is very likely to be structurally deficient and in need of major work. Only in cases of extreme deterioration and obvious failure of pavement layers is it readily apparent on the basis of one rating that rehabilitation work is required. These situations are relatively rare for Virginia roads, but when they occur, no formal system of identification is needed. Even then, however, the nature of the rehabilitation would be determined from structural testing, coring, or engineering judgment, all of which are beyond the scope of the present study.

In the more common case of deterioration that is more rapid than normal, at least two condition ratings are needed to make a sound decision. Clearly, this situation will not exist on a systemwide basis until the PMS has been implemented and two rounds of condition surveys have been completed.

The investigators concluded, therefore, that the pavement rehabilitation issue must be addressed as the secondary PMS matures and sufficient data become available. The issue cannot be adequately addressed with performance data collected only on a random sampling basis.

Resources Required

The consensus of the steering committee, the nine district maintenance engineers, and the state maintenance engineer was that there should be at least three raters to conduct the rating procedure for the secondary system. The raters should be from (1) the district pavement management coordinator's office, (2) the residency office, and (3) the area maintenance office. All paved roads should be rated by using the appropriate method for the pavement being rated.

Personnel

During the pilot study, the time required for office work, travel, and pavement rating was recorded for each person involved. A complete tabulation of this data is given in Appendix F. Table 4 gives the average time required to rate the average of 129 miles for each of the eight pilot areas used.

Although a small amount of office time was charged in several areas to the residencies and area headquarters and a great deal of office time was charged to the

Table 4

Average Time Required to Rate Pilot Areas (Minutes per Mile)

Person*	Office Time	Travel Time	Rating Time	Total Time
PMC	10.31	4.93	12.57	27.81
RMM		3.79	12.57	16.36
AMM		0.60	12.54	13.14

*PMC: district pavement management coordinator; RMM: residency maintenance manager; AMM: area maintenance manager.

area headquarters in one area, the investigators switched all charges of office time to the district pavement management coordinator. The pavement management coordinator from the district that charged a larger number of hours of office time to the area headquarters advised that the coordinator's office will perform this work where the system is implemented.

Adjustments were also made to the travel time charged to the area maintenance managers. Three areas employed area maintenance managers from areas not being rated, and two areas did not charge any travel time to the area maintenance manager. Therefore, the area maintenance manager's travel time of 0.60 minutes per mile rated was calculated from the remaining three areas that employed the area maintenance manager from the area being rated.

Based on the time required to rate the nine pilot areas, the average number of hours that will be required at the district, residency, and area headquarters to implement the secondary PMS on the 33,906 miles of paved secondary roads are given in Table 5.

Using the average staff hours in Table 5, the estimated FTEs (based on 1,850 work hours per year) that will be required are as follows:

Table 5

Average Time Required to Implement Secondary PMS

Person*	Minutes per Mile	Hours to Rate 33,906 Miles	Staff Hours per District	Staff Hours per Residency	Staff Hours per Area
PMC	27.81	15,715	1,746		
RMM	16.36	9,245		206	
AMM	13.14	7,425			32
Total	57.31	32,385	1,746	206	32

*PMC: district pavement management coordinator; RMM: residency maintenance manager; AMM: area maintenance manager.

- 1 per district
- 0.11 per residency
- 0.02 per area.

Thus, in order to implement the secondary PMS, VDOT must be committed to providing each district with at least one additional full-time employee. In addition, on the average, each residency and area headquarters must be capable of and committed to providing 0.11 and 0.02 FTEs, respectively.

Equipment

Each district will need an additional van equipped with a distance measuring instrument (DMI), a laptop computer, and a portable measuring wheel.

Office Space

Each district will need office space for one additional person and full access to a personal computer.

Secondary PMS Data Base

General

Upon reaching a decision to recommend full implementation of a secondary PMS, the study team found it necessary to consider existing VDOT data bases that might be adapted to a secondary PMS data base. Unlike in the case of higher classes of pavement included in earlier pavement management data bases, there was no "pavement history file" for secondary pavements. The essential requirements were that all, or nearly all, of the secondary system be included and that the roadways be described in terms of an established location-reference system.

The study team determined that the most directly applicable existing data base is the "secondary road inventory" produced periodically by the traffic engineering division. This data base has the majority of the secondary system located according to mile points. It breaks the system into sections based on a wide range of criteria and, if used directly, would create a PMS data base too large to be practical. However, it does appear reasonable to use the road inventory as a beginning data base while the pavement rating teams define the pavement management sections the first time the pavements are rated. It is anticipated that pavement management sections will correspond with changes in surface mix type or age. To be consistent with VDOT's other PMSs and to keep the number of sections manageable, it is expected that sections less than 0.25 mile in length will be combined with other sections. This modified data base would then become the data base for future ratings and would be updated or revised as resurfacings or other activities are performed.

Such data base revisions will be essential to maintaining the accuracy of the PMS and will accommodate not only resurfacings but also new additions to the system. The revisions can be made by using the information shown on completed contract schedules or "as built" plans. Revisions would be the responsibility of the district pavement management coordinator's office.

Subdivision Roads

One issue of some concern to the steering committee that arose during the pilot study was how subdivision pavements should be managed. Because of the large number of very short sections and because it may not be acceptable to the public to do spot resurfacing, the steering committee decided that the definition of *pavement management sections* should be the responsibility of local managers. In that case, the decision may be to manage an entire subdivision or large portions of a subdivision as a single section.

CONCLUSIONS

1. A structured approach to the management of paved secondary roads is feasible and defensible. Such an approach would provide VDOT management with objective information with which to support budget requests and use in the allocation of funds.

2. A pavement rating system such as developed and applied in this study would provide local managers with an additional tool for use in the prioritization of maintenance and maintenance replacement activities on various roadway sections.

3. The data on ordinary maintenance needs collected in the course of the study were considered to be of value to maintenance personnel even though they could not be related directly to pavement condition.

4. The implementation of the rating system to 100 percent of the system would be much preferred to a random sampling process.

5. The system developed in the present study does not have the capability to identify pavement rehabilitation needs directly. However, the application of the system over at least two rounds of pavement condition ratings will provide that capability.

6. Full implementation of the system would require at least one additional full-time person, one additional van equipped with a DMI, one additional laptop computer, and additional office space for each district.

RECOMMENDATIONS

1. A formal, structured system of managing paved secondary roads should be implemented. For maximum benefit, pavement condition ratings should be conducted annually.
2. The rating system developed in the present study is recommended for surface-treated pavements. Plant-mixed, cold-mixed, and slurry-seal pavements should be rated with the system developed earlier for primary and interstate pavements.
3. The system should be implemented on 100 percent of the system rather than through a random sampling process.
4. VDOT management should take the action necessary to secure the resources required to implement the system fully.
5. The system should be used to determine both the size of secondary resurfacing budget and how the funds are allocated among the various jurisdictions.
6. For at least one statewide application, the system should incorporate a provision for the capture of data on ordinary maintenance needs. The value of the data should be assessed after that full application is completed.
7. After the second year of use, the system should be critically assessed for its ability to define needed rehabilitation.

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ACKNOWLEDGMENTS

Because so many people have contributed to this project over the nearly 3 years it has been underway, the investigators are reluctant to attempt to name individuals. The members of the steering committee, who deserve the most heartfelt thanks, are listed in Appendix A. Even that list is incomplete because of changes in assignments during the course of the study. We apologize to those individuals whose names are left out. Others who we wish to thank as groups are the assistant district engineers for maintenance and all the members of the Maintenance Research Advisory Committee and the Pavement Management Research Advisory Committee. The advice and constructive criticism offered by all of these groups were most helpful to the study.

Some individuals we do wish to acknowledge by name are State Maintenance Engineer C. O. Leigh and Assistant State Maintenance Engineer R. L. Fink, both of whom have made major contributions through the personal review of pavements and through the advice provided.

Last, those people who spent many hours in front of personal computers and did most of the hard work are acknowledged. Some of these are technician supervisor L. E. Wood, Jr., and research assistants Bill Batts, Joyce Birdsall, and Kim Snow.

The study was conducted under the general direction of H. H. Newlon, Jr., former director of research, and Gary R. Allen, the present director. The study was funded through Highway Planning and Research funds allocated to research.

APPENDIX A

Steering Committee Members

DISTRICT PAVEMENT MANAGEMENT COORDINATORS

C. A. Hicks	Bristol
J. O. Jones	Salem
R. W. Sutton	Lynchburg
K. L. Hardy	Richmond
L. E. Winslow	Suffolk
E. E. Wright	Fredericksburg
W. B. Carder	Culpeper
J. W. Craig	Staunton
J. H. Beverly	Northern Virginia

RESIDENCY MAINTENANCE MANAGERS

E. M. Cochran	Tazwell
I. C. Crouch	Bedford
K. T. Saunders	Gretna
W. C. Dawson	Amelia
C. L. Moore, Jr.	Suffolk
S. M. Teese	Warsaw
H. W. Mills	Charlottesville
J. A. Copp	Edinburg
J. R. Gray	Warrenton

AREA MAINTENANCE MANAGERS

E. C. Haga	Baywood
G. L. Hopkins	Fairystone
C. R. Burnette	Brosville
R. H. Braswell	Bethia
M. D. Rew	Temperanceville
S. M. Forrester	Ladysmith
E. A. Hoffman	Zions Crossroads
J. D. Keyser	Front Royal
J. F. Coleman	Camp 30 (Fairfax)

APPENDIX B

VDOT Procedure for Rating the Condition of Surface-Treated Pavements

VIRGINIA DEPARTMENT OF TRANSPORTATION

SURFACE TREATED PAVEMENT CONDITION RATING PROCEDURE

1. Distress types are identified in "Bituminous Surface Maintenance," MT-5-70.

2. Pavement sections to be rated will generally correspond to those listed in the secondary roads inventory. However, new sections should be started (or ended) at intersections, county lines, city limits, and surface mix changes. Start a new section whenever there is a definite change (more than 1/4 mi. in length) in surface type, surface age, or surface condition. Rate only surface treated or slurry sealed pavements (no plant mix).

3. To rate, drive slowly (not over 15 mph) over the section to be rated and make an overall evaluation of the section by:

   (a) Estimating the frequency of occurrence of each major distress type and indicating it on the worksheet in column (2).

   (b) Estimating the predominant severity of each distress type and indicating it in column (3).

   (c) For the combination of frequency and severity, select a rating factor for each distress type and record on rating worksheet in column (4).

4. Make an assessment of the ride quality by riding over the pavement at normal traffic speeds and indicating the rating on the worksheet.

5. On a scale of 0 to 10 indicate how strongly you feel about surface treating the pavement section.

6. During your assessment of the pavement keep in mind the types and quantities of maintenance or maintenance-replacement activities you believe the pavement needs. Record the estimated quantity for each activity in the space provided on the worksheet.

   The activity codes are:

   111 Spot sealing or skin patching
   112 Premix patching
   113 Spot reconditioning
   114 Sealing cracks
   115 Treatment of bleeding pavement
   117 Heavy mechanized patching
   412 Reconditioning hard-surfaced roads
   414 Heavy bituminous retreatments

VIRGINIA DEPARTMENT OF TRANSPORTATION

SURFACE TREATED PAVEMENT CONDITION RATING

Definitions

Frequency of Occurrence	Percentage Affected
None	0
Rarely Observed	Less than 10%
Occasionally Observed	10% - 40%
Frequently Observed	More than 40%

Severity

Cracking (Rate on area)

Not Severe	--	Cracks not readily apparent
Severe	--	Well defined cracks
Very Severe	--	Well defined cracks with raveling (includes potholes)

Bleeding (Rate on area)

Not Severe	--	Apparent but not glossy
Severe	--	Apparent and glossy
Very Severe	--	Evidence of puddling or flowing

Edge Cracking (Rate on length)

Not Severe	--	Not readily apparent
Severe	--	Readily apparent
Very Severe	--	Readily apparent and raveling

Distortions (Rate on area)

Not Severe	--	Not readily apparent
Severe	--	Apparent and slightly rough
Very Severe	--	Apparent and rough

Oxidation (Rate on area)

Not Severe	--	Some wear with few loose particles
Severe	--	Aggregate and/or binder worn away with some loose and missing particles. The surface texture is slightly rough
Very Severe	--	Aggregate and/or binder worn away with many loose and missing particles. The surface texture is rough and pitted

Patching (Rate on area)

Rated only on basis of frequency of occurrence

VIRGINIA DEPARTMENT OF TRANSPORTATION
SURFACE TREATED PAVEMENT CONDITION RATING

Date ____________

County ________ Route ________ Surface Type ________

From: ____________ M.P. ________

To: ____________ M.P. ________

Length: ____________ Year Last Treated ________

(1) Distress Type	(2) Frequency (Circle One)				(3) Severity (Circle One)			(4) Rating Factor (0 to 9)
Cracking	N	R	0	F	NS	S	VS	____
Bleeding	N	R	0	F	NS	S	VS	____
Edge Cracking	N	R	0	F	NS	S	VS	____
Distortions	N	R	0	F	NS	S	VS	____
Oxidation (dry pavement)	N	R	0	F	NS	S	VS	____
Patching	N	R	0	F		NS		____

Ride Rating ____

Surface Treat-? (0 to 10) ____
(0 - Definitely Not)
(10 - Definitely Yes)

Other Maint:

Code		Quantity
111	(tons)	____
112	(tons)	____
113	(cy)	____
114	(gal)	____
115	-	____
117	(tons)	____
412	(sy)	____
414	(tons)	____
Other ( )		____

Frequency of Distress		Rating Factor: Not Severe (NS)	Severe (S)	Very Severe (VS)
None (N)		0	0	0
Rare (R)	Less than 10%	1	2	3
Occasional (0)	10% - 40%	2	4	6
Frequent (F)	Over 40%	3	6	9

Ride Quality	Ride Rating
Very Rough	0.7
Rough	0.8
Slightly Rough	0.9
Average	1.0
Smooth	1.1

APPENDIX C

Average Values of Variables by Surface Treatment Rating

SURFACE TREATMENT PILOT STUDY
AVERAGE VALUES OF VARIABLES
BY SURFACE TREATMENT RATING

ST	N	AGE	AGE RANGE	CR	BL	EC	DI	OX	PA	STR	111	112	113	114	115	117	412	414
0	204	1.4	0-8	0.4	0.9	0.5	0.7	0.0	0.2	95.2	3.2	0.9	0.0	0.6	0.4	3.8	0.0	0.0
1	46	2.0	0-6	1.0	1.0	0.7	1.1	0.0	0.3	92.1	5.6	5.0	0.7	0.0	0.0	5.7	123.2	0.0
2	103	2.8	0-8	1.1	0.8	1.4	1.2	0.2	0.5	89.6	12.1	4.2	1.0	16.7	0.0	3.3	0.0	0.0
3	101	2.8	0-10	1.3	1.3	1.3	1.5	0.1	0.7	87.7	15.0	6.6	0.2	79.2	0.6	11.8	99.0	0.0
4	70	3.0	0-9	1.7	1.7	2.1	1.7	0.1	0.6	85.4	17.2	6.4	2.5	154.5	1.8	14.2	25.2	4.0
5	82	3.1	0-8	1.9	1.3	2.3	1.9	0.2	0.7	84.4	13.1	5.1	1.0	0.0	0.1	17.5	0.0	2.9
6	60	3.2	1-8	2.1	2.0	2.4	2.6	0.4	0.7	81.3	25.5	11.7	2.2	118.6	3.8	22.1	258.9	1.8
7	47	3.9	1-9	2.0	1.8	2.4	2.0	0.7	0.9	80.5	17.9	8.7	2.2	89.6	0.1	13.9	15.6	6.7
8	63	4.2	1-9	2.3	1.9	3.1	2.5	1.2	0.9	76.6	22.0	3.7	1.6	56.0	0.2	21.0	82.5	1.4
9	66	3.8	1-8	2.7	2.1	2.9	3.2	1.7	1.1	72.4	41.4	6.8	2.1	0.0	1.3	27.8	57.6	26.3
10	117	4.7	0-9	3.6	2.9	4.4	2.9	2.4	1.3	65.1	25.1	4.7	2.9	69.9	1.2	30.4	187.2	13.6

CR - Cracking
BL - Bleeding
EC - Edge cracking
DI - Distortions
OX - Oxidation
PA - Patching
STR - Surface Treatment Rating
ST - Decision to Surface Treat

111 Skin Patching
112 Premix Patching
113 Spot Reconditioning
114 Crack Sealing
115 Treat Bleeding
117 Heavy Mechanized Patching
412 Reconditioning
414 Heavy Bituminous Retreatments

APPENDIX D

Results of Regression Analyses

KEY	
BL = Bleeding	OX = Oxidation
CR = Cracking	PA = Patching
DI = Distortion	STR = Surface treatment rating
EC = Edge cracking	

District 1

With oxidation

STR = 100 – 3.0CR – 1.4EC – 2.7PA

N = 116, R^2 = 0.753, SE = 2.2

BL, DI, and OX are not significant variables at a 90% confidence level.

District 2

With oxidation

STR = 100 – 1.5CR – 2.5BL – 1.0EC – 1.3DI – 2.3OX – 3.4PA

N = 103, R^2 = 0.888, SE = 3.8

District 3

With oxidation

STR = 100 – 3.1CR – 3.7BL – 1.8EC – 5.3PA

N = 111, R^2 = 0.798, SE = 2.9

DI and OX are not significant variables at a 90% confidence level.

District 4

With oxidation

STR = 100 – 2.6CR – 0.6EC – 1.7DI – 3.3OX – 3.7PA

N = 141, R^2 = 0.800, SE = 3.5

BL is not a significant variable at a 90% confidence level.

District 5

With oxidation

STR = 100 – 1.7CR – 1.9BL – 1.5EC – 1.3DI – 4.7PA

N = 231, R^2 = 0.687, SE = 2.4

OX is not a significant variable at a 90% confidence level.

District 6

With oxidation

STR = 100 – 3.4CR – 2.6BL – 1.3EC – 2.9OX

N = 59, R^2 = 0.920, SE = 4.3

DI and PA are not significant variables at a 90% confidence level.

District 7

With oxidation

STR = 100 – 3.3CR – 3.6BL – 2.2OX – 4.4PA

N = 83, R^2 = 0.903, SE = 2.9

EC and DI are not significant variables at a 90% confidence level.

District 8

With oxidation

STR = 100 – 1.4CR – 0.8BL – 1.3DI – 3.6OX – 4.3PA

N = 64, R^2 = 0.878, SE = 3.3

EC is not a significant variable at a 90% confidence level.

District 9

With oxidation

STR = 100 – 4.5CR – 4.4PA

N = 52, R^2 = 0.932, SE = 1.4

BL, EC, DI, and OX are not significant variables at a 90% confidence level.

Statewide

With oxidation

STR = 100 – 2.1CR – 1.1BL – 0.9EC – 1.4DI – 2.4OX – 4.1PA

N = 960, R^2 = 0.803, SE = 1.2

Without oxidation

STR = 100 – 2.2CR – 0.8BL – 1.4EC – 1.5 DI – 4.2PA

N = 960, R^2 = 0.763, SE = 1.2

APPENDIX E

Average Values of Variables by District and Age

SURFACE TREATMENT PILOT STUDY
AVERAGE VALUES OF VARIABLES
BY AREA AND AGE

DIST	AGE	N	CR	BL	EC	DI	OX	PA	ST	STR	111	112	113	114	115	117	412	414
4	0	7	0.00	2.29	0.00	4.00	0.00	0.00	0.00	90.47	2.14	15.20	0.00	0.00	0.00	0.00	0.00	0.00
4	1	54	2.02	0.94	1.46	2.13	0.00	0.24	3.50	87.66	26.56	16.82	5.05	0.00	4.23	26.56	9.26	0.00
4	2	15	1.27	1.20	1.60	2.53	0.00	0.80	3.33	85.63	11.38	3.46	1.63	0.00	0.29	18.35	49.02	0.00
4	3	57	2.23	0.90	2.12	2.47	0.09	0.88	4.13	82.60	18.03	8.85	2.98	0.00	0.59	14.15	135.45	0.00
4	4	8	2.75	1.25	1.63	4.13	0.00	0.63	5.63	80.14	6.82	2.08	0.00	0.00	0.00	45.94	1697.65	0.00
5	0	41	0.12	0.90	0.07	0.29	0.00	0.15	0.61	97.25	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00
5	1	50	0.38	0.22	0.18	0.22	0.00	0.16	0.44	97.46	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00
5	2	43	0.35	1.14	0.33	0.51	0.00	0.42	1.56	94.44	0.25	0.57	0.00	0.00	0.00	0.00	0.00	0.00
5	3	14	0.71	1.36	1.07	0.71	0.00	0.64	4.00	91.06	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00
5	4	50	0.84	1.08	1.26	0.78	0.00	0.60	4.02	91.02	0.35	4.43	0.00	0.00	0.00	0.00	0.00	0.00
5	5	14	1.00	0.93	1.50	0.64	0.00	0.43	4.57	91.64	0.00	4.97	0.00	0.00	0.00	0.00	0.00	0.00
5	6	9	1.56	1.33	1.56	0.56	0.00	0.44	5.56	89.77	0.00	3.99	0.00	0.00	0.00	0.00	0.00	0.00
5	7	1	0.00	0.00	2.00	2.00	0.00	1.00	7.00	89.80	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
5	8	7	2.86	1.29	3.71	0.86	1.29	1.14	6.71	76.77	1.43	3.57	0.00	0.00	0.00	0.00	0.00	0.00
5	9	2	0.00	0.50	0.00	1.00	0.00	1.00	1.00	92.80	0.00	8.34	0.00	0.00	0.00	0.00	0.00	0.00
6	1	6	0.00	0.67	0.67	1.33	0.00	0.50	0.00	93.82	0.23	0.32	0.00	0.00	0.00	2.83	0.00	0.00
6	2	9	1.11	1.00	2.78	1.33	0.00	0.89	2.56	86.58	1.78	0.28	0.00	0.00	0.00	18.42	0.00	30.86
6	3	14	1.71	1.29	2.21	1.71	1.79	0.79	5.14	80.02	1.87	0.41	0.00	0.00	0.00	9.90	0.00	12.59
6	4	18	1.94	1.61	3.61	1.89	1.56	0.94	6.94	77.19	7.80	10.09	0.00	0.00	0.00	21.24	0.00	51.25
6	5	10	2.10	3.00	3.50	2.30	2.80	1.00	8.60	70.57	3.76	2.50	0.00	0.00	0.00	38.73	0.00	91.94
6	6	2	1.50	0.50	2.00	1.00	4.50	1.00	7.50	74.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	1	18	2.00	0.89	1.94	1.67	0.50	0.67	3.67	84.52	4.96	2.94	0.00	0.00	0.00	6.16	0.00	0.00
7	2	22	2.36	0.96	2.73	2.00	0.55	0.86	4.96	81.08	1.84	1.71	0.00	0.00	0.00	13.53	0.00	0.00
7	3	19	2.58	1.16	2.63	2.42	1.32	1.11	6.95	76.28	3.76	2.43	0.00	0.00	0.00	20.21	0.00	0.00
7	4	18	2.50	1.61	3.39	2.39	1.78	1.28	7.06	72.96	14.20	2.11	0.00	0.00	0.00	15.19	0.00	0.00
7	5	2	2.00	1.00	2.00	2.00	2.00	1.00	8.00	77.80	23.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	6	1	1.00	0.00	0.00	2.00	0.00	0.00	1.00	94.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	7	2	3.00	0.00	3.00	3.00	5.00	0.50	6.00	67.70	0.00	0.00	0.00	0.00	0.00	104.17	0.00	0.00
7	8	1	4.00	0.00	6.00	4.00	6.00	2.00	8.00	50.30	37.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SURFACE TREATMENT PILOT STUDY
AVERAGE VALUES OF VARIABLES
BY AREA AND AGE

DIST	AGE	N	CR	BL	EC	DI	OX	PA	ST	STR	111	112	113	114	115	117	412	414
1	1	12	1.00	1.10	0.60	1.10	0.00	0.30	0.00	92.10	13.70	0.00	0.00	0.00	0.00	2.60	0.00	0.00
1	2	14	2.10	3.80	2.50	1.60	0.00	0.20	0.20	83.80	6.10	1.50	0.00	0.00	0.00	2.10	0.00	0.00
1	3	10	2.00	2.10	1.30	0.80	0.00	0.30	1.80	88.20	9.40	0.10	0.00	0.00	0.00	4.80	0.00	0.00
1	4	29	3.70	4.20	4.10	2.30	0.10	1.30	5.80	70.80	18.80	4.20	0.00	0.00	0.00	9.70	0.00	0.00
1	5	11	3.20	3.40	4.20	3.20	0.00	1.40	7.20	71.60	11.10	4.20	0.00	0.00	0.00	26.40	0.00	0.00
1	6	13	2.80	4.40	4.90	2.20	0.10	1.30	6.00	72.10	9.60	2.70	0.00	0.00	0.00	12.20	0.00	0.00
1	7	16	3.50	3.60	4.00	2.40	0.20	1.50	7.70	70.80	12.00	3.90	0.00	0.00	0.00	5.80	0.00	0.00
1	8	8	4.00	5.50	5.50	2.80	0.20	1.40	8.80	65.40	0.00	12.10	0.00	0.00	0.00	16.20	0.00	0.00
1	9	3	5.30	4.00	4.00	2.70	0.00	1.70	9.00	65.10	33.30	2.70	0.00	0.00	0.00	22.20	0.00	0.00
2	0	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	30	1.70	2.10	1.50	3.40	0.30	0.00	3.60	85.20	18.30	5.50	0.00	0.00	3.70	24.00	0.40	0.00
2	2	14	1.70	3.20	3.10	2.90	0.60	0.10	5.10	81.30	11.50	1.80	0.00	0.00	6.00	6.40	0.00	0.00
2	3	14	2.10	2.40	3.20	3.60	0.90	0.80	7.00	76.30	25.50	4.30	0.00	0.00	1.00	12.70	0.00	0.00
2	4	37	2.80	1.20	3.70	2.90	3.50	0.40	8.20	71.10	72.60	13.60	0.00	0.00	0.00	10.80	0.00	0.00
2	5	1	2.00	6.00	6.00	2.00	2.00	0.00	10.00	72.00	147.10	47.10	0.00	0.00	0.00	0.00	0.00	0.00
2	6	4	3.00	3.00	2.80	3.30	2.50	1.00	9.80	68.40	156.70	33.30	0.00	0.00	0.00	8.10	0.00	0.00
2	8	1	9.00	0.00	9.00	6.00	9.00	1.00	10.00	27.80	312.50	0.00	0.00	0.00	0.00	300.00	0.00	0.00
3	0	1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	99.00	0.00	7.14	0.00	0.00	0.00	0.00	0.00	0.00
3	1	20	0.25	2.15	0.25	1.40	0.00	0.30	4.45	92.58	5.22	0.00	0.00	0.00	0.00	13.77	0.00	0.00
3	2	37	1.51	0.49	1.60	1.65	0.00	0.68	3.89	88.01	33.65	1.28	1.01	0.00	0.00	21.77	10.14	0.00
3	3	25	1.68	0.76	2.56	2.36	0.00	0.80	5.80	84.48	38.09	0.32	0.00	0.00	0.00	19.21	0.00	21.63
3	4	16	1.88	1.06	1.44	2.38	0.31	1.13	6.44	82.23	20.18	0.70	0.00	0.00	0.00	8.06	3.29	16.45
3	5	10	1.40	1.90	0.80	1.70	0.50	2.10	8.00	78.75	17.87	0.83	0.00	0.00	0.00	12.76	0.00	33.33
3	6	2	1.50	1.00	1.00	2.00	2.50	2.00	8.50	73.70	9.30	0.00	0.00	0.00	0.00	16.56	0.00	0.00

SURFACE TREATMENT PILOT STUDY
AVERAGE VALUES OF VARIABLES
BY AREA AND AGE

DIST	AGE	N	CR	BL	EC	DI	OX	PA	ST	STR	111	112	113	114	115	117	412	414
8	0	12	0.00	2.92	0.33	1.33	0.00	0.00	0.83	93.68	0.56	0.00	0.00	0.00	18.79	7.58	0.00	76.92
8	1	5	0.60	1.80	1.40	3.00	0.80	0.60	3.00	84.56	21.62	0.00	0.00	0.00	0.00	0.00	1045.40	0.00
8	2	8	1.38	3.63	3.00	2.75	1.00	0.63	4.00	78.36	21.87	0.00	6.58	0.00	6.25	13.55	1250.00	0.00
8	3	10	0.40	1.70	2.30	1.90	2.30	0.70	4.60	81.22	19.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	4	6	0.67	2.33	1.83	1.83	4.33	0.83	8.17	73.80	16.29	0.00	0.00	0.00	0.00	16.95	0.00	0.00
8	5	8	2.88	3.50	3.63	3.88	2.50	1.38	8.38	64.34	25.02	0.00	0.00	0.00	0.00	78.95	576.88	0.00
8	6	12	1.58	1.67	2.33	2.83	4.00	0.50	8.33	72.86	17.10	0.00	2.78	0.00	0.00	40.97	1814.83	0.00
8	7	1	2.00	4.00	4.00	4.00	4.00	1.00	9.00	62.70	42.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8	2	3.00	1.50	3.00	1.50	3.00	0.00	7.50	76.45	40.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00
9	2	17	1.18	0.65	1.53	0.06	0.06	0.41	3.18	92.40	18.16	13.84	0.00	453.87	0.00	10.13	0.00	0.00
9	4	13	2.23	1.00	2.31	0.69	1.15	1.08	4.46	81.09	40.50	17.47	26.83	1204.91	0.00	56.15	0.00	0.00
9	7	12	2.25	1.08	2.08	0.92	1.08	0.92	4.25	81.78	17.20	17.59	14.49	359.18	0.00	54.56	0.00	0.00
9	8	7	2.86	0.71	3.43	1.43	0.14	1.29	5.14	79.47	73.79	26.39	15.87	1849.62	0.00	75.40	0.00	0.00
9	9	2	4.00	0.00	4.00	0.00	0.00	2.00	7.50	76.30	50.38	0.00	0.00	1259.47	0.00	67.28	0.00	0.00
9	10	1	1.00	0.00	1.00	0.00	0.00	1.00	3.00	91.60	21.43	21.43	0.00	535.71	0.00	0.00	0.00	0.00

Note: For abbreviations, see Appendix C.

APPENDIX F

Time Required for Pilot Study

Table F-1

Planning and Processing Time

Dist.	Person*	Hours per Workday 1	2	3	4	5	6	7	8	9	10	Total
1	PMC	4.00	8.00	8.00	2.00	1.00	2.00	4.00	2.00	1.50	4.00	36.50
	RMM											0.00
	AMM											0.00
2	PMC	1.00						1.00				2.00
	RMM	1.00						1.00				2.00
	AMM											0.00
3	PMC	8.00	8.00	8.00	8.00	8.00	8.00					4.00
	RMM											0.00
	AMM											23.00
	Other	8.00	8.00	8.00								32.00
4	PMC	0.50					4.00					4.50
	RMM	0.25										0.25
	AMM	0.25										0.25
	Other						1.00					1.00
5	PMC	5.00	5.00		8.00		8.00	8.00		8.00	9.00	51.00
	RMM											0.00
	AMM											0.00
	Other		3.00									3.00
6	PMC	1.00	0.50	0.50								2.00
	RMM	0.50										0.50
	AMM	0.50										0.50
7	PMC	1.00				1.00			1.00		2.00	5.00
	RMM											0.00
	AMM		1.00									1.00
8	PMC	1.00										1.00
	RMM	0.25										0.25
	AMM	0.75										0.75
Total												170.50

*PMC = district pavement management coordinator; RMM = residency maintenance manager; AMM = area maintenance manager.

Table F-2

Nonproductive Travel Time

Dist.	Person*	Hours per Workday										Total
		1	2	3	4	5	6	7	8	9	10	
1	PMC				0.80	0.80	0.80	0.80	0.80	0.80		4.80
	RMM				2.00	2.00	2.00	2.00	2.00	2.00		12.00
	AMM				2.40	2.40	2.40	2.40	2.40	2.40		14.40
2	PMC		2.75	2.50	2.50	3.50	2.00					13.25
	RMM		1.00	1.50	1.50	0.75	1.00					5.75
	AMM		2.50	3.75	2.50	4.00	3.00					15.75
3	PMC	2.00	2.00	2.00	2.00							8.00
	RMM											7.00
	AMM											0.00
4	PMC		1.00	1.00	1.50	1.50						5.00
	RMM		1.00	1.00	1.00	1.00						4.00
	AMM		0.50	0.50	0.50	0.50						2.00
5	PMC		3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	27.00
	RMM			3.00	3.00	3.00	3.00	3.00	3.00	3.00		21.00
	AMM			5.00	5.00	2.50	2.50	5.00	2.50	2.50		25.00
6	PMC	1.50	1.50	1.50								4.50
	RMM	2.00	2.00	2.00								6.00
	AMM			0.25								0.25
7	PMC	1.00		1.00	2.00		2.00	2.00		2.00		10.00
	RMM				1.00		1.00	1.00		1.00		4.00
	AMM											0.00
8	PMC	2.50	2.50	4.00								9.00
	RMM	1.00	1.00	1.00								3.00
	AMM	0.50	0.50	0.50								1.50
Total												202.95

*PMC = district pavement management coordinator; RMM = residency maintenance manager; AMM = area maintenance manager.

Table F-3

Rating Time

Dist.	Person*	Hours per Workday										Total
		1	2	3	4	5	6	7	8	9	10	
1	PMC				5.50	3.00	6.00	5.50	6.50	1.00		27.50
	RMM				5.50	3.00	6.00	5.50	6.50	1.00		27.50
	AMM				5.50	3.00	6.00	5.50	6.50	1.00		27.50
2	PMC		6.50	6.75	7.25	6.00	4.00					30.50
	RMM		6.50	6.75	7.25	6.00	4.00					30.50
	AMM		6.50	6.75	7.25	6.00	4.00					30.50
3	PMC	4.00	6.00	8.00	7.00							25.00
	RMM	4.00	6.00	8.00	7.00							25.00
	AMM	4.00	6.00	8.00	7.00							25.00
4	PMC		7.50	7.50	7.50	7.50						30.00
	RMM		7.50	7.50	7.50	7.50						30.00
	AMM		7.50	7.50	7.00	7.50						29.50
5	PMC			5.00	5.00	5.00	3.00	5.00	5.00	2.00		30.00
	RMM			5.00	5.00	5.00	3.00	5.00	5.00	2.00		30.00
	AMM			5.00	5.00	5.00	3.00	5.00	5.00	2.00		30.00
6	PMC	8.00	8.00	6.50								22.50
	RMM	8.00	8.00	6.50								22.50
	AMM	8.00	8.00	6.50								22.50
7	PMC				6.00		6.00	6.00		2.00		20.00
	RMM				6.00		6.00	6.00		2.00		20.00
	AMM				6.00		6.00	6.00		2.00		20.00
8	PMC	8.00	6.50	8.00								22.50
	RMM	8.00	6.50	8.00								22.50
	AMM	8.00	6.50	8.00								22.50
Total												650.00

*PMC = district pavement management coordinator; RMM = residency maintenance manager; AMM = area maintenance manager.