Form R-396 (1/1/87)

Standard Title Page -- Report on State Project

1101

Report No.	Report Date	No. Pages	Type Report: Status Report	Project No. : 9191
VTRC 87-R19	March 1987	31	Period Covered: Aug. 1984 - Dec. 1986	Contract No.:

Title and Subtitle

Status Report - Implementation of a Pavement Management System in Virginia

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Key Words

Pavement management
Priority programming
Maintenance replacement
Pavement monitoring
Allocations

Supplementary Notes

Abstract

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The report shows that the Department has made great progress both in the development and implementation of the pavement management system. Several recommendations address areas in which the system can be "fine tuned" and made more useful to both top and middle management.

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STATUS REPORT

IMPLEMENTATION OF A PAVEMENT MANAGEMENT SYSTEM IN VIRGINIA

by

K. H. McGhee
Senior Research Scientist

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

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

Charlottesville, Virginia

March 1987

VTRC 87-R19

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SUMMARY

The report summarizes the developments in pavement management in the Virginia Department of Transportation through late 1986. Included are discussions of the pavement management process with examples of priority programming, long-range projection of maintenance-replacement needs, and the monitoring of pavement rating teams.

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INTRODUCTION

As the Virginia Department of Transportation enters its fifth year of moving toward full implementation of a formal pavement management system, it is appropriate to review the progress to date, to summarize the applications made of the pavement management data, and to attempt to identify areas still needing special attention. It is the purpose of the present report to attempt to accomplish these goals and to provide management with a single source of information documenting the status of pavement management through late 1986.

BACKGROUND

The foundations for effective pavement management was established by the American Association of State Highway Officials (AASHO) in the early 1960s with the publication of the results of the AASHO road tests(1,2). Those studies showed that pavements perform in a predictable manner as described by the curve given in Figure 1. Typically, a pavement looses serviceability (deteriorates) very slowly for several years, and then enters a period of rather rapid deterioration marked by the presence of cracking and deformation and a decrease in rideability. As indicated in Figure 1, an overlay, at some time after the period of rapid deterioration begins, can restore the pavement to the original level of serviceability.

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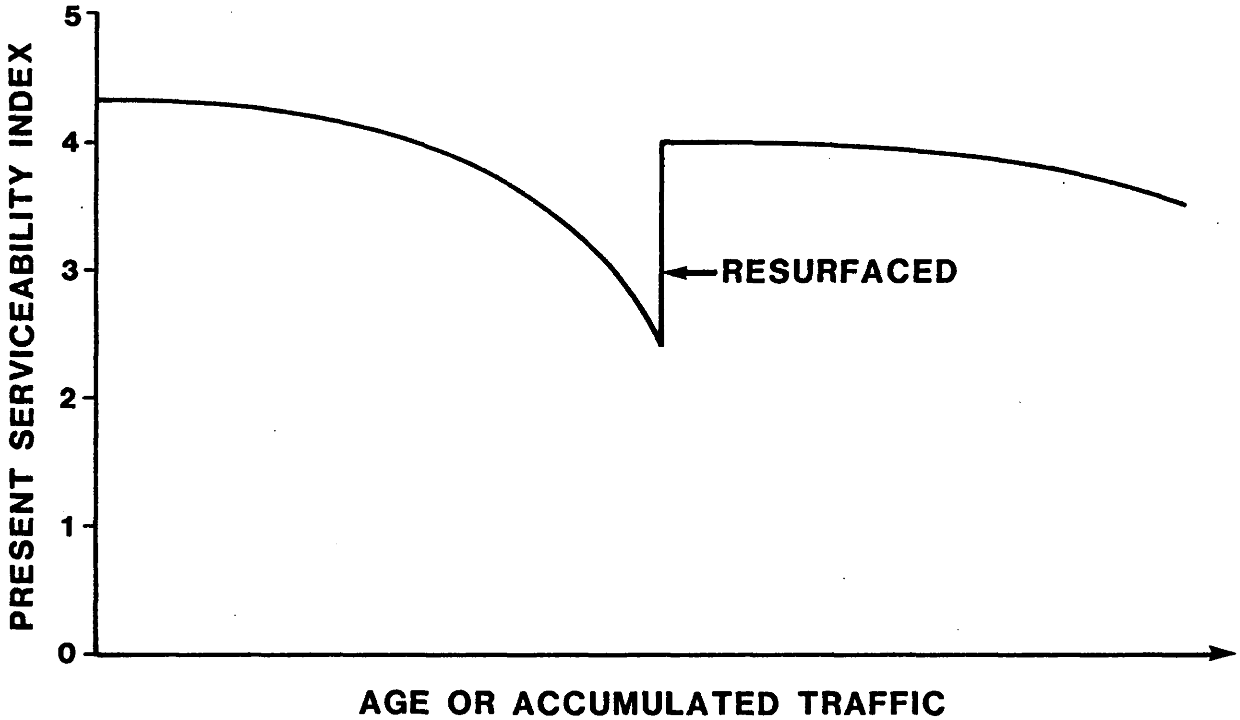

Figure 1. Typical pavement performance curve.

In projecting long-range pavement maintenance requirements the predictability of the relationship depicted in Figure 1 is useful. The road test data show that the shape of the pavement deterioration curve is generally related to traffic through a distress function defined in terms of load and design variables. For a particular pavement, an approximation of that distress function can be developed from at least two measurements of pavement condition and the traffic and age parameters at the time of the condition measurements. The distress function may then be used to predict pavement conditions at a later date. Conversely, if one can define the condition level at which major maintenance will be required, the distress function can be used to predict the approximate time of that maintenance.

Formal pavement management efforts in the Virginia Department of Transportation began in the mid-1970s when maintenance and research personnel cooperated in developing a pavement condition rating system based on the quantification of factors field engineers use to judge when pavement maintenance replacement activities will be performed(3). The rating system was demonstrated and refined during 1979-80 and applied to the full interstate system in 1981(4,5).

Based on the condition rating system, the general approach to pavement management for the state was set forth in a 1981 report in which pavement management was defined as predicting future funding needs for pavement and providing top-level management with data to indicate what level of service can be maintained within each funding level(6). This report listed the following potential benefits of pavement management:

1. Improved performance monitoring and forecasting
2. Objective support for funding requests
3. Identifiable consequences of various funding levels
4. Improved administrative credibility
5. A basis for cost allocation to highway users
6. Improved engineering input for policy decisions

The following pavement management elements were discussed and were deemed applicable to Virginia: (1) pavement condition (distress) inventory, (2) pavement structural integrity, (3) pavement ride quality, and (4) pavement skid resistance.

Pavement management costs estimated in the 1981 report were developmental costs of $125,000 to $150,000 per year for each of the first two years and an annual operating cost of about $90,000 thereafter.

Subsequent to the 1981 report, a pavement management steering committee appointed by Maintenance Engineer C. O. Leigh issued its report setting forth the following recommendations for the development and implementation of the first phase of formal pavement management(7).

1. Visual condition surveys should be conducted on the interstate system in odd-numbered years and on the primary system in even-numbered years. These surveys should be conducted on 100% of the systems.

2. Visual condition surveys should be conducted on 3% (later increased to 5%) of the secondary mileage each year.

3. Skid tests should be conducted on the entire interstate and primary systems each four years.

4. Roughness tests should be conducted on the interstate system concurrent with the visual surveys each even-numbered year.

5. The Department, through the purchase and use of a digital profilometer or equivalent equipment, should equip itself to efficiently conduct roughness tests on the primary and secondary systems.

6. A deflection survey should be conducted on the entire interstate the first time it is visually rated. The frequency of and need for subsequent tests would depend upon the results of the first survey.

7. Training sessions for the visual condition survey teams should be conducted prior to each of the first two surveys and thereafter as needed.

The development and implementation process has followed the above recommendations (with minor modifications as discussed below). It should be noted that early efforts focused only on formal management of flexible pavements. Later efforts, which are discussed later in this report, have included concrete pavements(8).

ADMINISTRATION OF PAVEMENT MANAGEMENT

An earlier status report on pavement management stated concerns of the pavement management steering committee and of the pavement management research advisory committee that the pavement management effort needed a more formal organizational structure(9). Specifically, these groups had recommended the establishment of a full-time pavement management coordinator with statewide responsibility and the designation of a pavement management specialist in each district.

After due consideration by management, the first of these recommendations was implemented in 1984 with the appointment of a pavement management engineer housed within the department's Maintenance Division. This engineer was charged with statewide oversight of collection, reporting, and use of pavement management data. He was provided with an assistant and with technical staff to expedite editing, entry, and retrieval of pavement management data.

The second recommendation was implemented in 1985 with the appointment of a pavement management coordinator in each district. These coordinators are charged with local responsibility for field data collection and for providing assistance to field personnel in the establishment of priorities, the development of pavement maintenance-replacement budgets, and in general implementation of pavement management practices.

Important elements of the pavement management effort are housed in the materials division, which has responsibility for roughness, skid, and deflection testing programs. This division also provides design inputs for both new and rehabilitation projects and coordinates life-cycle-costing activities for projects in which such analyses are appropriate.

Finally, the information systems division plays a vital role in the pavement management process by the operation, maintenance, and integration of various data bases forming portions of the pavement management system. Some of these are the pavement data system, the traffic records file, the pavement condition file, and the skid records file. Numerous pavement management reports are generated from the above files, some of which will be discussed later.

PAVEMENT MANAGEMENT PROGRESS

Flexible Pavements

Interstate System

Following a fall 1981 training session, all condition surveys, roughness tests, skid tests, and deflection measurements were completed on the interstate system by early 1982. All data collected were referenced to physical mile markers rather than the traditional county mileposts. This approach, although helpful to personnel collecting the data, hampered efficient merging of the interstate pavement management data with previously existing automated data files. For this reason, the second set of condition surveys (made in 1984) was referenced to the county milepost system. Under this system, pavements are rated within the limits of particular surface mixes and the work sheets are computer generated and sent to the field for the entry of condition data.

As discussed in detail in an earlier report(5), the interstate pavement management effort has resulted in a printout on which the following information is given for each section of interstate flexible pavement.

1. Location and direction of travel
2. Surface mix type and date placed
3. Condition rating (DMR)
4. Cumulative 18,000 lb. axle loadings sustained by the surface course
5. Year in which the next overlay is projected to be required

Revisions to later printouts will depend on the results of ongoing studies of roughness testing equipment and on the availability of up-to-date deflection and friction data.

The interstate data, as presently given, are valuable tools for both field engineers and upper management. Field engineers use the data to prioritize surface maintenance replacement activities to ensure that funding is directed to the most pressing needs, and they also find the data of value in responding to public inquiries and disagreements relating to resurfacing priorities. The data have been used extensively by all levels of management in establishing maintenance replacement schedules since 1983. An important use of the data in project development is in justifying federal 4R funding.

Central Office personnel can use the data in projecting long-range maintenance replacement activities, in which consideration must be given to needs, legislative inquiries, and the documentation of funding requests.

As subsequent biennial inventories are conducted, the data will become even more useful and reliable and may provide valuable feedback to pavement design personnel.

Among the more important findings of a research analysis of the interstate pavement management data were the following:

1. The condition inventory method is capable of differentiating among candidate projects for the establishment of maintenance replacement priorities.
2. The ride quality of Virginia interstate pavements is generally so high that roughness tests are of little value in priority programming.
3. A significant portion of the interstate system is structurally inadequate for the prevailing traffic.
4. If the inordinate increases in 18,000 lb. equivalent axle loadings experienced over the past several years continue, dramatic decreases in the average life of overlays can be expected.
5. A 5% random sample of pavement sections is adequate for system monitoring purposes.
6. Condition rating teams for the various districts rate pavements on a reasonably consistent basis, although there will be a continuing need for surveillance and training of the teams to prohibit any biases which might otherwise develop(3).

Primary

The first condition inventory of primary system pavements was completed in the winter of 1982-83. Unlike the first inventory of the interstate system, work sheets did not originate in the field but were provided by the Information Systems Division from a previously developed data base called the Surface Mix Section Direction Report. An important part of the inventory was the updating of the automated files to correct inconsistencies between observed conditions and those given on the computer printed work sheets. Data for 10,000 miles of flexible pavements in the systems were collected on the basis of changes in the age or type of surface mixes. Divided highways were inventoried in both directions. Some 16,000 work sheets were submitted to the Maintenance Division for review and the initiation of changes in the data base.

In October 1983, the Information Systems Division provided the first comprehensive computer printout of primary system pavement management data. In March 1986, another printout was provided for the latest inventory.

The primary system pavement management printouts provide details of pavement condition ratings (including a subjective ride quality assessment) for each pavement section in the state. In addition, a DMR distribution report is provided for each county, residency, and district. These data provide management with a tool for the comparison of pavement condition among the various jurisdictions. They have also been used since 1984 by field managers to prioritize their activities and by central office management in the allocation of funds to the jurisdictions.

An example of the usefulness of the DMR distribution data is given in Appendix 1 where the percentages of pavements, for each district and for the state, below threshold values are given for 1982-83 and 1985-86. Note that the thresholds are slightly different for the two periods of time.

In both rounds of pavement ratings, which are summarized graphically in Figure 2, there are significant differences between districts in the percentages of pavements below the threshold value. Maintenance Division and Research Council validation of the ratings shows that the various rating teams are working to consistent standards, although some major adjustments have been required. Further, in both cases, the district rankings based on the ratings are consistent with rankings in 1948 by Stevens et.al.(10) in which pavement performance was shown to be correlated with soil area and traffic volume. Thus, the 1948 report and the studies reported here show that the worst pavement conditions occur in the poor soil areas (Culpeper District, for example) and in the heavy traffic corridors. The latter is shown dramatically in the poor rating of pavements in the Northern Virginia District and in the coal counties of western Virginia.

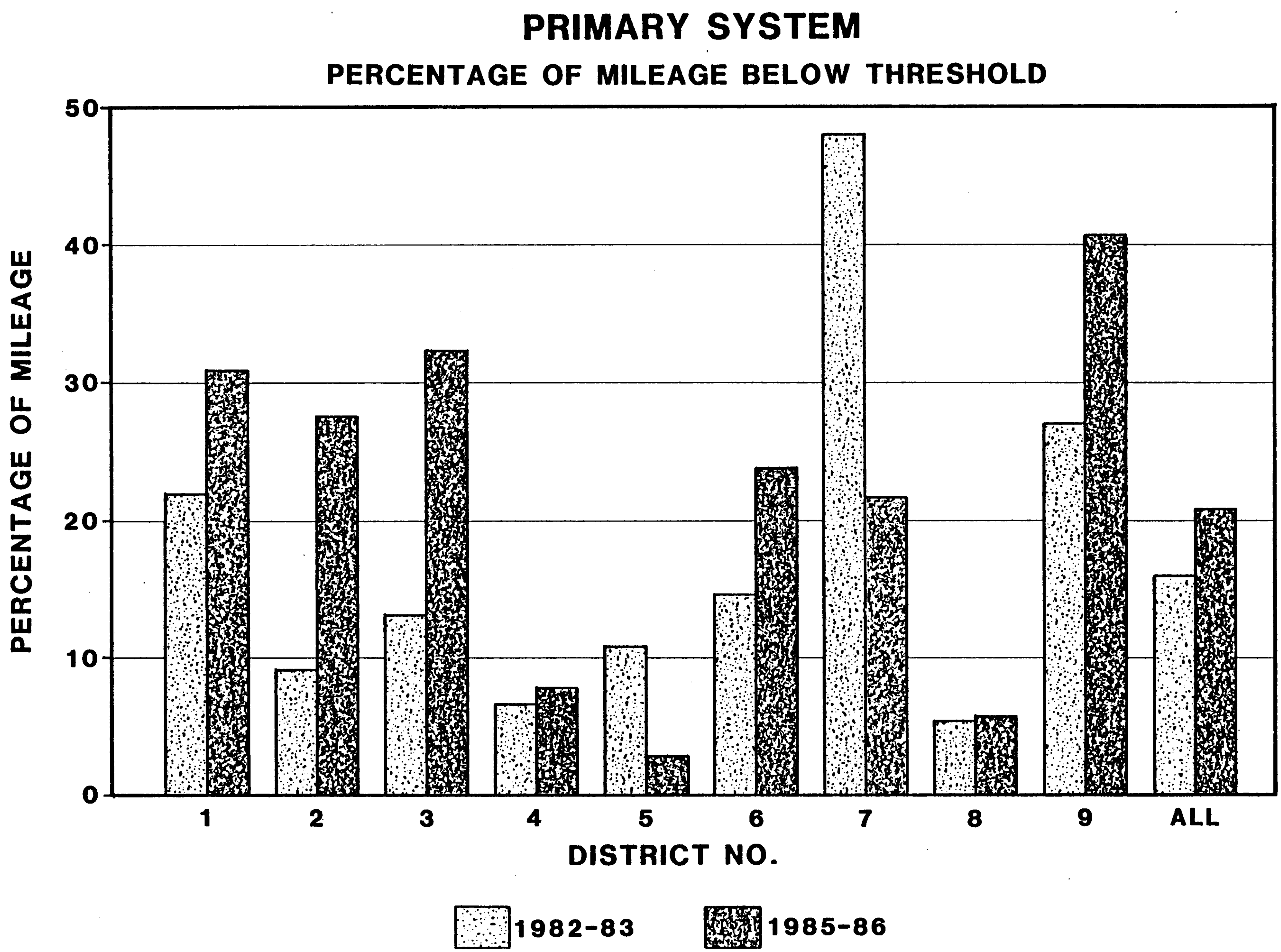
PRIMARY SYSTEM
PERCENTAGE OF MILEAGE BELOW THRESHOLD
PERCENTAGE OF MILEAGE
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
ALL
DISTRICT NO.
1982-83
1985-86

Figure 2.

In Figure 2, it is evident that some redistribution of overall pavement condition occurred between the two rating periods analyzed. Note that there was a substantial increase in the deficient roadway mileage in the Bristol (1), Salem (2), Lynchburg (3), and Fredericksburg (6) Districts, a substantial decrease in the Suffolk (5) and Culpeper (7) Districts, whereas the Richmond (4) and Staunton (8) Districts are virtually unchanged. The Northern Virginia District (9) data are unclear due to the absence of Fairfax County from the 1982-83 data. On the basis of statewide data reflected in Figure 2 by the bar charts marked "ALL", there is evidence that there was a decline in overall pavement condition between the 1982-83 and 1985-86 rating periods. One could infer from these data that primary pavement maintenance replacement funding needs to be increased more than the traditional inflationary amount. This shows that pavement management data can be used to determine the size as well as the allocation of the pavement maintenance replacement budget.

The data in Appendix 1 can be used to allocate the funds from the pavement maintenance replacement budget among the districts. Such an allocation for 1987, which is based only on the mileages of pavements maintained and the observed condition of those pavements in 1985 and 1986, would be approximately as shown in Figure 3. Clearly, such a distribution of funds appears inequitable and may be difficult for management and others to accept. For this reason, it is important to keep in mind that the allocations given are based only on need without regard to political and other factors.

Secondary

The first condition ratings on the secondary system were completed in early 1984. Because of the size of the system (44,000 miles), the pavement management steering committee deemed full assessment to be unfeasible. Two decisions by that committee reduced field work to a manageable level. First, it was decided that the condition rating methodology was appropriate only for paved roads (31,500 miles). Second, it was concluded that a random sampling process could be used to monitor 5% of the system (about 1,500 miles) on a biennial basis. To expedite the sampling, an algorithm developed by information systems personnel was used to randomly select roadway sections from the automated file "Road Inventory Mileage Records"(11). The system is devised to identify a totally new sample on each iteration (every second year). Once the roadway sections were identified, computer-printed work sheets were provided to field personnel.

PRIMARY SYSTEM MAINTENANCE REPLACEMENT
1987 ALLOCATIONS PER 1985-86 PMS DATA

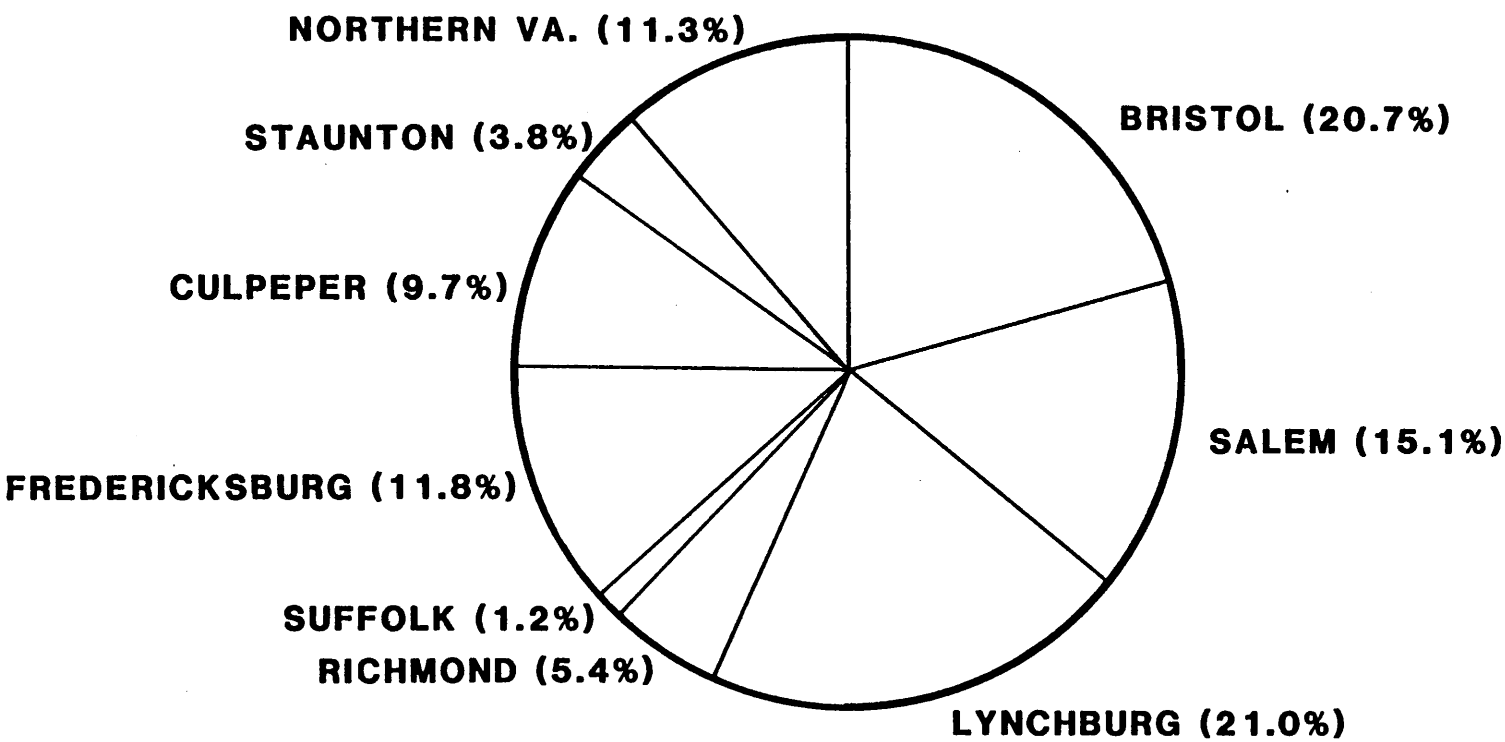

Figure 3.

In the random sampling process employed it is implicit that the secondary pavement condition data be used somewhat differently from those for the interstate and primary systems. Specifically, the secondary data will be used to gain a biennial assessment of pavement conditions on a system or network basis. For this reason, the data will be most useful over a period that includes several assessments to determine whether or not maintenance levels are adequate. However, since the random sample is stratified over each county and over six levels of traffic volume, data could be immediately useful in the allocation of maintenance replacement funds over political subdivisions and traffic classifications.

A major difference in the secondary data is their inapplicability to site specific (project) purposes. Since field engineers will have data on only about 5% of the secondary pavements under their jurisdictions, it will not be possible to establish priorities for action. However, since field personnel are so familiar with secondary pavements for which they are responsible, an objective means of establishing priorities is not considered essential.

The first secondary sampling identified several problems that had to be addressed in later iterations. The first of these was a strong tendency toward biased sampling created by the fact that stratifications within a county could be represented by one observation. An adjustment to the plan to provide for a minimum of four observations per stratification corrected the problem so that later samples more truly reflect the population.

A second problem, occurring in counties with a high proportion of subdivision streets was that of an unwieldy number of sections. Study of the sample results and of work done by others led to the conclusions that a ceiling of 100 pavement sections per county would not seriously detract from the validity of samples(12). This change in procedures is in the process of being implemented.

PAVEMENT MANAGEMENT RELATED ACTIVITIES

The adoption of a pavement management system by the department has led to numerous peripheral activities. Some of these are only indirectly related to pavement management, but draw on the pavement management data base or provide some input to the system. Some of the most important of such activities are discussed below.

Pavement Condition Evaluation

Activities in this area are directly related to pavement management and include studies to monitor the results reported by field rating teams, the development of a pavement condition rating manual, and the study of improved road roughness measuring techniques.

Monitoring Activities

The state pavement management engineer conducts periodic reviews of pavements rated by the field rating teams to determine the consistency of rating practices between teams. Such monitoring is done on randomly selected pavement sections and the data statistically analyzed. An example of monitoring data is given in Table 1 for data collected in 1984-85 on the primary system. Statistical analysis showed a strong probability of real differences between the monitoring and rating teams only for two districts where small adjustments were made to the data reported by the district rating team(13). The pavement management engineer later identified an inconsistency in the manner the condition evaluations were conducted by the rating teams for those two districts. Such monitoring activities are conducted on each series of pavement ratings for each highway system.

Pavement Condition Rating Manual

A pavement condition rating manual was developed by the department and distributed to all rating teams in 1983-84(14). The manual provides step-by-step instructions, including pictorial examples, for rating the condition of flexible pavements. The manual has never been put into final form because we have been awaiting the addition of concrete pavement rating procedures, which should be available in late 1987.

Road Roughness Measurement Activities

The need for roughness measurements as a pavement management tool was recognized early by the Pavement Management Steering Committee, which recommended that such measurements be conducted on the primary and interstate system concurrent with the biennial condition ratings. Although these tests were conducted with the Mays Ride Meter on the first rating of the interstate system, they were deemed to be too labor intensive and were dropped on subsequent ratings of that system and on all ratings of the primary system.

Table 1

Primary System Monitoring

1984-85

District	Number Sections	Average District DMR Rating	Standard Deviation	Average Monitor DMR Rating	Standard Deviation	Probability of Difference*
Bristol	24	87.54	9.30	86.50	8.38	22%
Salem	25	89.24	9.36	87.48	8.81	36%
Lynchburg	24	89.67	8.68	86.92	11.66	49%
Richmond	25	87.65	9.61	92.42	7.11	84%
Suffolk	24	87.79	6.39	88.62	8.05	22%
Fredericksburg	24	87.04	11.99	85.33	12.61	26%
Culpeper	25	83.88	13.13	88.00	10.32	62%
Staunton	25	89.72	6.72	88.28	9.18	35%
Northern Va.	24	84.04	9.86	84.12	9.04	2%

*Probability that there is a real difference between district ratings and those by the monitoring team on the same pavements.

Even though roughness tests were not found to be an important input to interstate pavement management, there is good reason to believe they would be much more useful on the primary system. For this reason, in 1984 the Research Council purchased a Model 8300 (K. J. Law, Inc.) ultrasonic roughness surveyor purported to provide more reproducible results than the Mays Meter with no laborious analysis time. The device may be mounted in any vehicle and runs tests at regular highway speeds with no interference with traffic.

Unfortunately, the device was recalled by the manufacturer shortly after delivery and was not returned for nearly a year. Evaluation of the equipment was recently begun under a research project to be conducted by the author(15). Current plans are to have one or more surveyors ready to put into operation for pavement management inventory purposes during 1987.

Priority Programming

Additional work on the programming of maintenance replace activities over the past two years includes a study to develop thresholds for the resurfacing of interstate and primary highways and a study of surface treatment management on the secondary system. These are discussed briefly below.

Primary and Interstate Resurfacing Thresholds

The first applications of pavement management data in the prioritization of pavements for resurfacing made use of condition thresholds determined by research personnel from statistical analysis of the data collected during the development of the pavement condition rating system. These data showed that almost 10% of interstate pavements were at a condition rating (DMR) of 85 or below in 1982. Reasoning that it would be appropriate to attack the worst 10% first, an action threshold of 85 was established for the interstate system, whereas a threshold of 80 was chosen for the primary system (based on the assumption that it would be appropriate to maintain the primary system at a level somewhat below that of the interstate). These thresholds were applicable to resurfacings programmed from 1982-85.

Following a study of the Department's management practices, the Joint Legislative Audit and Review Commission noted that more defensible thresholds were needed and urged the Department to proceed with their development. In 1985 the Research Council and the Maintenance Division conducted a cooperative study directed at developing defensible thresholds through an expert systems approach. This research entailed the use of 29 pavement maintenance experts to view 28 sections of roadway under various traffic conditions and stages of deterioration. The experts selected ordinary maintenance or maintenance replacement actions they would take for each set of conditions. Statistical analysis of the data, using a two-thirds consensus to establish the threshold levels, yielded the levels given in Table 2 for resurfacing each system(15).

Table 2

Resurfacing Thresholds

System	Threshold DMR
Interstate	83
Primary	78
Secondary	75

These thresholds were used to develop 1986 resurfacing priorities for the interstate and primary system and to guide the comparison of the relative condition of secondary pavements between the various jurisdictions.

A desirable refinement to the establishment of pavement condition thresholds involves the determination of life-cycle-costs as a function of pavement condition rating. The condition rating for a given pavement or class of pavements yielding the minimum life-cycle cost would be the optimum condition threshold for that pavement or pavements. Analyses of this type, recently undertaken by the Research Council, involve the use of maintenance-replacement, ordinary maintenance, and user costs to establish the optimum thresholds. Further, since the rate of pavement deterioration is a critical element in the life-cycle cost analysis, pavement performance curves, which are discussed under long range planning, also are used in the analyses. It is anticipated that thresholds based on these studies will be available for use by the time 1988 maintenance-replacement budgets are developed.

Surface Treatment Management

The early decision to manage the secondary system through a random sampling process leaves field personnel with no real tool to establish project resurfacing priorities for that system. Melville, in 1985, set forth plans to examine surface treatment management through a study of warrants for performing maintenance and justifying surface treatment expenditures(17). The study is to develop a system in which all significant parameters, including time or aging, engineering, fiscal, economic, social, environmental, and safety, will be considered. The study is scheduled for completion in 1987 at which time it is anticipated that a formal system will be proposed.

Long Range Planning

The use of pavement condition evaluation data in the long-range planning process, specifically in establishing maintenance replacement and rehabilitation budget estimates, requires the use of project specific pavement performance curves to determine rates of pavement deterioration. The development of these curves from the two or three conditions ratings now available on most primary and interstate pavements was discussed in an earlier report(5).

An interstate pavement management computer printout entitled "Master DMR Report" and dated July 2, 1986, is the first extensive use of the performance curve concept in Virginia pavement management. On that printout a column entitled "Projected Over Year" lists the projected year in which the next overlay will be required for each section of interstate pavement. These dates are determined from the solutions of performance curve equations for each pavement section using a threshold value of 83. This printout permits the local manager to establish resurfacing priorities with the additional tool of being able to compare the projected performance and various pavement sections.

A companion printout aggregates the lane mileage projected to need resurfacing each year until the year 1992 for each district and for the state as a whole (Appendix 2). These data are of value to statewide managers in projecting long range funding needs and in the allocation of resources according to measured needs. It should be noted that the accumulated needs, which are shown graphically in Figure 4, for the early years of the projection contain large "catch-up" mileages. Since budget constraints probably would prohibit doing all the "catch-up" work at one time, it will be necessary to judiciously prioritize the indicated work. An approach to this second order prioritization is discussed below.

Figure 5 shows three performance curves for pavement sections on Interstate 81 in Washington County. Note that all curves have the general equation

$$DMR = 100 - A\,(ESAL)^{B}$$

(Where DMR equals distress maintenance rating, ESAL equals cumulative 18-kip axle loadings sustained by the present pavement surface, and A and B are coefficients for a specific pavement section.)

The year a pavement is predicted to need an overlay is determined by setting the DMR equal to the threshold value (DMR = 83 for interstate pavements), and with known traffic characteristics, solving the equation for the time required to generate the threshold cumulative ESAL's.

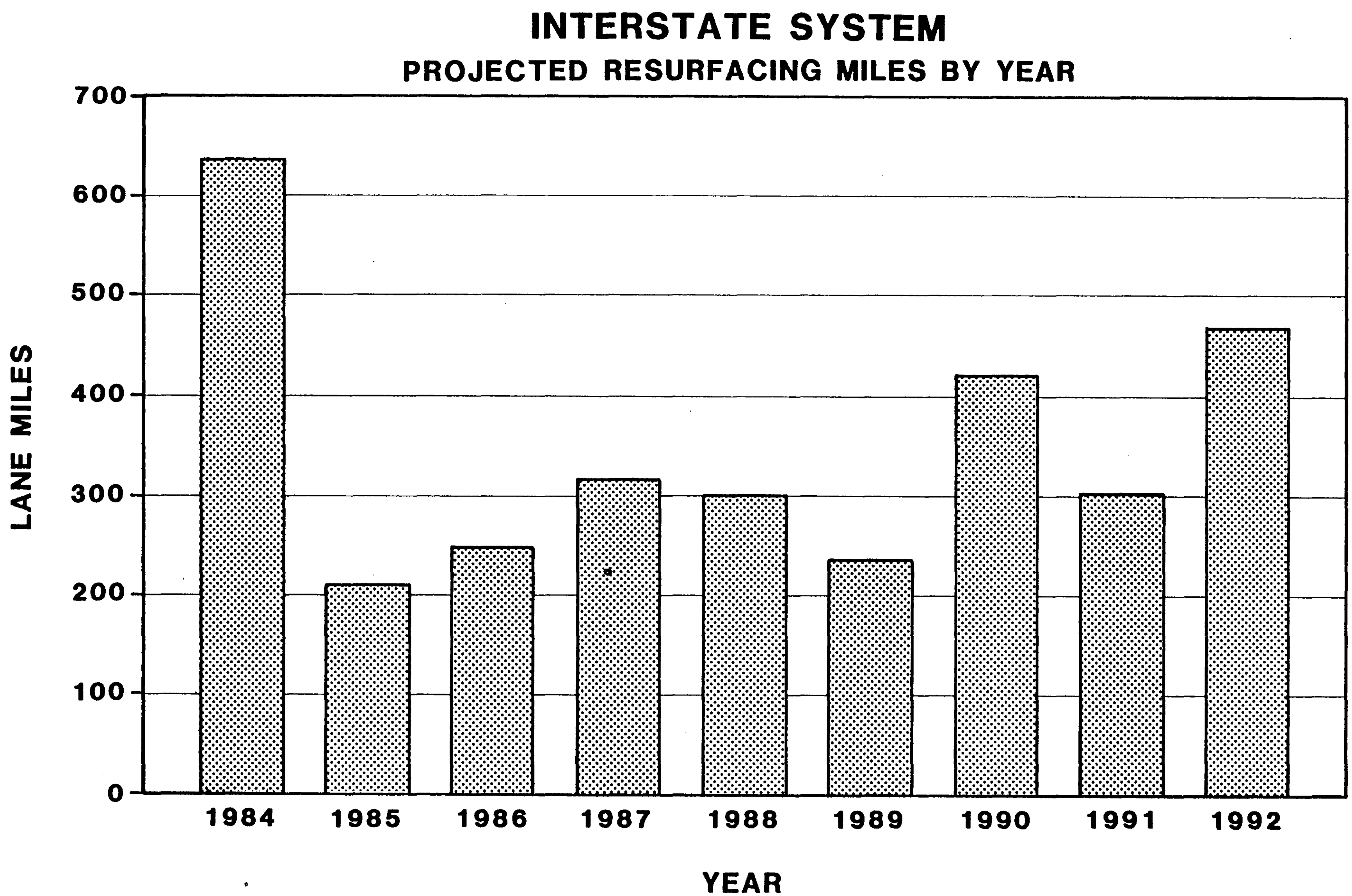
INTERSTATE SYSTEM
PROJECTED RESURFACING MILES BY YEAR
LANE MILES
700
600
500
400
300
200
100
0
1984
1985
1986
1987
1988
1989
1990
1991
1992
YEAR

Figure 4.

TYPICAL PERFORMANCE CURVES
I-81 WASHINGTON COUNTY

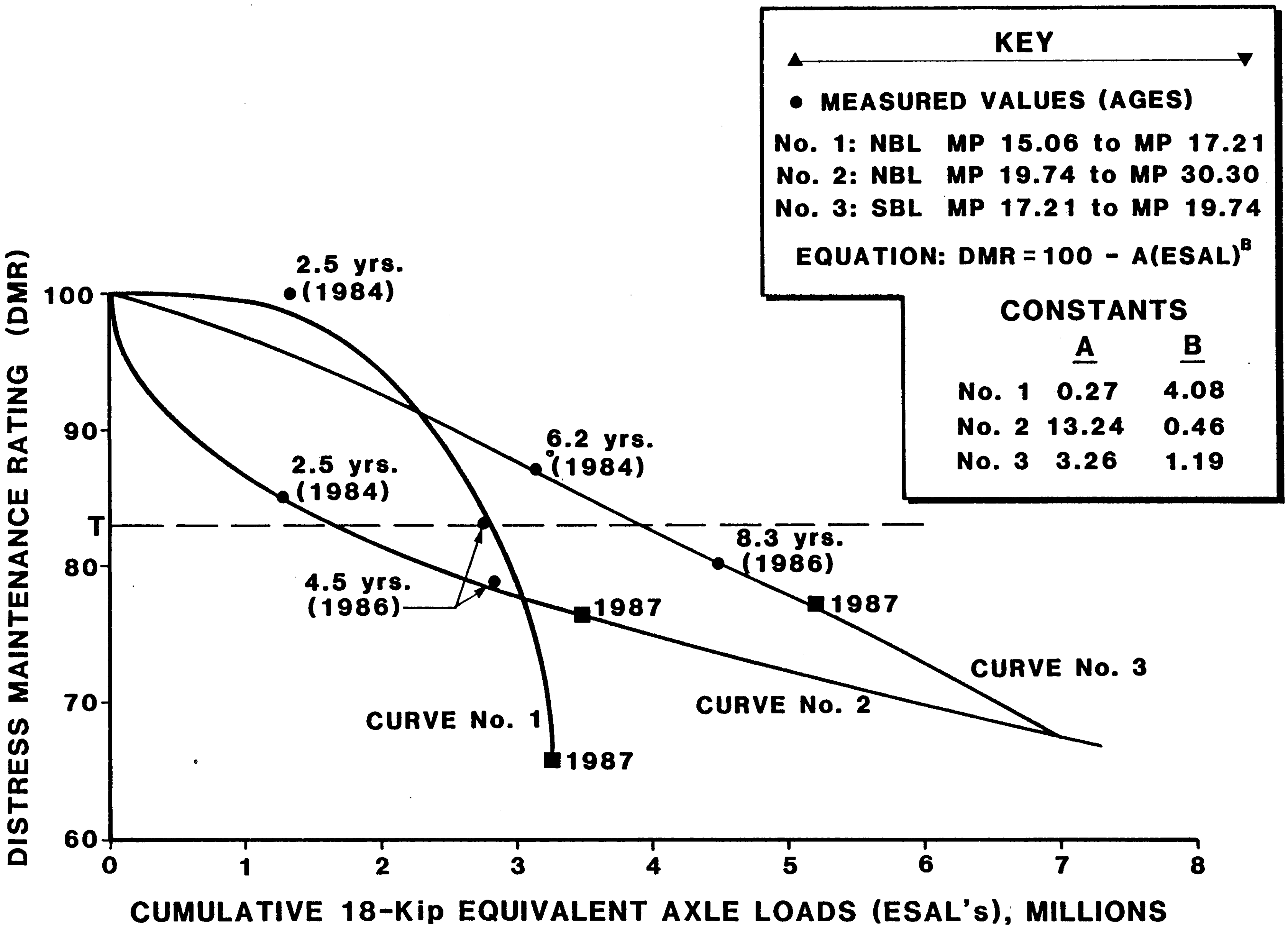

Figure 5.

In Figure 5, the parameters A and B are tabulated for each of the three performance curves. Note that the magnitude of B determines the shape of the curve and that when B approaches one (1) the curve approaches a straight line. When B is greater than one (1) the curve is concave and when B is less than one (1) the curve is convex. Another way to view the value B is in terms of the pavement's traffic sensitivity. The larger the value B, the more sensitive the pavement is to traffic. Note that curve No. 1 is very steep, the pavement is very sensitive to traffic loadings, and the pavement will suffer a rapid decline in DMR value. Curve No. 2 is much less traffic sensitive, and although the pavement suffered an early loss in quality, its long term decline in quality will be gradual. Curve No. 3 is almost a straight line, suggesting that there is a uniform gradual loss in quality and moderate traffic sensitivity. Interestingly, pavement No. 1, with the highest condition rating (DMR value) in 1986, is projected to have the lowest rating by 1987. This pavement, then, should have the highest priority of the three. Further, because of its rapid decline in condition, pavement No. 1 is a candidate for close study and possible major rehabilitation.

At least two conclusions are evident from the above discussion.

1. A simple threshold value is not a sufficient prioritization tool; the shapes of performance curves need consideration as well.

2. It may not be possible to define through economic analysis a single threshold condition value for each highway system. Clearly the shapes of the performance curves are important and may lead to the adoption of different threshold values for different pavements.

Rehabilitation Alternative Analysis

During the past two years the Department has made good progress in developing the background data and the techniques for the selection of pavement rehabilitation alternatives on the basis of economic analysis to achieve the most cost effective alternative. Most of this work has been done by the Staunton and Salem Districts where a number of interstate pavements are under consideration for major rehabilitation.

In general, pavements to be considered are selected on the basis of data from the pavement management system by coring and testing in-place materials and by non-destructive testing. A number (often six to eight) of alternatives considered feasible from an engineering point of view are selected for the economic analysis. This analysis consists of determining the present worth of the immediate action (including traffic handling costs and costs associated with any necessary grade change), the costs of projected maintenance, and the salvage value of the rehabilitated pavement at the end of a 25 year analysis period. Pavements are presumed to be rehabilitated to carry the projected traffic over the analysis period so that, in most cases, the rehabilitated pavement must be structurally stronger than the original pavements, which are usually 20 to 25 years old.

To supplement the pavement rehabilitation effort, the Maintenance Division and the Research Council have jointly sponsored three 28 hour Federal Highway Administration shortcourses on pavement rehabilitation. These shortcourses provided the participants with an overview of the methods of pavement condition evaluation, the rehabilitation techniques available, and the many factors which must be considered in rehabilitation design. A hundred and twenty engineers, inspectors, and technicians employed by the Department have participated in these courses.

As a final aid to the rehabilitation effort, two non-destructive testing activities have taken place. The first, to supplement the Department's own activities, was to enter into a contract for deflection testing using the falling weight deflectometer. This device, which applies a more realistic load than the Department's dynaflect, should provide operations personnel with a good evaluation of the structural properties of in-place pavements under consideration for rehabilitation.

The second non-destructive testing activity makes use of ground penetrating radar to assess the voids beneath concrete pavements under consideration for rehabilitation. The method shows good promise of providing an improved evaluation of pavement foundation and a much better estimate of grout quantities needed for slab stabilization(18).

Pavement Design for Microcomputers

As an aid to more efficient design of both new and rehabilitated pavements, the Research Council and the Materials Division have recently developed the programs for and adopted the Virginia pavement design procedure to microcomputers. The program is written in BASIC to run on IBM compatible machines with two disk drives and formatted with Microsoft DOS 2.1.

The microcomputer design program will permit designers to consider several thousand alternate pavement designs and readily select the one having the least initial cost. The program is in use in the Materials Division and will be distributed to field personnel pending review and approval by the Information Systems Division and by the management of the Department(19). Ongoing efforts will incorporate full life-cycle cost analysis into later versions of the package.

The Management of Portland Cement Concrete Pavements

Owing to the relatively few miles of concrete pavements in the state and to complexity of the subject, the Pavement Management Research Advisory Committee endorsed a 1984 proposal that both the development and first stage of implementation of the pavement management system be undertaken by the Research Council(8).

Procedures developed in National Cooperative Highway Research Program project No. 1-19 Portland Cement Concrete Evaluation System (COPES)(20) were chosen as the basic data gathering approach for the study. Standard statistical analyses are applied to the data in determining significant variables and the relationships among those variables.

By mid 1986, all concrete pavements on the interstate system had been surveyed and data reduction, data base organization, and data analysis were underway. Pavement roughness as determined by the Mays Ride Meter was used as the objective measure against which various distress parameters were compared. Permanent patching, transverse joint faulting, transverse joint seal damage, and transverse joint spalls had a significant affect on the roughness of jointed pavements. For continuously reinforced pavements, only transverse cracking was statistically related to roughness. This latter finding suggested that owing to the relatively good condition of continuously reinforced pavements in the state, it will be very difficult to develop a meaningful rating scale for those pavements. Early indications are that continuous pavements will need to age and deteriorate further before useful management approaches can be developed. However, rehabilitation priorities for both jointed and continuously reinforced pavements are being established using pavement roughness as an interm index of condition.

A report on the development of the management system for concrete pavements is anticipated in early 1987. Full implementation to both the interstate and primary systems will require about four years.

CONCLUSIONS

1. The Department has made excellent progress in the development and implementation of a pavement management system.

2. Pavement management data are used both in priority programming and in the development of long-range pavement maintenance-replacement needs.

3. Pavement management has lead to a significant redistribution of average pavement condition among the various districts, although there was some indication of a gradual decline in overall condition between 1982 and 1985.

4. The pavement condition survey monitoring process employed by the Maintenance Division is effective in identifying differences in the way various teams conduct their ratings.

5. A simple pavement condition threshold is not a sufficient prioritization tool; the shapes of pavement performance curves also need to be considered.

RECOMMENDATIONS

The following recommendations are offered in the hope that the pavement management effort in Virginia will be further enchanced by their implementation.

1. In the selection of priorities among potential rehabilitation projects, the shapes of the performance curves as well as the pavement condition ratings should be considered.

2. Pavement management data should be used to determine the size of the maintenance replacement budget, as well as how budgeted funds are to be allocated among the districts; that is, in addition to the usual monetary inflation factor, a traffic growth factor and pavement management data including condition ratings and pavement performance curves should be used in the development of long range pavement maintenance-replacement budgets.

3. The Maintenance Division should continue its program of monitoring, through a random sampling process, the pavement condition ratings by field rating teams.

4. The move toward decentralization of the entry of pavement management data should be continued, and the information retrieval aspects of pavement management would be enhanced through the provision of on-line access to pavement management data bases.

ACKNOWLEDGEMENTS

The research reported herein was conducted under the general direction of Howard H. Newlon, Jr., director of research and funded with state research funds. The author is grateful to Maintenance Division personnel, C. O. Leigh, J. K. McEwen, A. D. Newman, and R. H. Duncan for the helpful information provided. Appreciation also is expressed to Ann McDaniel, Ray Gunn, and Bob Long of the Research Council for their assistance in the research and in the report preparation.

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APPENDICES

Appendix 1

Percentage Primary Pavements
Rating Below Threshold
by District

	1982-83		1985-86	
District	% Below DMR = 80	Deficient Miles	% Below DMR = 79	Deficient Miles
Bristol	21.9	357	31.0	413
Salem	8.8	119	27.4	303
Lynchburg	13.1	167	32.4	419
Richmond	6.8	102	8.0	108
Suffolk	10.8	83	2.9	24
Fredericksburg	14.7	158	23.8	237
Culpeper	48.0	490	21.8	194
Staunton	5.4	67	5.9	77
Northern Virginia	27.0*	97*	40.5	226
State	16.0	1636*	20.7	2001

*1982-83 Data does not include Fairfax Co. (approx. 290 miles total) which has 44.5% below threshold in 1985-86.

Total Miles Reported (Statewide) : 1982-83 -- 10,220
1985-86 -- 9,652

Appendix 2

Virginia Department of Highways and Transportation
Pavement Management System
Interstate Highways
Resurface Lane Mileage by Year for DMR = 83

District	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	81.00	42.24	30.08	12.38	47.30	35.22	102.68	46.14	88.35
2	119.93	18.42	28.09	16.18	12.28	18.42	53.96	85.09	72.18
3	2.72	0.0	2.72	0.0	0.0	0.0	0.0	0.0	0.0
4	36.88	34.26	27.88	62.40	102.12	100.01	69.24	73.37	95.39
5	0.0	1.78	0.0	0.0	0.0	8.36	41.48	19.86	39.54
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	73.00	6.02	0.0	12.12	6.32	0.0	57.96	1.74	0.0
8	266.12	104.16	102.36	77.32	113.18	74.04	78.18	38.66	117.08
9	56.32	3.75	61.81	132.78	15.66	0.0	17.01	35.58	47.11
Statewide	635.97	210.63	252.94	313.18	296.86	236.05	420.51	300.44	459.64

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