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16. Abstract

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The key distresses identified for jointed concrete pavements are permanent patching, lane/shoulder separation, transverse joint faulting, transverse joint seal damage, and scaling, map cracking, or crazing. For continuously reinforced pavements, spacing of transverse cracks, lane/shoulder separation, and scaling, map cracking, or crazing were identified. Field surveys of the occurrence of these distresses provided the necessary data for estimating distress roughness through the use of prediction equations that have been established from the standard statistical analysis of pavement section distress data and roughness measurements.

The use of distress roughness to reflect a pavement's service condition provides a common basis for comparison of pavement sections. This, in turn, enables managers to set priorities for pavement rehabilitation. These rating procedures and a comprehensive system for managing portland cement concrete pavements will be implemented in a subsequent project.

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FINAL REPORT

A PAVEMENT MANAGEMENT SYSTEM FOR CONCRETE ROADWAYS IN VIRGINIA

Phase I: Condition Ratings

By

R. R. Long, Jr.
Research Scientist

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

In Cooperation with the U. S. Department of Transportation
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SUMMARY

This report traces the development of a rating system proposed by the author and reviewed by a subcommittee of the Pavement Management Research Advisory Committee for use in evaluating the service condition of Virginia's portland cement concrete pavements. The service condition is assessed in terms of distress roughness, i.e., that portion of a pavement's poor ride characteristics directly attributable to the occurrence of certain key distress types.

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INTRODUCTION

As new highway construction slowed and our nation's existing roads continued to age, it became increasingly obvious that all those years of emphasis on construction and de-emphasis of maintenance left us facing a rather formidable task: to continue to provide acceptable levels of service to the travelling public through maintenance of an aging and deteriorating roadway system within the limits of increasing budgetary restraints. Early efforts to meet these needs soon showed that existing maintenance policies were inadequate in the wake of the overwhelming needs. A new approach was needed to help our maintenance dollars do the most good. This new approach was pavement management.

The fundamentals of pavement management can be traced to the results obtained from the American Association of State Highway Official's road tests published in the early 1960s (1,2). During these tests, subjective ratings of the condition of pavements were made by a panel of road users. These ratings were on a scale of 0-5 (very poor to very good). Later these ratings were transformed into a more objective index of serviceability based on the occurrence of certain distress types. The term "pavement management," however, did not come into usage until the late 1960s and early 1970s. There are probably as many variations of the definition of "pavement management" as there are pavement management users, but, generally, pavement management is an ordered and objective approach to providing the most serviceable pavements possible to the travelling public at the lowest cost.

In Virginia formal pavement management efforts began in the mid-1970s. Maintenance and research personnel worked together to develop a flexible pavement condition rating system designed for use by field engineers to assist in determining when maintenance activities should be performed. This system was demonstrated and refined in 1979-80 and applied to all the flexible pavements in the interstate system in 1981 (3).

With the pavement condition rating system as its foundation, the Virginia Department of Transportation's (VDOT) pavement management system (PMS) was under development. The potential benefits to VDOT for implementing such a system were (4):

- o improved performance forecasting and monitoring
- o objective support for funding requests
- o identifiable consequences of various funding levels
- o improved administrative credibility
- o a basis for cost allocation to highway users
- o improved engineering input for policy decisions.

These benefits along with a legislative mandate led to full support from management to proceed with full development and implementation of a comprehensive PMS.

Concentrated efforts have carried Virginia's PMS considerably beyond simple pavement condition ratings. The pavement management data base is used in both priority programing and in projecting long-range pavement maintenance needs. Funding allocations based on condition data have led to a significant redistribution of average pavement condition among the various VDOT districts (3).

Great strides have clearly been taken in the management of Virginia's flexible pavements; however, management of rigid pavements has been conspicuously missing. Manpower limitations forced the pavement management efforts to be directed where they could do the most good. VDOT has responsibility for 62,753 miles of roads the majority of which (53,653) is contained in three systems--interstate, primary, and secondary. Virginia's PMS is currently applied to these three systems, and of that mileage, 41,646 miles are paved (i.e., hard surfaced). Portland cement concrete pavements (PCCP) comprise only 463 miles (just over 1 percent) of the paved roads (5). Quite reasonably then, Virginia's PMS has been developed around flexible pavements.

In addition to lack of manpower and the relatively small quantity of PCCP, the complex nature of the performance of these pavements makes them more difficult to analyze and model than flexible pavements. All of these hindrances cannot reduce the importance of PCCP to Virginia's highway system. This importance is clearly illustrated by the fact that 26 percent of Virginia's highest volume roads, the interstate system, is PCCP. The ability of these pavements to withstand today's high traffic loadings and high tire pressures along with their long design life emphasizes the need to manage them properly.

The benefits of pavement management certainly apply to rigid pavements as well as flexible pavements. The short-term benefit will be the assimilation of scattered, outdated information on Virginia's concrete pavements into an organized data system. In the long-term, the development and integration of a PMS for concrete pavements with the comprehensive PMS currently in operation would draw the Department toward completion of the system. So with all these factors in mind, the VDOT Pavement Management Research Advisory Committee endorsed pursuing the development and implementation of a PMS for concrete roadways. As a first step toward that end, this project was initiated in April 1984.

PURPOSE AND SCOPE

The purpose of this project was to develop a system for evaluating the service condition of Virginia's existing PCCP. This system includes procedures for collecting data on the pavement sections and subsequently deriving numerical ratings of the condition of the sections from the data obtained. The project is the first step in developing a functional PMS for concrete pavements. The system will be implemented and integrated with VDOT's comprehensive PMS in a subsequent project.

The rating system developed is applicable to all types (jointed plain, jointed reinforced, and continuously reinforced) of concrete pavement in the interstate, primary, and secondary highway systems in Virginia. The development of the system centers on the PCCP in the interstate system.

APPROACH

Background

A review of some literature on other states' PMS shows that some type of pavement field evaluation is conducted on both flexible and rigid pavements in order to collect basic pavement condition data (6,7,8,9). This literature along with Virginia's experience with flexible pavement management clearly indicate that the first and most important step in the establishment of a PMS for concrete pavements is the development of a procedure that would enable managers to assess the present service condition of the existing pavements. Ideally, this evaluation would yield numerical ratings of the service condition that would be relatively easy to determine. These ratings should permit consistent comparisons of pavement sections so that priorities for rehabilitation can be established.

The determination of the service condition of a pavement centers on the user's perception of serviceability, that is, the comfort or smoothness of the ride. Unfortunately, this is an extremely subjective quantification process. The preference of Virginia engineers has been to derive serviceability from the pavement's engineering characteristics as exhibited by the manifestations of certain distresses and the way they relate to ride quality (4,10). Therefore, the approach selected for this project was to collect pavement condition data through field surveys and compare it with the pavement's ride characteristics in order to determine a numerical condition rating.

Researchers at the University of Illinois developed the Concrete Pavement Evaluation System (COPES) under the National Cooperative Highway Research Program's Project 1-19 (11). This system was designed for state and nationwide use in evaluating concrete pavement performance and is capable of efficiently collecting, processing, and evaluating large amounts of pavement data to improve design, materials, construction, and maintenance of concrete pavements. COPES has three main components (Figure 1): data collection, data storage and retrieval, and evaluation. Once all the necessary pavement data have been assembled, it is entered into a carefully structured, computerized data file. This data file permits effective retrieval and evaluation of the data.

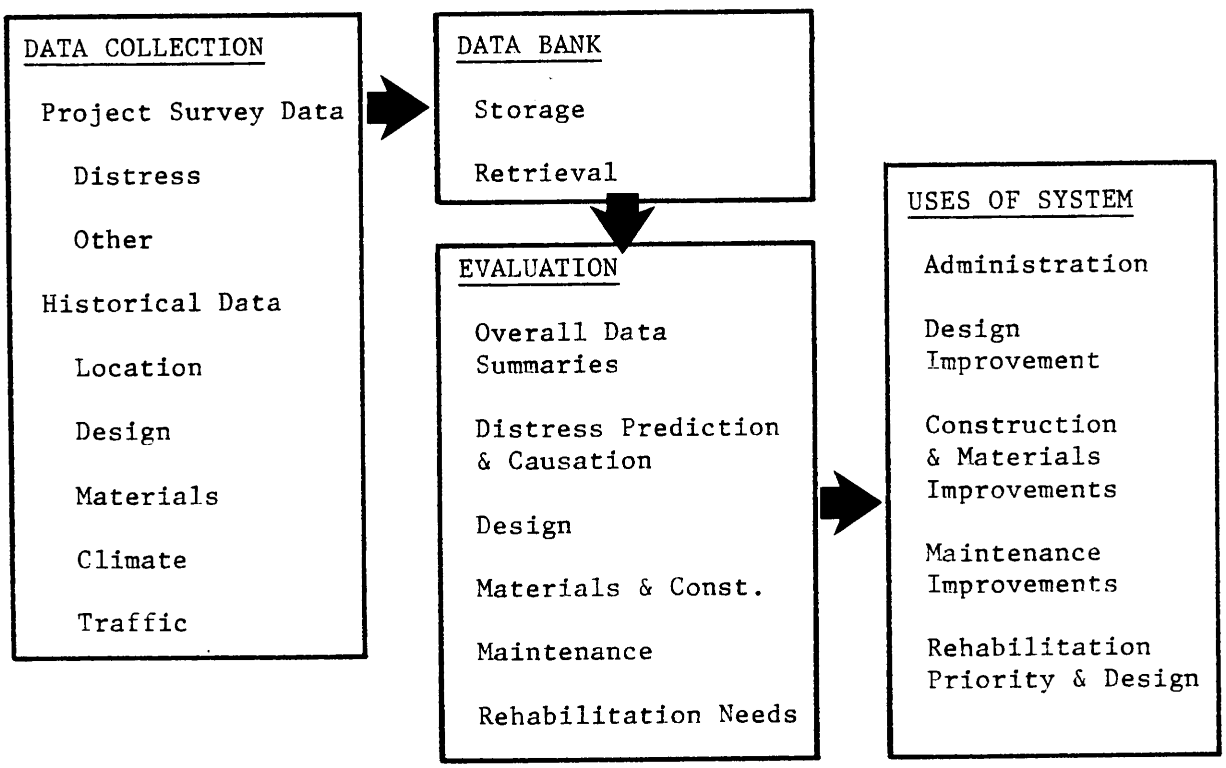


Figure 1. Concrete Pavement Evaluation System--COPES
Source: Portland Cement Concrete Pavement Evaluation.

Although COPES is far more comprehensive than VDOT needs at this time, its field-tested procedures for assessing pavement distress certainly do provide excellent guidelines for the development of similar procedures for Virginia's PCCP.

Condition Surveys

Because of the relative complexity of distress occurrences and their causes in portland cement as compared to bituminous concrete pavements, it was anticipated that, if the survey was to be effective, rigid pavement distress surveys would have to be considerably more detailed than the "windshield survey approach" often employed when rating flexible pavements. Difficulty with more detailed surveys would be encountered under implementation as a result of the increased manpower requirements for such surveys. Therefore, the project sampling approach as set forth in COPES was adopted in order to maintain detail without increasing manpower needs by surveying sample sections instead of entire projects.

Uniform Sections

A pavement's characteristics and environment greatly affect the types and occurrences of distress; therefore, one of the first steps in establishing a sampling plan was to divide the PCCP mileage into uniform sections. COPES defines a uniform section as one having the following characteristics along its entire length:

- structural design
- joint and reinforcement design
- truck traffic
- number of lanes
- subgrade conditions
- construction by the same contractor
- opened to traffic the same year
- pavement materials
- general distress occurrence
- maintenance applied
- same local government jurisdiction.

It was decided that the original construction project limits would effectively meet these criteria of uniformity. In some cases, however, a portion of a particular project may have been overlaid with bituminous concrete at some point in its life. The limits of these projects would have to be adjusted to matching surface type. The lengths of all projects in the interstate system range from 0.3 to 10.68 miles.

Sampling Plan

A statistical sampling plan was employed to reduce actual survey time. Each uniform section was divided into smaller sample units. Then the survey was conducted on a certain number of the sample units and the results of the survey from these units were used as estimates to represent the condition of the entire uniform section.

How many sample units must be measured to obtain statistically representative results? According to COPES, analysis has shown that normally one sample unit must be surveyed for every ten in the uniform section to obtain a reasonable degree of accuracy in the pavement survey. Therefore, a 10 percent sample should be sufficient or a 0.1 = mile sample for each mile in each uniform section.

As far as selecting which sample units to measure, the simpler and much preferred of the two valid methods mentioned in COPES is simply to sample 0.1 mile at each mile marker or post within the limits of the uniform section, adjusting as necessary to avoid sampling bridges and approaches. This method was selected for use with the realization that changes would be necessary for rating the primary PCCP because there are no mile markers on the primary system.

Distress Types

The initial distress surveys that were conducted on the sample units closely followed the survey procedures outlined in COPES. The comprehensive nature of the procedures would best enable the raters to document all distresses that affect the assessment of the pavement's serviceability. This approach would be appropriate for the development of the system; however, for practical purposes the final rating procedures were expected to be reduced to documenting only those distresses determined to have a direct influence on pavement service condition.

Due to the fact that COPES was designed with national application in mind, before the initial surveys were conducted, the COPES distress types were carefully reviewed and those less likely to be applicable to Virginia--like durability cracking, studded tire damage, etc.--were eliminated from the survey. Tables 1 and 2 show the respective jointed concrete pavement (JCP) and the continuously reinforced concrete pavement (CRCP) distress types initially surveyed. Note that jointed plain and jointed reinforced pavements were surveyed in the same way.

Table 1

JCP DISTRESS TYPES SURVEYED

Permanent Patching
Transverse Joint Faulting
Lane/Shoulder Separation
Transverse Cracking
Longitudinal Cracking
Transverse Joint Spalls
Longitudinal Joint Spalls
Shoulder Condition
Transverse Joint Seal Damage
Temporary Patching
Pumping
Map Cracking and Scaling
Wheelpath Wear

Table 2

CRCP DISTRESS TYPES SURVEYED

Permanent Patching
Lane/Shoulder Separation
Transverse Cracking
Longitudinal Cracking
Longitudinal Joint Spalls
Shoulder Condition
Temporary Patching
Pumping
Map Cracking and Scaling
Wheelpath Wear

Shoulder condition, transverse joint seal damage, temporary patching, pumping, and map cracking and scaling were all rated on separate occurrence or condition scales. The area of permanent patching was estimated, whereas transverse joint faulting and lane/shoulder separation were measured. Finally, transverse cracking, longitudinal cracking, transverse joint spalls and longitudinal joint spalls were each quantified and then rated according to the severity of occurrence. For more detailed information on how these distresses were initially quantified and rated, see Appendix A.

Data Collection

For the most part, condition surveys were conducted with a two-man team. Before leaving the office, slightly modified COPES condition survey data sheets were prepared. These sheets were partially filled in at the office from construction project information. The set of sheets for each project was composed of a background sheet and a set of rating sheets, including a section sketch and a distress rating and summary sheet for each sample section to be rated.

Upon arriving at the project, the survey team drove over the entire length of the project in each lane at the posted speed. At the end of each pass a consensus ride rating was determined using a rating of 5 to 4 as very good, 4 to 3 as good, 3 to 2 as fair, 2 to 1 as poor, and 1 to 0 as very poor. Also during the ride-rating passes, the driver verified the project limits or made necessary adjustments required by changes resulting from rehabilitation. The passenger noted when structures fell within the proposed sample sections, which required altering the sample section location.

Next, the team returned to the beginning of the project and drove to the first sample section and pulled the vehicle well onto the shoulder. The vehicle's flashers were turned on and a rotating caution light was placed on top of the car. The team left the vehicle and proceeded to walk the entire 0.1-mile sample length of the section. One team member measured the area of permanent patching and transverse joint faulting and counted and rated all transverse joint spalls. The other team member sketched the occurrence of longitudinal and transverse cracks, permanent and temporary patches, longitudinal joint faulting, and any other notable section specifics (Figure 2). Additionally, this person measured lane/shoulder separation, counted and rated longitudinal joint spalls, and rated transverse joint seal damage and pumping. A consensus on shoulder condition, map cracking and scaling, and wheelpath wear was arrived at after returning to the vehicle.

When rating projects in areas with particularly high traffic volume, it was preferable that the surveys be conducted with a three-man team for safety reasons. The third member of the team became the driver, and his ride rating is included in the team's consensus. While the actual survey was being conducted, the driver remained in the car and followed the raters along the shoulder at a distance of 100 to 150 feet. The vehicle then became a more effective barrier between the raters and the traffic.

The majority of the surveys on the approximately 262 miles of interstate PCCP were conducted from April 1984 through July 1985. The amount of time it took to survey each sample section varied from 15 to 45 minutes. The time depended on the pavement design (20-ft jointed, 61.5-ft jointed, continuously reinforced, etc.), the condition of the pavement, the traffic volume, the size of the crew, and the experience of the crew.

PCCP CONDITION SURVEY DATA SHEET

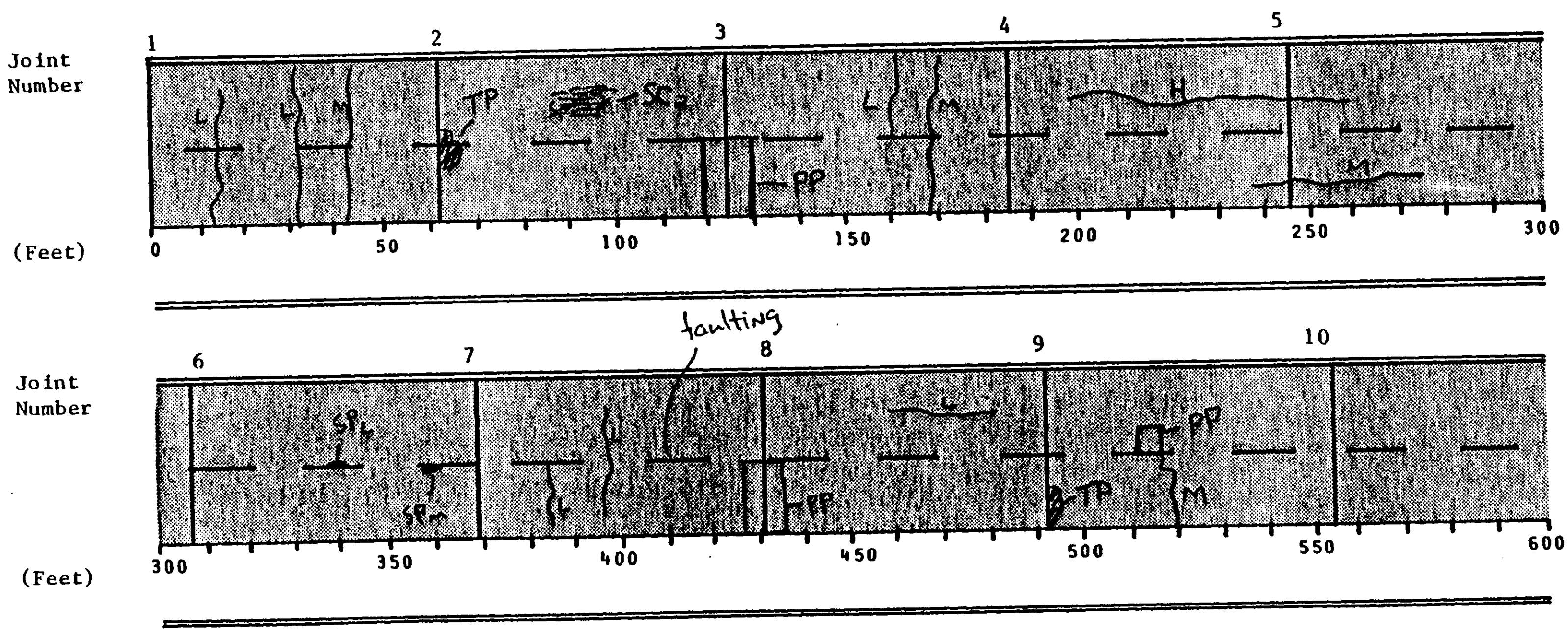
Sample Section Sheet 1

Project Number: 5-039-064-3-05

Sample Section Number: 3

Joint Spacing: 61.5 ft.

Mile Marker 107.0



Transverse Joint Faulting Measurements: 0, 1/16, 1/16, 1/8, 1/16, 0, 0, 1/8, 1/16, 1/16

Lane/Shoulder Separation Measurements: 1/8, 1/8, 1/4, 1/4, 1/16, 1/4, 1/4

Figure 2.

Finally, Mays meter roughness data was collected for the traffic lane of each project during the summer of 1985. Although most of the distresses were surveyed for the two outermost lanes, time constraints prohibited measuring roughness in more than just the traffic lane. For purposes of the statistical analysis, only having roughness for the traffic lane was not seen as a drawback owing to the fact that by far the greatest concentration and highest severity of distress was found to occur in the traffic lane.

SURVEY RESULTS

Data Reduction

Once all of the pavement projects had been surveyed and roughness had been measured, the distress data from the sample sections were converted to project averages. Quantified sample section distresses became project average quantities per mile and rated distresses became average project ratings. For example, for a 3-mile project the three sample sections yielded values of 100, 200, and 300 feet per mile of low severity transverse cracking. The sample sections also showed that the transverse joint seal damage was rated medium (2), medium (2), and severe (3). The average project values for low severity transverse cracking and transverse joint seal damage would be 200 feet per mile and 2.3 respectively.

Finally, descriptive, roughness, and distress data for each project were used to construct a condition data base. All this information was entered on floppy disks in spreadsheet format. This format permitted easy data manipulation, updating, and analysis.

Data Analysis

The objective of analyzing the data was to determine the influence of occurrence and/or severity of each distress type on the pavement's condition. A pavement's condition or serviceability can be assessed in terms of its ride quality, which essentially constitutes the users' perception of its serviceability. Therefore, by establishing relationships between distress types and ride quality, a pavement's serviceability may be established from the measurement and rating of its distresses.

Although the rating team's assessment of each project's ride quality was available, the much more objective roughness values obtained using the Mays meter were selected to be used as the dependent variable during this critical stage of establishing the basic relationships between distress types and ride quality. The rating teams' values actually represented the public's "seat-o-meter" perception; however, since the team's rating was found to be highly correlated ($R^2 \simeq 0.92$) to the actual roughness measurements, little accuracy would be lost with the use of either.

Standard statistical techniques were employed to analyze the data. Because of the inherent differences in the design, performance, and distress between JCP and CRCP, each type of pavement was examined separately. Early analysis showed no need for continued examination of some of the distress data. Some of the distress types (especially the medium and high severity classifications) occurred with such infrequency that no meaningful relationships could be established. Likewise, some distresses, such as wheelpath wear and temporary patching, occurred with such little variability (i.e. practically all sections have them) that they also needed no further consideration. Although shoulder condition was always rated and showed plenty of variability, since it had no direct bearing on the roughness of the traffic lane, it was also eliminated from further analysis. For the same reason, all distresses surveyed on the inner lane were also eliminated. Tables 3 and 4 show the remaining distress types.

Table 3

JCP Distress Types with Enough Variability and/or Number of Occurrences to Analyze

Permanent Patching
Transverse Joint Faulting
Lane/Shoulder Separation
Transverse Cracking (L)
Transverse Joint Spalls (L)
Scaling, Map Cracking, or Crazing
Transverse Joint Seal Damage
Pumping

Table 4

CRCP Distress Types with Enough Variability and/or Number of Occurrences to Analyze

Permanent Patching
Lane/Shoulder Separation
Transverse Cracking (L)
Scaling, Map Cracking, or Crazing
Pumping

Although the severer occurrences of some distresses should not be considered separate variables in the remainder of the analyses, it was decided that the quantities of these occurrences should not be omitted. Therefore, the quantities for such distresses would be the sum of the quantities at each distress level. For example transverse cracking equals low transverse cracking plus medium transverse cracking plus high transverse cracking. The author attempted to weigh the quantities of medium and severe occurrences relative to the low occurrences in an effort to better reflect the effect of these occurrences, but found that no statistically significant improvement in the relationship was gained. So, the quantities used represent the sums.

The results obtained from the analysis of the project-average data were excellent and yielded some strong statistical relationships. However, in light of the objective of the analysis, some questions were raised as to the appropriateness of using project-average data. The survey results often showed that the occurrence and severity of distress types varied considerably among sample sections within a given project. The effect of the sample section exhibiting a great deal of distress could be greatly lessened when averaged with other project sections. Likewise, the effect of these distresses on project ride quality would be reduced. For that matter, the measured roughness of the distressed section would also be reduced when averaged with the other sections in order to determine a project roughness: how can the relationship between distress occurrence and roughness be determined when the direct association between a sample section and its corresponding roughness can be lost when averaged with other sections exhibiting variable levels of distress and roughness?

It seemed that the initial analyses might not have established the most direct relationship between specific distress occurrence and roughness as originally intended. So, it was decided that the analyses would be re-run on a section-by-section basis within a given project in order to eliminate the effects of averaging.

Extensive data base changes were required. First, the Mays meter data was re-calculated from mile marker to mile marker within the limits of each project. Next, the project-average distress data was expanded to data for each sample section for each project and extrapolated to one mile (mile marker to mile marker). For a sample of the finalized database, see Appendix B.

Analyses performed on the revised data base yielded very similar results statistically, but the distress types with the strongest relationship to roughness did change somewhat. Since the more accurate determination of the relationships should have been obtained from the revised data base, the distresses selected from these analyses were chosen for use in the condition equations. These distresses are given in Tables 5 and 6 for JCP and CRCP.

Table 5

JCP Statistically Significant Distress Types

Permanent Patching
Lane/Shoulder Separation
Transverse Joint Faulting
Transverse Joint Seal Damage
Scaling, Map Cracking, or Crazing

Table 6

CRCP Statistically Significant Distress Types

Transverse Cracking
Lane/Shoulder Separation
Scaling, Map Cracking, or Crazing

It is somewhat of a misnomer to refer to permanent patching as a distress itself since patching is simply recorded as the square feet of patching found in the section. The strength of the correlation between patching and roughness, however, clearly indicates that patching increases roughness. This leads to the conclusion that the condition of most patches is less than satisfactory. Similarly, the transverse cracking shown in Table 6 (which is all low severity) can hardly be considered a distress for CRCP since such cracks are there by design. On the other hand, the closer the crack spacing (i.e., the greater the amount of transverse cracking) the more likely localized distresses like irregular cracking and edge punchouts are to occur. These distresses can have a significant influence on roughness. Also, although lane/shoulder separation and joint seal damage do constitute distresses, they do not directly affect roughness. Nevertheless, the well-documented effects of the damage that can result when water is permitted to enter the pavement support system most certainly affect roughness.

After the significant distresses were identified, a method of using them to calculate a value that would represent pavement condition and permit comparisons of the relative condition of pavement sections needed to be devised. For flexible pavements a condition index referred to as the distress maintenance rating (DMR) is used. The DMR uses a base score of 100 from which deductions are made based on the occurrence and severity of certain key distress types. Frequency of occurrence is determined by the percentage of the section affected. The ratings are "none," "rare," "occasional," and "frequent." Guidelines given for each distress classify each as "not severe," "severe," or "very severe." The ratings given to each distress are up to the judgment of each rating team. Once rated, each distress is assigned a rating factor from 0 to 9 as shown in Table 7. These factors are then multiplied by the relative weight of each distress (relative to its influence on pavement condition) in order to determine the deduct points. This procedure is fully explained in reference 12.

Table 7

Rating Factors for Flexible Pavements

Frequency of Distress	Not Severe (NS)	Severe (S)	Very Severe (VS)
None (N)	0	0	0
Rare (R) less than 10%	1	2	3
Occasional (O) 10% - 40%	2	4	6
Frequent (F) over 40%	3	6	9

Unfortunately, this approach is not directly applicable to the distress data collected for PCCP. The quantification process varies with each distress and only one severity level is recorded (Table 8). Thus another approach must be employed.

Table 8

Distress Measurements and Ratings for PCCP

Distress	Measurement/Rating
Permanent Patching	Square Feet
Lane/Shoulder Separation	Inches
Transverse Joint Faulting	Inches
Transverse Joint Seal Damage	1-3 (Low-High)
Scaling, etc.	0-3 (Low-High)
Transverse Cracking	Linear Feet

Using the coefficients determined for each distress type from the multiple linear regressions performed on the data, roughness prediction equations can be derived. The equation for JCP (Equation 1) and for CRCP (Equation 2) are shown below.

$$\text{Distress roughness} = (0.002 \times \text{patching}) + (60.56 \times \text{lane-shoulder separation}) + (95.23 \times \text{joint faulting}) + (29.76 \times \text{joint seal damage}) + (66.41 \times \text{scaling}) \tag{1}$$

$$R^2 = 0.93$$

$$\text{Distress roughness} = (46.96 \times \text{lane-shoulder separation}) + (0.039 \times \text{transverse cracking}) + (21.28 \times \text{scaling}) \tag{2}$$

$$R^2 = 0.87$$

The excellent correlation coefficients (R^2s) for both equations clearly indicate the ability of the distress measurements and ratings to predict distress roughness. It must be kept in mind, however, that this predicted roughness is actually only the portion of the pavement's roughness that is a direct result of distress manifestation. Poor workmanship, depressions and swells, etc. are obviously not taken into account. This point was readily illustrated when the predicted roughnesses were compared to the Mays meter roughnesses. The two pavement sections with the lowest distress roughness had two of the highest Mays meter values. Further investigation quickly revealed that poor workmanship was the culprit. There was very little distress present; in fact, the pavement was less than five years old.

Since the objective of the ratings is to determine the relative need of major rehabilitation among pavement sections, the fact that distress roughness is used is certainly acceptable because major rehabilitation should be needed only as a result of pavement distress. In the example cited, the rehabilitation required would simply be pavement grinding. Although these two sections would not be identified by the prediction equation as being in need of attention, the displeasure with the ride quality invariably expressed by the travelling public would quickly bring the need to the attention of the engineer. Also, it should be noted that projects like these two are the exception and not the rule.

It appears that data obtained for the distresses in Table 8 from pavement condition surveys can be used with the distress roughness prediction equations derived earlier to establish values that will permit managers to make consistent comparisons of pavement sections so that priorities for rehabilitation can be established. The priorities would be established by giving sections with the highest distress roughness the highest priority.

At this point no threshold values for distress roughness (i.e., values beyond which rehabilitation is considered a necessity) have been ascertained. Also, no attempts have been made to convert distress roughness values to a 100-point scale in order to permit direct comparison with flexible pavement sections in terms of DMRs. It is anticipated that both of these issues will be addressed under the implementation of the system.

Subcommittee Review

In order to make a final review of the proposed rating procedures developed herein, a subcommittee of the Pavement Management Research Advisory Committee consisting of engineers with experience with Virginia's concrete pavements was formed. This subcommittee's task was to review the findings of this study and make suggestions for improvements. The members were encouraged by the fact that there would finally be a rating system for concrete pavements. After reviewing the significant distress types, they explained that including some additional distresses in the survey would be useful. Although this additional information would not significantly improve the prediction of distress roughness, the engineers would know more about the pavement deterioration and would be better able to determine the appropriate rehabilitation alternatives. For JCP they felt that pumping and transverse joint spalling should be included, and in addition to just measuring the area of permanent patching, the condition of the patch should be rated based on the amount of cracking, spalling, and faulting present. For CRCP the subcommittee added pumping, irregular cracking, and localized distress (e.g., spalling, potholes, punchouts, etc.). As for transverse cracking, they felt that low severity cracks should not be counted and only medium to severe cracks should be included.

Virginia's CRCPs are young relative to the JCP and are generally found in lower traffic volume areas; therefore, they don't really exhibit much distress. The surveys conducted on all of the CRCP did not show a single linear foot of medium or severe transverse cracking. So, if low severity cracking were eliminated, essentially all cracking would be eliminated. Removing cracking from the prediction equation would have rather undesirable effects on the prediction results, which are questionable to begin with because of the infrequency of distress occurrence found on these pavements; consequently, low severity transverse cracking will remain in the rating procedures.

Finally, it was agreed that only the traffic lane needs to be rated because of the fact that the highest occurrence and severity of distress tends to be found there. All details of the proposed condition survey procedure and rating sheets, including the subcommittee's recommendations, may be found in Appendix C.

Other issues were discussed by the subcommittee. The establishment of an ongoing roughness testing program was given some priority in an attempt to identify rough projects that do not have much distress roughness before the travelling public brings these projects to our attention. It was also mentioned that thresholds for each distress type should be set that would by themselves trigger the need for some type of immediate rehabilitation. These and other issues will be addressed under the implementation of these procedures.

CONCLUSIONS

The findings presented in this report appear to support the following conclusions:

1. A viable procedure for conducting condition surveys on has been established.

2. Equations have been developed for the prediction of a value referred to as "distress roughness" for both jointed and continuously reinforced PCC pavement sections from the data collected from the condition surveys.

3. Distress roughness ratings provide a common means by which different pavement sections of the same type may be compared and prioritized.

4. Because of the relatively good condition of the CRCP surveyed, the accuracy of the developed equation for assessing roughness directly caused by distress is somewhat less than the equation developed for JCP. However, both equations are acceptable for use in establishing serviceability ratings.

RECOMMENDATIONS

In light of the completion of the development phase of this system and the shift to implementation, the following recommendations are offered.

1. The implementation of this rating system should be actively pursued, and to that end the subcommittee of the Pavement Management Research Advisory Committee established to assist with the development of the system should remain active to assist in its implementation.

2. The PCCP in the primary system should be incorporated into the system as soon as possible.

3. Efforts should be undertaken to establish threshold distress roughness values.

4. A training program and manual should be created in order to turn the rating system over to the field personnel.

5. Monitoring of the ratings should be instituted in much the same way the flexible ratings are monitored.

6. The system needs to be interfaced with the flexible system so that direct comparisons between surface types can be made.

7. Due to the unequal distribution of PCCP throughout the state, implementation of this system must address the resulting disparity in manpower needs among the districts.

ACKNOWLEDGMENTS

The author gratefully acknowledges the assistance received from many people on this project. This research was conducted under the general guidance of Howard H. Newlon, Jr., Director of Research, and was funded by the Federal Highway Administration. The author is especially grateful to Messrs. R. W. Gunn, K. H. McGhee, and C. S. Hughes, and Ms. M. A. McDaniel for their patient and tireless assistance in the conduct of the research and in the report preparation. A special thanks also goes to the Pavement Management Research Advisory Committee for their input.

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APPENDIX A

PCCP Distress Measurements and Ratings

PCCP DISTRESS MEASUREMENTS AND RATINGS

L = Low severity level
M = Medium severity level
H = High severity level
* = How to measure

Transverse Joint Faulting

Severity is determined by the average faulting (in inches) of the joints within the sample section.

* Faulting is determined by measuring the difference in elevation of slabs at transverse joints for the slabs in the sample section. Faulting is measured one to two feet in from the outside edge of the slab on the outermost lane. If temporary patching prevents measurement, proceed on to the next joint.

Joint-Seal Damage of Transverse Joints

1 - Joint sealant is in good condition throughout the section with only a minor amount of damage present. Little water and no incompressibles can infiltrate through the joint.

2 - Joint sealant is in fair condition over the entire surveyed section: there is only a moderate degree of damage. Water can infiltrate the joint fairly easily; some incompressibles can infiltrate the joint. Sealant needs replacement within 1 to 3 years.

3 - Joint sealant is in poor condition over most of the sample unit: there is a severe degree of damage. Water and incompressibles can freely infiltrate the joint. Sealant needs immediate replacement.

* Joint sealant damage ratings of transverse joints are based on the overall condition of the sealant over the entire sample unit.

Lane/Shoulder Joint Separation

Severity is determined by the average opening (in inches) of the lane/shoulder joint within the sample section.

* Lane/shoulder joint separation is measured and recorded in inches near transverse joints and at mid-slab.

Longitudinal Cracks

L - Hairline (tight) crack with no spalling or faulting, or a well sealed crack with no visible faulting or spalling.

M - Working crack (less than 1/2 inch) with moderate or less severe spalling (less than 3 inches) and/or faulting (less than 1/2 inch).

H - A crack with a width greater than 1 inch with severe spalling; or a crack faulted 1/2 inch or more.

* Cracks are measured in linear feet for each level of distress. The length and average severity of each crack should be identified and recorded.

Longitudinal Joint Faulting

No levels of severity are defined.

* If the maximum longitudinal joint faulting is greater than 1/2 inch, it is recorded as a distressed area.

Pumping

1 - No fines can be seen on the surface of the traffic lanes or shoulder. However, there is evidence that water is forced out of a joint or crack when trucks pass over the joints of cracks. One evidence of water pumping is the existence of small blowholes in the asphalt shoulder adjacent to a transverse joint. The asphalt surface may have settled, sometimes indicating a loss of material beneath the surface. Other evidence of low severity pumping is the bleeding of water from the longitudinal lane/shoulder joint.

2 - A small amount of pumped material can be observed near some of the joints or cracks on the surface of the traffic lane or shoulder. Blowholes may exist. Some pavement or shoulder deformation is present.

3 - A significant amount of pumped material is present on the pavement surface of the traffic lane or shoulder along the joints or cracks. Considerable pavement or shoulder deformation is present.

* If pumping exists anywhere in the sample unit, it is counted as occurring at the highest severity level defined above.

Scaling and Map Cracking or Crazing

Note: Scaling is the deterioration of the upper 1/8 to 1/2 inch of the concrete slab surface. Map cracking or crazing is a series of fine cracks that extend only into the upper portion of the slab. Map cracking or crazing may lead to scaling of the surface. Scaling can also be caused by reinforcing steel being too close to the surface.

1 - Crazing or map cracking exists over a majority of the slab area; the surface is in good condition with no scaling.

2 - Less than 10% of any slab exhibits scaling.

3 - More than 10% of any slab exhibits scaling.

* Scaling and map cracking or crazing are rated according to the severest level found in a sample unit.

Shoulder Condition

1 - Very good: Shoulder is in nearly perfect condition (like new).

2 - Good: Shoulder exhibits occasional distress--such as cracking, deformation, raveling, etc.

3 - Fair: Shoulder exhibits fairly regular occurrence of low severity distress.

4 - Poor: In addition to the regular occurrence of distress, there are some medium and severe distresses.

5 - Very poor: Greater than 50% of the shoulder is distressed, and the majority of the distress is severe.

Spalling (Transverse and Longitudinal Joint)

L - The spall or fray does not extend more than 3 inches on either side of the joint. No temporary patching has been placed to repair the spall.

M - The spall or fray extends more than 3 inches on either side of the joint. Some pieces may be loose and/or missing but the spalled area does not present a tire or safety hazard. Temporary patching may have been placed because of spalling.

H - The joint is severely spalled or frayed so that a safety hazard exists or tire damage is possible.

* Spalling is measured by counting and recording separately the number of spalls with each level of severity. Spalling of cracks should not be recorded. The spalling of cracks is included in rating the severity of cracks. Spalling of transverse and longitudinal joints will be recorded separately.

Temporary Patching

1 - None or only a very few (6 or less) small temporary patches found in the section.

2 - Any greater occurrence than in 1 above.

* All occurrences are sketched roughly to scale. No levels of severity are assigned because all temporary patches are considered to be in poor condition.

Transverse Cracking

L - Tight (hairline) cracks with no faulting or spalling.

M - A crack with faulting less than or equal to 3/8 inch and/or low severity spalling (less than 3 inches).

H - Faulting greater than 3/8 inch or medium to high severity spalling (greater than 3 inches).

* Faulting is determined by measuring the difference in elevation across transverse cracks one to two feet from the slab edge. All cracks in the inspection unit will be identified as L, M, or H, and the number of linear feet of each is recorded. All cracks within the sample unit are sketched with severity levels indicated.

Wheelpath Wear

* No level of severity is defined; if wheelpath wear occurs anywhere in the sample unit, it is counted.

1 - Wheelpath wear occurs anywhere in the sample section.

2 - No wheelpath wear occurs.

APPENDIX B

Finalized Data Base

PORTLAND CEMENT CONCRETE PAVEMENT DATA BASE
##

PROJECT NUMBER	TYPE	ROUGHNESS	TLP	MTJF	MLSS	TCTL	TJSD	PUMP	SCTL	TJSTL
5-047-064-3-03	2	107.6	1100	0	0.125	0	1	0	1	40
#2	2	121.5	1200	0	0.125	0	1	0	1	40
5-047-064-4-03	2	130.6	4200	0	0.125	60	1	0	1	10
#2	2	107.2	3600	0	0.125	60	1	0	1	20
5-121-064-3-01	2	130.4	0	0.125	0.375	0	1	1	1	60
#2	2	108.6	4100	0	0.25	0	1	1	1	10
#3	2	137.6	1200	0.125	0.375	0	1	2	1	30
5-121-064-4-01	2	96.5	1540	0.125	0.125	60	1	1	1	10
#2	2	126.1	1300	0.06	0.125	0	1	0	1	20
#3	2		1200	0.06	0.125	0	1	1	1	10
5-121-064-3-02	2	132.4	1470	0	0.125	100	1	1	1	20
5-121-064-4-02	2	124.5	2530	0.125	0.125	0	1	0	1	20
5-121-064-3-03	2	142.6	1560	0	0.125	400	1	2	1	20
#2	2	123.8	2080	0.125	0.125	340	1	1	1	10
5-121-064-4-03	2	139.2	1950	0.125	0.125	540	1	0	1	0
#2	2		1500	0.125	0.125	0	1	0	1	0
5-121-064-3-04	2	113.1	2820	0.125	0.125	0	1	0	1	20
#2	2	128.7	3940	0	0.125	0	1	2	1	0
#3	2		2740	0	0.125	0	1	1	1	0
5-121-064-4-04	2	97.6	4250	0	0.25	0	1	1	1	0
#2	2	109.8	1240	0	0.125	360	1	1	1	0
#3	2		3240	0	0.125	0	1	1	1	0
5-121-064-3-05	2	124.5	0	0.125	0.125	0	1	0	1	40
#2	2	117.5	0	0	0.5	400	1	2	1	10
5-121-064-4-05	2	121	0	0.125	0.125	0	1	0	1	60
#2	2	127	720	0.125	0.125	60	1	0	1	60
5-121-064-3-06	2	144.1	1800	0.125	0.5	120	1	2	1	40
#2	2		960	0.125	0.5	1680	1	2	1	20
5-121-064-4-06	2	138.5	720	0	0.375	240	1	1	1	0
#2	2		600	0.125	0.125	540	2	0	1	30
5-114-064-3-01	2	102.7	600	0	0.25	0	1	0	1	40
#2	2	133.1	1140	0.125	0.375	0	1	1	1	50
#3	2		2410	0.125	0.375	0	1	1	1	20
5-114-064-4-01	2	110.3	840	0	0.25	0	1	1	1	30
#2	2	126.1	1320	0.125	0.125	0	1	1	1	30
#3	2	135.3	3820	0	0.25	0	1	0	1	20
5-122-064-3-01	3	92.7	0	NA	0.06	1540	NA	0	1	NA
#2	3		0	NA	0.375	980	NA	0	1	NA
#3	3	87.5	0	NA	0.375	1310	NA	0	1	NA
5-122-064-4-01	3	83.2	0	NA	0.375	1210	NA	0	1	NA
#2	3		0	NA	0.125	1550	NA	0	1	NA
#3	3	115.6	0	NA	0.25	2000	NA	0	1	NA
5-122-064-3-02	3	97.6	0	NA	0.375	1780	NA	0	1	NA
#2	3		0	NA	0.375	1330	NA	0	1	NA
5-122-064-4-02	3	106.5	0	NA	0.125	1560	NA	0	1	NA
#2	3		480	NA	0.25	1900	NA	0	1	NA

KEY

Project Number: District - County - Route - Direction - Section Number
Direction: 1 = North
2 = South
3 = East
4 = West

Section Number: The number of the uniform section for a particular route within a given county (section numbers increase from the county line with the mile posts).

Type: 2 = Jointed Concrete Pavement
3 = Continuously Reinforced Concrete Pavement

Roughness: Sample section roughness as measured by the Mays meter in inches per mile.

TLP: Permanent Patching (square feet per mile).

MTJF: Mean Transverse Joint Faulting (inches).

MLSS: Mean Lane/Shoulder Separation (inches).

TCTL: Total Transverse Cracking (linear feet).

TJSD: Mean Transverse Joint Seal Damage (1-3, low - high).

PUMP: Highest Severity Occurrence of Pumping (0-3, none - high).

SCTL: Highest Severity Occurrence of Scaling, Map Cracking, or Crazing (0-3, none - high).

TJSTL: Total Number of Transverse Joint Spalls (count).

APPENDIX C

Condition Survey Rating Procedure

VDOT PCCP Condition Rating Procedure

Surveys are conducted on the assumption that original construction projects constitute a uniform section. Overlays may change these limits, and these changes should be noted on the rating sheets.

A 10 percent sampling system is used to reduce the actual rating time. Each project is sampled for a distance of about 0.1 mile (528 feet) in the direction of travel at each mile marker (interstate) or mile post (primary). If the 0.1-mile sample section taken at the last mile marker or post crosses into another project, then the sample section should be "backed-up" so that it falls within the project limits. Also, bridges (including approaches and departures) are not sampled. If the mile marker's or post's location means a bridge is within the sample section, then the section should be moved back or ahead depending on the location of the mile marker or post.

Establishing the precise limits of each sample section also varies with the pavement design. For CRCP the sample section simply runs for 528 feet starting at the mile marker or post. JCP sections begin at the first joint beyond the mile marker or post and include as many joints as is necessary to cover at least 528 feet. For example, a pavement with a joint spacing of 61.5 feet would have sample sections that covered 10 joints encompassing 9 slabs for a total sample of 553.5 feet. Jointed pavement sections are delineated by joints; therefore, any distresses associated with the approach side of the first joint or the departure side of the last joint are omitted.

For the most part, condition surveys are conducted with a two-man team. One rater fills out data sheet #1 from construction project information in the office. Projects are numbered in the following format: X-XXX-XXX-X-XX (district - county - route - direction - section number). Direction is coded as 1 - north, 2 - south, 3 - east, or 4 - west. The section number refers to the number of the uniform section (i.e. construction project) for a particular route within a given county. These numbers increase from 01 at the county line with the mile markers or posts.

One set of sample section sheets (#2a and #2b) are included with each sheet #1 for each sample section to be surveyed within the project or uniform section. It's a good idea to draw in the joints for jointed pavements and number them on sheet #2a before leaving the office. The sample sections are numbered as encountered in the direction of travel.

Upon arriving at the project, the survey team drives over the entire length of the project in the outermost lane at the posted speed. At the end of each pass a consensus ride rating is determined using a rating of 5 to 4 as very good, 4 to 3 as good, 3 to 2 as fair, 2 to 1 as poor, and 1 to 0 as very poor. During the ride-rating passes, the driver also verifies the project limits and makes necessary adjustments required by changes resulting from overlays. The passenger notes when structures fall within the proposed sample sections and might require altering the sample section location.

Next, the team returns to the beginning of the project and drives to the first sample section and pulls the vehicle well onto the shoulder. The vehicle's flashers are turned on and a rotating caution light is placed on top of the car. The team leaves the vehicle wearing hard hats and safety vests and proceeds to walk the shoulder of the entire 0.1-mile sample section and to survey the condition of the outermost lane.

For jointed pavements, one rater counts and records the number of transverse joint spalls, measures transverse joint faulting, and estimates and records the area of each level of permanent patch deterioration present. The other rater records the joint faulting measured, measures and records the lane/shoulder separation, and sketches the permanent patching and other notable distress occurrences on sheet #2a. Transverse joint seal damage, pumping, and scaling are all rated by consensus on returning to the vehicle. For CRCP pavements, one rater counts the number of transverse cracks. The other rater measures lane/shoulder separation and sketches irregular cracking, localized distresses, and other notable distresses. Pumping and scaling are again rated by consensus.

When rating projects in areas with particularly high traffic volume, it is safer to conduct the surveys with a three-man team. The third member of the team becomes the driver, and his ride rating is included in the team's consensus. While the actual survey is being conducted, the driver remains in the car and follows the raters along the shoulder at a distance of about 100 to 150 feet. The vehicle thus becomes a more effective barrier between the raters and the traffic.

VDOT CONCRETE PAVEMENT CONDITION RATING DATA SHEET
#1

Project Number . . . . ______________________________

Type of highway__________________________ Interstate 1
Primary. 2
Secondary. 3
Other (specify)_____________ 4

Direction of survey_____________________ North 1
South 2
East. 3
West. 4

Beginning mile post. __ __ __.__ __

Ending mile post . . . . __ __ __.__ __

Project length . . . . __ __.__ __

Number of sample sections in project . . . . __ __

Number of lanes in project ______________ 1 lane 1
2 lanes. 2
3 lanes. 3
More than 3 lanes. 4

Type of original concrete slab__________ JPCP 1
JRCP 2
CRCP 3

Joint spacing____________________________ 20 feet. 1
30 feet. 2
40 feet. 3
50 feet. 4
61.5 feet. 5

Date surveyed. . . . . ___/____/____

Mean team ride rating. . . . . __.__

VDOT CONCRETE PAVEMENT CONDITION RATING DATA SHEET

#2a

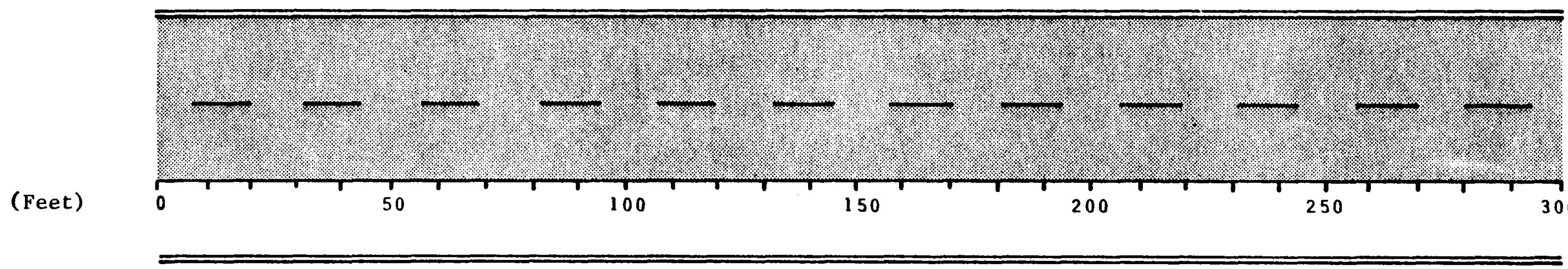
Sample Section Sheet 1

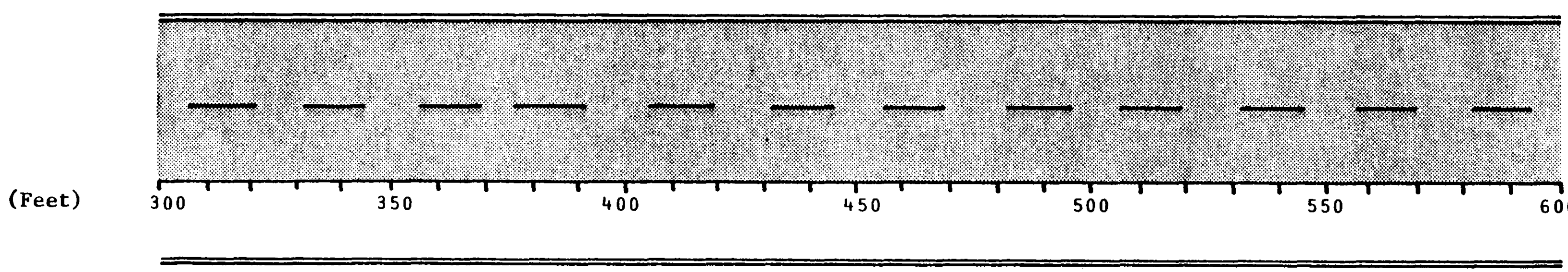
Project Number: ____________________

Sample Section Number: ____________________

Joint Spacing: ____________________

Mile Marker ________________





Transverse Joint Faulting Measurements: ____

Lane/Shoulder Separation Measurements: ____

VDOT CONCRETE PAVEMENT CONDITION RATING DATA SHEET
#2b - JCP

Sample Section Sheet 2

Project number. . . . . ____________________

Sample section number . . . . ____________________

Number of transverse joint spalls . . . . ____________________

Average lane/shoulder separation (in) . . . . ____________________

Average transverse joint faulting (in). . . . . ____________________

Transverse joint seal damage ____________ low. 1
(circle one) medium 2
high 3

Pumping ____________ none 0
(circle one) low. 1
medium 2
high 3

Scaling, map cracking, or crazing ____________ none 0
(circle one) low. 1
medium 2
high 3

Permanent patch deterioration ____________ low. . . . . ______
(sq. ft of each level) medium . . . . ______
high . . . . ______

Notes:

VDOT CONCRETE PAVEMENT CONDITION RATING DATA SHEET
#2b - CRCP

Sample Section Sheet 2

Project Number. . . . . ______________________________

Sample section number . . . . .________________

Number of transverse cracks . . . . .________________

Average lane/shoulder separation (in) . . . . .________________

Irregular cracking (linear ft) . . . . ________________

Localized distress (number of areas). . . . . .________________

Pumping________________________________ (circle one)

- none. 0
- low 1
- medium. 2
- high. 3

Scaling, map cracking, or crazing________ (circle one)

- none. 0
- low 1
- medium. 2
- high. 3

Notes:

PCCP DISTRESS MEASUREMENTS AND RATINGS

(* = How to measure)

Transverse Joint Faulting

Severity is determined by the average faulting (in inches) of the joints within the sample section.

* Faulting is determined by measuring the difference in elevation of slabs at transverse joints for the slabs in the sample section. Faulting is measured 1 to 2 feet in from the outside slab edge on the outermost lane. If temporary patching prevents measurement, proceed to the next joint.

Joint Seal Damage of Transverse Joints

1 - Joint sealant is in good condition throughout the section with only a minor amount of damage present. Little water and no incompressibles can infiltrate through the joint.

2 - Joint sealant is in fair condition over the entire surveyed section, with damage occurring to a moderate degree. Water can infiltrate the joint fairly easily; some incompressibles can infiltrate the joint. Sealant needs replacement within 1 to 3 years.

3 - Joint sealant is in poor condition over most of the sample unit with damage occurring to a severe degree. Water and incompressibles can freely infiltrate the joint. Sealant needs immediate replacement.

* Ratings of joint sealant damage of transverse joints are based on the overall condition of the sealant over the entire sample unit.

Lane/Shoulder Joint Separation

Severity is determined by the average opening (in inches) of the lane/shoulder joint within the sample section.

* Lane/shoulder joint separation is measured and recorded in inches near transverse joints and at mid-slab.

Pumping

0 - No sign of pumping.

1 - No fines can be seen on the surface of the traffic lanes or shoulder. However, there is evidence that water is forced out of a joint or crack when trucks pass over them. One evidence of water pumping is the existence of small "blowholes" in the asphalt shoulder adjacent to a transverse joint. The asphalt surface may have settled some indicating a loss of material beneath the surface. Another evidence of low severity pumping is the bleeding of water from the longitudinal lane/shoulder joint.

2 - A small amount of pumped material can be observed near some of the joints or cracks on the surface of the traffic lane or shoulder. Blow holes may exist. Some pavement or shoulder deformation is present.

3 - A significant amount of pumped materials exist on the pavement surface of the traffic lane or shoulder along the joints or cracks. Considerable pavement or shoulder deformation is present.

* If pumping exists anywhere in the sample unit it is counted as occurring at the highest severity level defined above.

Scaling and Map Cracking or Crazing

Note: Scaling is the deterioration of the upper 1/8 to 1/2 inch of the concrete slab surface. Map cracking or crazing is a series of fine cracks that extend only into the upper surface of the slab. Map cracking or crazing may lead to scaling of the surface. Scaling can also be caused by reinforcing steel being too close to the surface.

0 - None.

1 - Crazing or map cracking exists over a majority of the slab area; the surface is in good condition with no scaling.

2 - Less than 10% of any slab exhibits scaling.

3 - More than 10% of any slab exhibits scaling.

* Scaling and map cracking or crazing are rated according to the highest severity level found in a sample unit.

Transverse Joint Spalling

Note: Spalling of joints is the cracking, breaking, or chipping (or fraying) of the slab edges within 2 feet of the joint. A spall usually does not extend vertically through the whole slab thickness, but extends to intersect the joint at an angle.

* Spalling is measured by counting and recording the number of spalls.

Permanent Patch Deterioration

Severity Levels:

1 - Patch has little or no deterioration. Some low severity spalling of the patch edges may exist. Faulting across the slab-patch joint must be less than 1/4 inch. Patch is rated low severity even if it is in excellent condition.

2 - Patch has cracked and/or some spalling exists. Faulting of 1/4 to 1/2 inch exists. Temporary patches may have been placed because of permanent patch deterioration.

3 - Patch is badly deteriorated either by cracking, faulting, or spalling to a condition that requires replacement. Patch may present tire damage potential.

How to Measure:

* Patches at different severity levels within a slab are counted and recorded separately, as is the approximate square footage of each patch. Again, all patches are rated either 1, 2, or 3.

Localized Distress

Note: A localized distress is an area of a slab where the concrete has broken into pieces or spalled. The localized distress takes many shapes and forms. Many times it occurs within an area between intersecting (Y-shaped) or closely spaced cracks. Localized distress can occur anywhere on the slab surface, but is frequently located in the wheelpaths.

An edge punchout is another form of localized distress, and it is characterized by a loss of aggregate interlock at one or two closely spaced cracks (i.e., usually less than 48 inches apart) near the edge joint. The crack or cracks begin to fault and spall slightly, which causes the portion of the slab between the closely spaced cracks to begin to rock. Eventually the transverse cracks breakdown further, the steel ruptures and the pieces of concrete punch downward under load into the subbase and subgrade. There is generally evidence of pumping near edge punchouts, and sometimes there is extensive pumping.

* The number of localized distress areas are counted and recorded.

Transverse Cracking

* The number of transverse cracks that extend at least three-fourths of the way across the lane are counted.

Irregular Cracking

* The linear feet of all cracking other than transverse (longitudinal, diagonal, etc.) are estimated and sketched.