WASHINGTON PAVEMENT RATING SYSTEM: PROCEDURES AND APPLICATION

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Since its inception in 1965, a pavement condition rating system developed by the Materials Division of the Washington Department of Highways has been employed in evaluating and predicting the remaining service lives for some 7,000 miles of state highways. The method, used by highway personnel with little or no previous experience in pavement evaluation, has provided quick, statistically ranked ratings from surveys of the entire roadway system performed by as few as 4 teams during 4 to 5 weeks of field work. The method involves a combined rating of the quality of ride provided by a pavement and the degree of structural distress observed in that pavement. For application to the priority programming system as used in Washington State for legislative budgeting of highway construction, the results of the original survey were analyzed to develop critical rating levels for the various functional classes of highways and to develop formulas for predicting when any given roadway will reach this critical level. The critical rating level can be defined as that numerical rating at which some form of roadway rehabilitation is warranted. From the initial survey by this method, annual point loss rates were based on a one-time survey and were subject to much speculation, but subsequent surveys have proved them to be surprisingly accurate as estimates of average pavement deterioration. To date, the method has been used in 3 statewide surveys and numerous special evaluations of selected pavement segments. It has also been employed by other governmental agencies in its original form as well as in slightly modified versions as dictated by specific requirements.

The problem of rating pavement condition is not new. It is an unfortunate fact that pavements wear out, and highway engineers have been working for years to produce a method whereby the present serviceability of a pavement could be rated, levels of satisfactory service established, and predictions made as to the most economical time for any particular section of pavement to be reconditioned.

As the result of legislative action, we were presented the task of providing a method for conducting a pavement condition survey on the 7,000 miles of pavement that make up our state highway system. The data from this survey were to be used by the priority programming section in preparing a recommendation for scheduling of future highway construction. Known methods of conducting pavement condition surveys were researched and reviewed.

Work of particular note was accomplished during research on the AASHO Road Test at Ottawa, Illinois, resulting in a means of determining objectively the present serviceability of a roadway. Objective ratings developed from the tests run by various instruments were compared with visual observations and subjective ratings made by a

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panel of people with strong interests in highways. Included among the raters were highway administrators, materials producers, trucking people, and automotive manufacturers. From the analysis of these duplicate ratings, the researchers developed formulas for determining the present serviceability of a roadway based on instrumented measurements of distresses in the roadway and thereby eliminated the need for retaining the rating panel for the duration of the road test research. The roadway properties measured for flexible pavements were slope variance in the longitudinal profile, rut depths, cracking, and patching and for rigid pavements were slope variance, cracking, and patching. (For definitions of these terms and how they were used, see reference 3.)

This method of measuring the degree of roadway distress by special instruments was satisfactory for the controlled conditions of the AASHO Road Test. However, to date, we know of no other instances where this method has been practical except for short sections of roadway, and then at a pace that would permit only a fraction of our highway system to be rated in the time allowed under our conditions and requirements for priority programming.

The work of the Highway Research Board Committee on Flexible Pavement Design (1) provided the basis for the development of the pavement condition rating system presented in this paper. The demands of time, equipment, and the computer necessitated our modification of the HRB method. Where the HRB method specified raters with extensive backgrounds in observing pavement failures, we wanted a system that could be used by raters who had little or no background in the field but who could be rapidly trained to use the method. Although the HRB method included evaluation of roughness and skid hazard by skid meters and roughometers, we were unable to include such instruments in our initial survey. However, as we will discuss later, incorporation of certain mechanical measurements into the system is now under study.

DESCRIPTION OF RATING SYSTEM

The pavement condition rating system is based on the belief that the present serviceability of a roadway should be a combination of 2 factors. The first is the type of ride provided by the roadway, and the second is the presence of pavement distress or failure. The first factor has the most, and often the only, influence on the average motorist; his only interest in the second is usually the degree to which the distress or failure affects the ride. Conversely, this second factor is generally a primary consideration in the highway engineer's evaluation of the roadway. For these reasons, the ride rating and the pavement defect rating carry equal weight in the determination of the final pavement condition rating.

The ride rating and defect rating are obtained in this system through subjective evaluation of the roadway by one or more qualified observers. It is recommended that the rating be done by a 2-man team—one man to serve as driver and the second man to observe and record data on the rating sheets. They first drive over the section of pavement at normal driving speed to determine the ride rating. In scoring the ride, a scale of 0 to 10 is used; a score of 0 would indicate a perfect ride (no deficiencies), and a score of 10 would indicate a roadway that is virtually impassable. The raters then retrace the route to detect, evaluate, and list any defects on prepared rating data forms according to established categories and guidelines. Numerical values assigned to pavement defects increase with the seriousness and extent of the defects.

The ride rating is calculated from the following formula:

$$\text{Ride rating} = G_R = 100 - (10 \times \text{ride score})$$

The defect rating is calculated from the following formula:

$$\text{Defect rating} = G_D = 100 - \Sigma \text{ defect values for pavement distress}$$

These data are reduced by computer to give a numerical rating for the pavement according to the following formula:

$$\text{Final rating} = R_R = \sqrt{G_R \times G_D}$$

Charts showing the numerical values that are assigned to flexible and rigid pavement defects, detailed operating instructions for raters, and a field rating data form were prepared.[1] The indicated values are, in general, a compromise between those given by the Highway Research Board (1) and our assessment of the relative local importance of the noted types of distress. In addition, it should be noted that the values generally reflect the relative importance of the parameters used in the AASHO present serviceability index equation.

Also influencing the selection of these values was the desire to keep the sum of defect values on any rated pavement below 100. There were a few instances, however, when the sum of these values would total more than 100. These were handled by adjustments according to the following scale:

Total Negative Values	Adjusted Values
90 or under	No adjustment, same value
91 to 94	91
95 to 105	93
106 to 115	95
116 to 125	97
126 to 140	98
141 or over	99

This adjustment is not considered unwarranted, as normally only comparative ratings are desired when the pavement reaches this level of deterioration and the rankings of the roadways for priority programming will not be affected.

The division of relatively uniform sections of pavements into rating units is more or less a matter of choice. This selection will generally be influenced by the total length of roadway to be evaluated. For surveys on Washington highways, a maximum length for a rating unit is specified as one mile. Whatever the units of length used, there must be a separate rating section established whenever there is a definite change in condition or in the type, age, or design of pavement.

The success of this system depends on a uniform recognitition and classification of pavement distress. This is most important. If several raters, or teams of raters, are to be employed in a survey, uniformity of results can only be achieved by first having all raters trained in the recognition of defects and the use of the rating sheets. We use color slides and pictures of typical pavement distresses as a first step in training raters to properly identify defects. With this background, the raters, or rating teams, then individually rate a preselected section of roadway. The ratings are compared and any areas of disagreement are discussed until there is a mutual understanding as to type and extent of defects noted. This is repeated for both flexible and rigid pavements, and at various levels of pavement distress, until the raters are "calibrated" within ±5 percent of the mean rating. This approach, or one giving the same results, is mandatory whenever a comparative rating is desired on a number of roadways and the task of rating the various roadways is divided between 2 or more raters or teams of raters.

This system has been used satisfactorily for 3 statewide surveys. The first 2 surveys employed raters from each of the 7 highway districts that divide Washington's state highway network. Each district supplied 2 men; but in the makeup of the rating teams, the men were divided so that each district was rated by a team composed of 1 man from the district being rated, for highway route familiarity, and 1 man from another district to reduce possible bias in favor of the rater's home district.

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[1]The original manuscript of this paper included an appendix that contained instructions for rating condition of pavements, pavement condition survey glossary of terms, negative values to be assigned to various degrees of pavement failures, and pavement condition data form. This appendix is available in Xerox form at cost of reproduction and handling from the Highway Research Board. When ordering refer to XS-33, Special Report 116.

Although this system did provide a rapid, accurate statewide survey in a short period of time, it did create problems for some districts in providing personnel and vehicles during the period of time required for the survey. This prompted the decision to use rating teams from the headquarters Planning Survey Section. These personnel were already trained in roadway inventory work associated with sign inventories and highway geometrics. They also had available inventory vehicles equipped with calibrated survey odometers—a necessity in accurately identifying rating sections.

After a short training and orientation program as described earlier, four 2-man rating teams completed a pavement condition rating survey of the 7,000-mile state highway network in approximately 4 weeks.

DEVELOPMENT OF CRITICAL RATING LEVELS

In order to present the results of the survey in terms required by our priority programming plan, it was necessary to establish numerical rating levels at which the various types and classes of highways were deemed ready for some measure of reabilitation. This was termed the critical rating level. Also needed was a formula for predicting the expected pavement life for any given roadway, or how much the numerical ratings would decrease each year.

In the initial 1965 survey, this was somewhat like attempting to establish a curve from one point when we used the results of one condition survey as a basis for the curve. However, we determined a yearly point loss by plotting curves of age versus current survey rating for a number of sections of highways at random. This was done for each functional class of highway on our system.

The average point loss per year for flexible pavements varied from 2.14 to 2.37 points. For the range in which we were working, and to provide a small margin of safety, a value of 2.5 points/year was selected.

Using the same method on portland cement concrete (PCC) pavements, we determined the calculated rating loss to be 0.98 points/year. However, because the rating for PCC pavements applied only to those pavements that had never been resurfaced, it was felt that adjusting the yearly point loss to 1.5 points would more accurately reflect the situation as far as all PCC pavements were concerned.

These yearly rating losses were satisfactory for averaging pavement deterioration over a period of years. However, it was our belief that the actual deterioration curve relating pavement condition and age was somewhat more complex—that initially deterioration was gradual and at some point in time accelerated significantly. Our analysis of this possibility, based on the 3 surveys to date, is presented later in this report.

Analysis of the survey results to establish critical rating levels showed that the percentage of roadway mileage above any given rating level increased as we proceeded from the lower to the higher functional class of highway. Considering this in light of the fact that the classes of highways are keyed somewhat to the type and amount of traffic they carry, we thought it reasonable to adjust the critical rating levels according to class of highway. This could be done from the results of the condition survey if we used the same percentage of mileage in each class of highway as a basis. Using the 70 percentile rating for each functional class, we established the following critical rating levels for flexible pavements:

Facility	Points
Interstate	60
Principal	60
Major	55
Collector	50
Other	45

Comparison of the previously determined yearly rating loss and the initial condition survey results with the estimated pavement life used in our design methods showed reasonable correlation with the proposed critical rating levels. Therefore, these values were officially adopted.

The total mileage of PCC pavements rated was much less than that for the flexible pavements, and over half of this was in the principal and Interstate classes. It was decided that, for rigid pavements, one critical rating level should be established for all classes of highways. Again, by using the value above which 70 percent of the roadways were rated, the critical rating level for rigid pavements was set at 50.

Subsequent surveys have indicated little need for any change in these critical rating levels except in the Interstate class. Because of the amount and type of traffic that this class of highway must carry, the more rapid rate of deterioration commences at a higher rating level (Fig. 4). These results indicate a need to adjust the critical rating level for the Interstate System to 65 for flexible pavements.

DISCUSSION OF RATING SURVEY ANALYSIS

Portland Cement Concrete Pavements

With the data of 3 statewide pavement condition surveys now available, we are able to provide a more detailed analysis of the pavement age-serviceability relationships.

In the study of PCC pavements, we limited our analysis to the 3 higher classifications of highways, Interstate, principal, and major, because of the construction history of this type of pavement in Washington. Figure 1 shows the polynomial curve that best fits the rating versus age relationship for PCC pavements and is derived from the 1969 pavement condition survey. This curve, as were the others in this report, was developed from a computer program (POLFIT) that provides the best-fit curve of Y in terms of X (rating versus age) for all powers of X through the eleventh and the index of determination, or closeness of fit, for the derived curve. In general, there was little increase in the index of determination for equations involving powers of X greater than 3, so all curves shown are based on third order equations.

The curve shown in Figure 1 represents only the PCC pavements that have never been overlain and verified the approximate one point per year rating loss found in the initial survey. The influence of PCC overlays appears in the configuration of the curve for pavements over 20 years of age. There is a noticeable break in the curve at approximately 20 years, after which the curve tends to flatten out again as the more distressed pavements are eliminated from the survey as PCC pavements by reason of being overlaid.

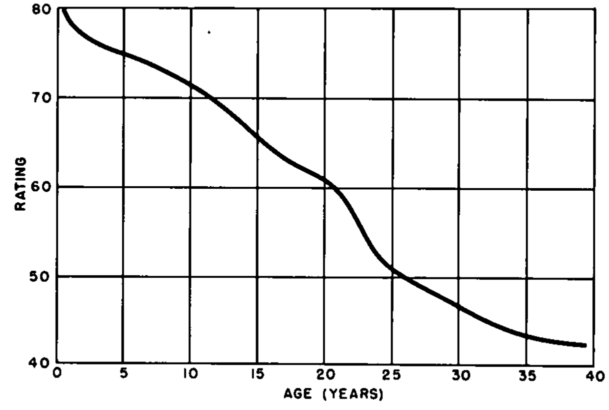

Figure 1. Average performance of PCC pavements on Interstate, principal, and major systems based on 1969 ratings.

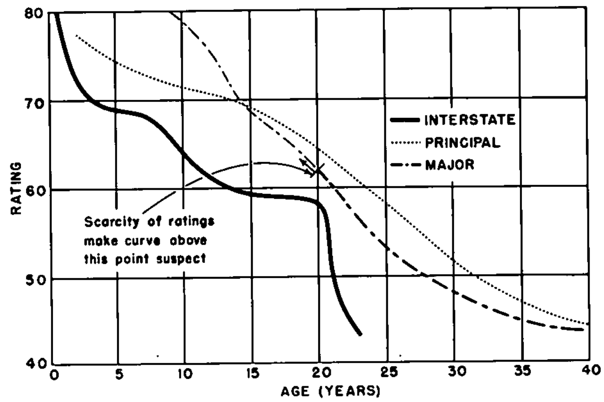

Figure 2. Individual performance of PCC pavements on Interstate, principal, and major systems based on 1969 ratings.

The majority of pavements built with PCC during the past 25 years in Washington have been on the Interstate System. When the pavement condition, rating versus age, curve for these pavements is plotted (Fig. 2), several speculations are worthy of note.

First, the very rapid point drop for the first 3 years suggests that the pavement raters are subjectively influenced in their ratings by the very newness of a pavement and may tend to give obviously new pavements higher ratings than they would comparable older pavements. This influence would be most evident in the ride rating.

The apparent change in the slope of the curve between ages 7 and 8 years corresponds with the time at which slip-form paving was introduced into Washington. This paving method has produced noticeable smoother pavements. It was also about 7 years ago that Washington introduced a smoothness specification of 7 in./mile maximum vertical deviation as measured by the California profilograph.

The sudden drop at age 20 years quite possibly reflects the effect of incorporating into the Interstate System some older PCC pavements, compounded by the almost total absence of new construction during the middle 1940's. In point of fact, there are relatively few PCC pavements on the Interstate System over 20 years of age and, because the ratings of these few pavements are quite low, the curve breaks downward more rapidly than a more representative sampling of pavements of like age would produce.

Asphalt Concrete Pavements

Figure 3 is the POLFIT curve of the 1969 ratings of the asphalt concrete (AC) pavements on the Interstate, principal, and major systems. This curve illustrates the potential error in assuming a constant rate of pavement deterioration as indicated by the 2½-point/year loss assigned to AC pavements.

Figure 4 shows the individual rating versus age curves for AC pavements from the 3 higher classes of highways in the state system. The curves are not significantly separated during the first 10 years. Washington's flexible pavement design method assigns a 20-year design life to AC pavements and presumes that an overlay will be placed at the end of 8 to 10 years. Unfortunately, the availability of money and construction priorities have precluded following originally designed overlay schedules, and this has resulted in many miles of asphalt pavement being used beyond the optimum time for rehabilitation. The efficient use of the results of these pavement condition surveys will tend to reduce this occurrence within budgetary limitations.

The slope of the curve shown in Figure 4 for Interstate AC pavements illustrates the primary basis for increasing to 65 the critical rating for that class of highway.

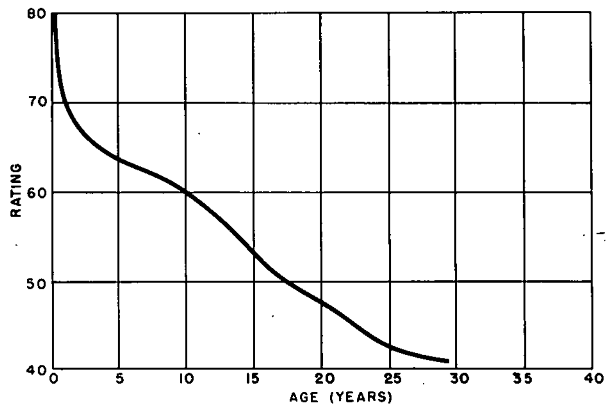

Figure 3. Average performance of AC pavements on Interstate, principal, and major systems based on 1969 ratings.

In the natural course of priority programming, legislative action, and planning, there is an inherent delay between the time the need is recognized and the time action can be taken. In light of the results of pavement condition ratings to date as shown in Figure 4, there is need for additional lead time on Interstate flexible pavements to ensure their being rehabilitated by overlay or whatever at the most economical time. The realization of this would also be further ensured if the deterioration rate were to parallel the curve for Interstate pavements shown in Figure 4. This paralleling of the rating versus age curves for each functional class of highway would provide a more accurate estimate of the remaining service life in a pavement and ensure its being programmed for improvement at the proper time.

AC Pavements on Cement-Treated Bases

During the period from 1950 to 1965, a high type of flexible pavement in Washington was constructed of asphalt concrete on a cement-treated base (CTB). There was a

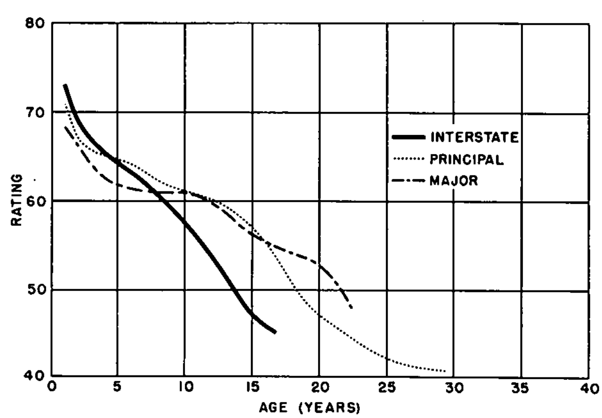

Figure 4. Individual performance of AC pavements on Interstate, principal, and major systems based on 1969 ratings.

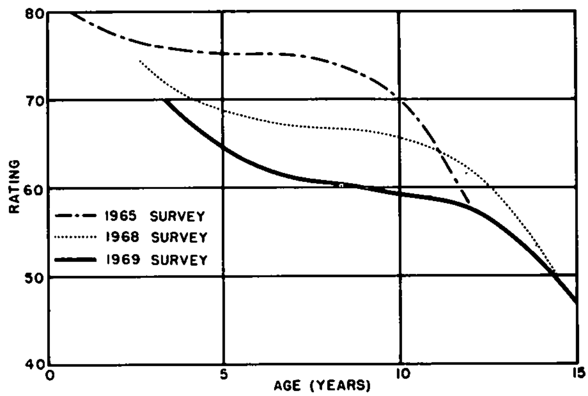

Figure 5. Individual performance of AC pavements on cement-treated bases based on 1965, 1968, and 1969 ratings.

fundamental change in construction technique during this period when the road mixing of the CTB was supplanted by a plant-mixing operation. The basic design for these pavements was 6 in. CTB and 3 in. AC, although there were occasional variations in which the design thickness of the CTB would be reduced to 5 in. or the thickness of AC might be increased to 4 in. or reduced to $2\frac{1}{2}$ in. Basically, however, this type of pavement is substantially the same and lends itself to a special study.

Included in this study are 83 contracts involving 908 lane-miles of pavements. The pavement that had received overlays since original construction was eliminated, and the rating analysis includes only the pavement remaining as originally constructed.

Figure 5 shows the POLFIT curves for the AC pavements on CTB from the 3 statewide pavement condition surveys taken to date. The obvious similarity of these curves illustrates the degree of relative accuracy obtainable by the Washington method of performing pavement condition surveys. The 3 surveys, taken in 1965, 1968, and 1969, were performed by different rating teams for each survey. The deviation from parallelism that is present could possibly reflect the variation introduced by the changing

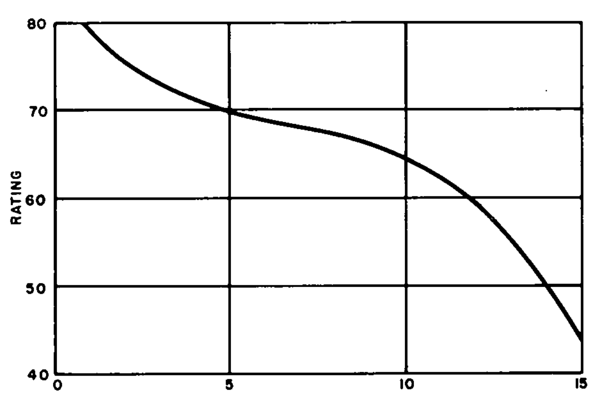

Figure 6. Average performance of AC pavements on cement-treated bases based on 1965, 1968, and 1969 ratings.

from road-mixing to plant-mixing construction for the CTB. This influence becomes less apparent as the pavements become older.

The rating versus age curves indicate an average 10- to 12-point drop in ratings during the approximate 3½ years between the initial and latest rating surveys. This rate (3 to 3½ points/year) is significantly higher than the 2½-point/year average presently used by our priority programming section. There is every indication that special attention will be required by this type of pavement in the immediate future to ensure optimum rehabilitation. Figure 6 shows the average rating versus age curve as derived from the 1965, 1968, and 1969 surveys and will be recommended for use in predicting overlay warrants.

CONCLUSIONS AND RECOMMENDATIONS

From the results and analysis of each statewide pavement condition survey, several suggestions for improvement have come to light. Some minor changes have been made that have had little or no effect on the comparative results of the 3 surveys. The initial survey was performed in the fall, while the 1968 and 1969 surveys were done in the spring. There was evidence that pavements surveyed in the fall would be rated significantly higher than the same pavements would be rated if surveyed in the spring because of the "covering up" of some distresses through normal summer maintenance. On this basis, we have recommended that surveys be taken in the spring.

The highest potential for error in this rating system is in the ride rating. This purely subjective evaluation of the rideability of a roadway is difficult to perform uniformly among rating teams. Moreover, it is quite possible that the same team would not give an identical ride score to the same section of pavement if the surveys were duplicated on successive days. In seeking a means of eliminating or reducing this potential source of error, we propose to investigate the use of a road roughness measuring device that is a modification of the PCA road meter. The applicability of such a mechanical measuring system and the degree of its influence on the overall rating system can only be judged after a thorough study with the instrument.

Should the road meter prove unsatisfactory in correcting the potential deficiency from the ride rating as presently used, consideration will be given to reducing the influence of the ride score on the overall rating. We continue to support the philosophy that prompted basing 50 percent of the final rating on the ride rating, but realize that this should be tempered if a greater consistency of ratings could be obtained by adjusting the proportional factors in the calculation of the final ratings.

These statements are not meant to reflect dissatisfaction with this pavement condition rating method. The response to this method has been most gratifying, and by its use we have successfully produced a comparative ranking for over 7,000 miles of state highways during 3 separate surveys using new rating teams for each survey. Each survey has been completed in approximately 1 month's time. The ability to rate the entire state highway network in this relatively short time is a requisite of our priority programming system and therefore eliminates from consideration proposed rating methods requiring more time.

However, we recognize the potential criticism or weakness of any subjective method of performing a pavement condition rating survey that is to be used as a means of making a comparative ranking of pavements and predicting the remaining service life for any pavement. Consequently, we hold to the opinion that a system employing objective measurements by mechanical or electronic means will ultimately provide the more unbiased and potentially irrefutable results, and we will join with others in attempting to achieve a workable system of this nature. The successful introduction of the road meter into the Washington method will be a step in this direction. In addition, we are studying methods of rating the remaining structural adequacy of pavements. These innovations together with the skid-measuring potential we now have could give what appears to be the ultimate in a pavement evaluation system.

Until that happy day, however, we firmly believe the subjective rating system described here fills the very present need for a means of determining the condition of our pavements and, from such accumulated data, a measure of their performance and predictions of future maintenance.

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