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Pavement Management Study: Illinois Tollway Pavement Overlays

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Since 1967, when Byrd, Tallamy, MacDonald and Lewis (BTML) performed the original pavement maintenance study for the Illinois State Toll Highway Authority, there have been major changes in the characteristics of the highway, volume of traffic, and in the pavement composition itself. Several studies have provided information to update the original maintenance and rehabilitation program, and the study reported here has created a continuity in this process. As the result of the comprehensive pavement evaluation by BTML, data have been accumulated on current conditions of serviceability, slipperiness, surface defects, and deflection. These factors were considered individually as well as collectively to provide recommendations for improvements or rehabilitation. Current pavement condition was determined through visual and instrument surveys to provide present-serviceability-index factors and computations, traffic and axle-load analyses, and skid numbers for each of the three tollways in each direction. The visual pavement deficiencies—cracking, patching, faulting, and pumping—on rigid pavements were addressed by the visual survey. The instrument survey was concerned with the determination of roughness, skidding, and deflection data. Pavement condition was determined through the study of traffic volume, lane distribution, axle load, and the number of axle repetitions. Cumulative 18-kip single-axle loads were determined for the tollway. An integral part of a pavement management system is an adequate data base. The evaluation performed by BTML compiles the data necessary to create a format adaptable for use in an effective pavement management system for the tollway. The pavement management framework is a management tool to aid consistency and optimization in the decision process. It is designed to expand decision-making capability as well as to provide necessary feedback on these decisions.

The Illinois Tollway consists of three toll highways--the Tri-State, East-West, and Northwest Tollways, as illustrated in Figure 1. Together they total approximately 243 centerline miles, of which 104 miles have three traffic lanes in each direction. In addition to the main-line mileage, the Illinois Tollway consists of several access ramps, interchanges, and toll-collection facilities. The Illinois Tollway is a high-level system that serves motorists in the metropolitan Chicago area as well as throughout the state of Illinois. Segments of the tollway system serve more than 100 000 vehicles daily, which includes Interstate transport and localized commuter travel.

Management decisions are made as a part of normal daily operations for an active highway system such as the Illinois Tollway. The pavement evaluation and rehabilitation criteria provided as a part of this study are intended as management tools to aid the decision maker. They are designed to improve the efficiency and consistency of the decision-making process.

Current pavement-rehabilitation needs are in part a function of management decisions made in the past. Likewise, decisions made today will have an impact on future pavement-rehabilitation needs and, consequently, costs.

HISTORY OF PAVEMENT EVALUATION

The American Association of State Highway Officials (AASHO) Road Test conducted near Ottawa, Illinois, during 1956-1961 produced basic concepts about the evaluation of existing pavement conditions and the relationship of a pavement service life to the number of axle loads to which it is subjected.

Realizing the importance of this approach to the prediction of pavement service life, tollway officials in 1967 engaged Byrd, Tallamy, MacDonald and Lewis (BTML) (then Bertram D. Tallamy and Associates) to evaluate long-range pavement-maintenance needs for the tollway system. As part of that study, a detailed pavement condition survey was conducted on the entire tollway system. One of the principal purposes of the field inspection was to obtain the factual data required for the serviceability-index equation developed at the test road.

In the application of road-test equations to the tollway, it was necessary during 1967 to undertake a comprehensive study of traffic. This was required to estimate the characteristics and amount of traffic that had used the road between each interchange section since it had been opened. Similarly, extensive axle-load computations were made to determine the number and magnitude of axle loads. Pavement design and present-serviceability-index (PSI) values were then used to plot the service-life curves for each average PSI section between major interchanges. The year at which the pavement is estimated to reach a terminal serviceability condition (TSI) was determined from these curves.

The need existed to extend and make slight modifications to the service-life curves developed during the 1967 study because of the environmental and traffic effects on the tollway pavements. Also, there was a need to develop new service-life curves for those pavement sections that had been resurfaced since 1967. The tollway engaged BTML to perform the necessary observations, measurements, calculations, and analyses to adjust these curves and extend the resurfacing schedule in 1969, 1971, and 1975.

More than 20 years have passed since the original pavement evaluation, and major changes have occurred in both the composition and the volume of traffic on the tollway, as well as in the pavement structure itself. For a comprehensive pavement evaluation, skid data and structural-strength data are obtained in addition to serviceability indices and a visual survey in 1979.

Figure 2 illustrates the study approach for the systemwide pavement evaluation and project identification for the Illinois Tollway.

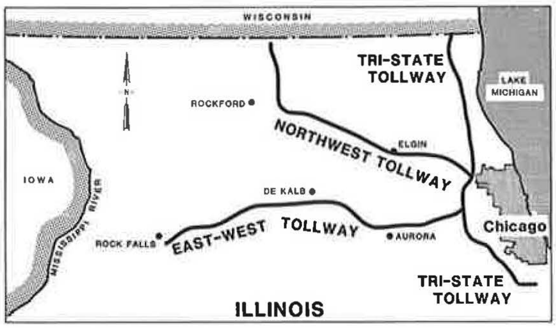
PAVEMENT-CONDITION ANALYSIS

The pavement-condition analysis survey is a three-part procedure. The first two parts consist of collecting field data through visual and instrument surveys. The third part reduces the field data to numerical values of PSI, skid numbers (SNs), and structural deflections.

By using previous studies as a data base, service-life curves can be effectively and adequately updated by selecting representative sampling areas for which detailed pavement-condition surveys would be performed.

The current study recognizes the need to base pavement-rehabilitation decisions on safety and structural capacity in addition to adequate serviceability. This pavement evaluation includes collection of field data necessary to calculate PSIs, time to reach terminal serviceability, SNs, and structural indices. All of these form a basic data base for development of a pavement-inventory system.

Figure 1. Illinois Tollway.



VISUAL SURVEY

In order to conduct a detailed visual survey representative of the tollway pavement sections, analyses of roughness measurements, rut-depth measurements, structural-deflection measurements, average daily

Figure 2. System pavement evaluation and project selection.

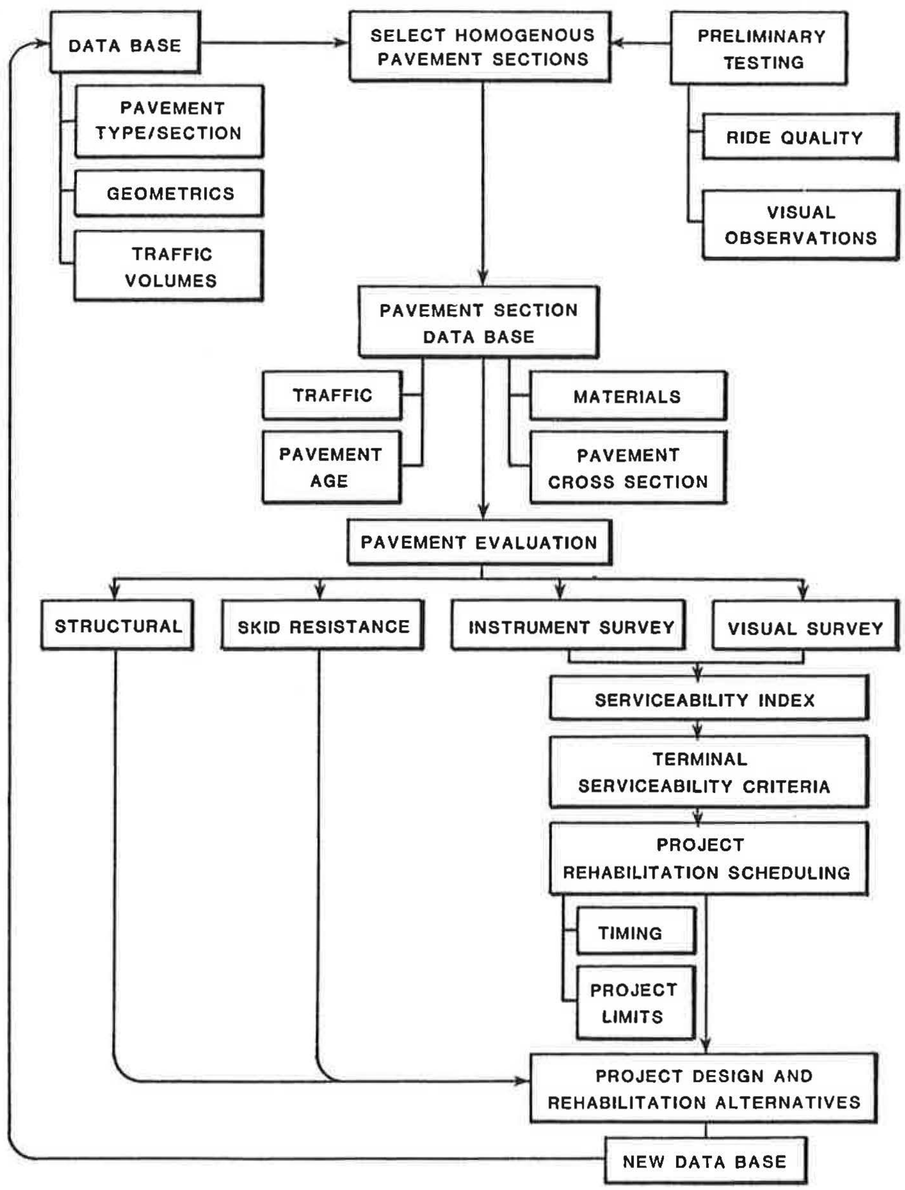


Figure 3. Lane numbers.

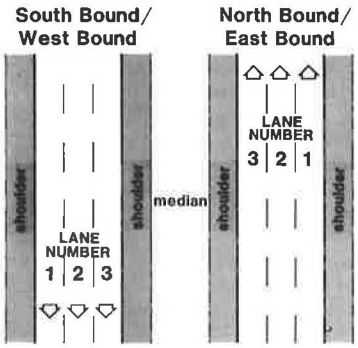
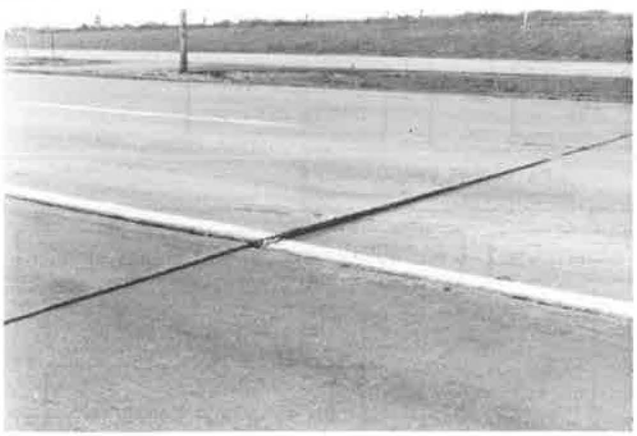


Table 1. Visual-inspection limits and corresponding pavement sections.

Tollway	Visual-Inspection Limits (milepost)	Detailed Visual Survey Limits	
		Milepost	Direction
Tri-State	0-16	14.0-14.5	NBL and SBL
	16-30	26.5-27.0	NBL and SBL
	30-42	36.5-37.0	NBL and SBL
	42-70	54.5-55.0	NBL and SBL
	70-77	76.0-76.5	NBL and SBL
Northwest	0-5	3.5-4.0	EBL and WBL
	5-17	13.0-13.5	EBL and WBL
	17-24	22.5-23.0	EBL and WBL
	24-63	43.0-43.5	EBL and WBL
	63-76	64.5-65.0	EBL and WBL
East-West	60-68	66.0-66.5	EBL and WBL
	68-96	82.5-83.0	EBL and WBL
	96-129	109.0-109.5	EBL and WBL
	129-133	130.5-131.0	EBL and WBL
	133-144	139.5-140.0	EBL and WBL
	144-156	151.0-151.5	EBL and WBL

Note: NBL = northbound lane; SBL = southbound lane; EBL = eastbound lane; WBL = westbound lane.

Figure 4. Pavement faulting on East-West Tollway, westbound lanes, milepost 109.5.



traffic volumes, and pavement compositions were used. Based on these analyses and a visual inspection of the entire tollway system for pavement defects, limits were established for a detailed visual survey. Results of cracking and patching counts within these limits were used in PSI determinations for all pavement sections contained within these limits.

Although all pavement lanes were observed and lane conditions recorded in the representative sections (Figure 3), the formula data were developed only from those conditions recorded in the outside driving lane (lane 1). The outside driving lane generally represents the most critical condition and is the controlling lane when resurfacing or rehabilitation measures are scheduled. Visual-inspection sections and the inspection limits representative of them are summarized in Table 1.

Deficiencies common to rigid pavements were inspected and recorded. To provide data for the PSI computations for rigid pavements, the visual-survey team observed and recorded two specific types of pavement distress--cracking and patching. These measurements were in accordance with criteria used at the AASHO Road Test.

In addition to patching and cracking data obtained for use in the serviceability computations, the visual-survey team inspected the substantial cracks, joints, and edges of pavement to determine the extent of faulting, spalling, and pumping. These supplemental data provide valuable information for immediate maintenance and rehabilitation program planning. In instances in which low PSI values are found, the type of distress may suggest specific causes and the corrective action required.

Faulting

Faulting is defined as a vertical displacement of the pavement slabs adjacent to a joint or crack (Figure 4). In the case of longitudinal joint faulting, settlement is generally confined to the lane that receives the heavier traffic. When transverse joint or crack faulting is present, the impact from axle loads generally causes settlement of the downstream slab. Faulting was measured to the nearest 0.125 in. Faulted transverse cracks and joints were recorded by numerical count.

Pumping

Pumping is the term used to identify the ejection of water and/or subbase material along the pavement joints, cracks, and edges caused by movement of the pavement slab that results from the passage of heavy axle loads. It can be detected by the stained appearance of the pavement surface adjacent to the joint, crack, or edge and/or by deposit of fine material adjacent to the pavement.

The pavement surface was inspected for other forms of deterioration, which included blowups, corrugations, disintegration, frost heave, pitting, popouts, settlements, curling, and warping.

INSTRUMENT SURVEYS

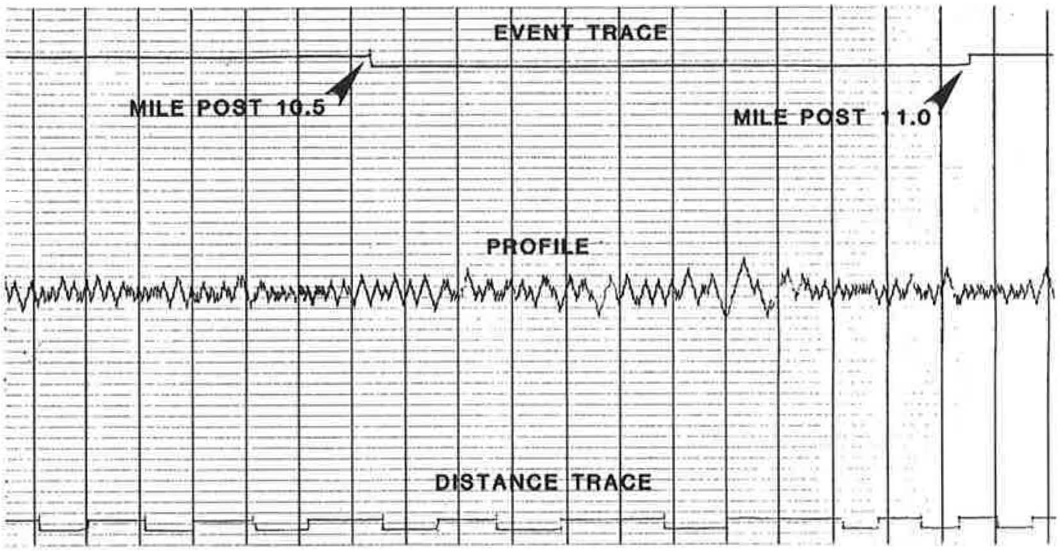
Instrument surveys were conducted to measure road roughness through the use of the Mays ride meter. SNs were determined by using the Law skid trailer and deflection by using the Dresser Atlas Dynaflect.

Roughness

Although the visual survey obtains data that reflect the deterioration of the pavement surface, the roughness survey records roadway ride-quality characteristics. Ride-quality deterioration is known to result from the cumulative effects of the pavement environment, mainly traffic loadings and climate. This phase of the field survey consisted of taking measurements by using a Mays ride meter to obtain variances from the longitudinal profile of the pavement surface. The Mays ride meter was mounted in a 1979 Chevrolet Impala to obtain roughness data.

Roughness surveys conducted in 1967, 1969, 1971, and 1975 used the Bureau of Public Roads (BPR) roughometer to determine roughness. Consequently, it was necessary to calibrate the Mays ride meter for use in serviceability equations that had a

Figure 5. Typical Mays ride meter roughness profile.



common base. Correlations were made by using the Illinois Department of Transportation BPR-type roughometer, which yielded a correlation coefficient of 0.91 from an analysis of variance.

Roughness measurements were made for each mile of the tollway in lanes 1, 2, and 3 in both directions. Roughness measurements were also made for each ramp on the tollway system. Figure 5 illustrates a typical roughness profile.

Roughness data used in PSI determinations represent an average roughness (in inches per mile in lane 1) of all miles in that particular pavement section. Lane 1 is generally the decision lane that controls pavement overlay or rehabilitation.

On the main line, a constant test speed of 50 mph was maintained. The beginning and ending of bridge structures were noted on the profile-event trace and were factored out from the pavement sections. Inches of roughness per lane mile of pavement were then determined.

Interchange ramps were surveyed at their posted speed. When two lane ramps were encountered, only lane 1 was tested. Ramp lengths were recorded and the corresponding inches of roughness per mile determined.

Skid

Pavement skid testing was conducted to obtain an initial skid-resistance survey of the tollway system. SNs provide a friction value for the tire-pavement interface representative of potential wet-weather skidding.

Skid testing was conducted by using a Law model 965 skid-measurement system owned by the Transportation Research Center of Ohio. The skid trailer nozzle is an Ohio State University nozzle that provides a uniform trace width of approximately 7 in in front of the test tire.

These tests were conducted in conformance with ASTM E274. Tests were conducted on a 500-ft section that began at every 0.50-mile post marker in lane 1 for each direction of travel on the main line. Tests were conducted at the standard 40 mph.

To obtain SNs at the main-line toll plazas, a series of tests was conducted at the approach, and a series of tests was conducted leaving the lane-2 toll gate. At selected interchange ramps and loops, tests were conducted at the standard 40 mph or the highest speed below this value that could be achieved depending on roadway alignment and traffic conditions. When possible, three readings were obtained per ramp.

Deflection

Structural capacity can be evaluated indirectly by noting the defects in an existing pavement or by measuring the deflection of the pavement system under an applied load. Typically, pavement deflections are measured at specified or selected locations, usually at critical sections detected by other routine monitoring. In most cases, deflection measurements are used for the design of sections that are candidates for rehabilitation. To aid in establishing a data base for a tollway inventory system, representative deflection data indicative of structural capacity and joint efficiency were obtained on the main-line pavements. A Dresser Atlas Dynaflect was used for the deflection survey.

Deflection measurements were obtained in lane 1 at the center of concrete slabs and across pavement joints. Testing frequency routinely varied from 0.25 to 0.50 mile. In sections where deflection data produced very little variance, testing frequency was increased to as much as 1-3 miles. At 6 percent of the testing locations, two test replications were made to ensure instrument and operator repeatability. On the tollway's main line, 314 test locations were evaluated.

PRESENT SERVICEABILITY INDEX

To permit orderly processing of field data and computation of PSI values, field records for each type of pavement distress were assembled. Visual and roughness data were tabulated for each recording segment. The data were then processed to develop the cracking, patching, and roughness factors for the PSI equation.

As part of the National Cooperative Highway Research Program, a study was conducted to develop PSI equations by using various models of roughometers and profilometers (1). A study conducted by Purdue University led to the development of a modified AASHO Road Test equation for obtaining the PSI value of a rigid pavement when the CHLOE profilometer is used. This equation produces PSI values that differ only slightly from those obtained by using the original AASHO Road Test equation. The Purdue equation was modified by the Illinois Department of Transportation to allow use of the Illinois BPR-type roughometer to measure roughness.

Both these equations give essentially the same results. Since serviceability data collected on the tollway system previously were compiled by using the modified AASHO equation, it was decided to continue the use of that equation adjusted for Mays ride meter roughness measurements. Thus, for rigid pavements, Equation 1 is used for PSI computations:

$$PSI = 12.00 - 4.27 \log RI - 0.09\sqrt{C+P} \quad (1)$$

$$RI = 63.74 + 0.29MRM \quad (2)$$

where

MRM = roughness values from the Mays ride meter,
RI = roughness index,
C = cracking factor, and
P = patching factor.

TRAFFIC AND AXLE-LOAD ANALYSES

Traffic data are required to determine the axle loadings that have occurred on the pavement sections of the tollway and to allow the prediction of future traffic loadings to which these pavement sections will be subjected. The data collected include traffic volume, vehicle classification, lane distribution, and variations in axle loads for each vehicle classification.

Traffic Volume

Traffic volumes were obtained directly from the Illinois Tollway's annual traffic reports. These reports were compiled by the Traffic Division of the tollway's Engineering Department.

The traffic data are summarized from traffic volumes at the main-line toll plazas for the years 1960, 1965, 1970, 1975, and 1978. All traffic-volume data obtained from these annual traffic reports were summarized in average daily traffic (ADT) figures.

When axle loads on pavement sections are estimated, commercial vehicles have a far more detrimental effect on pavement life than does noncommercial traffic. For this reason, a separate analysis was made of commercial ADT for the years 1960, 1971, 1975, and 1978. It was found that commercial ADT volumes did not follow total volume trends, particularly for combination-type vehicles. Therefore, it was not appropriate to express commercial traffic as a simple percentage of total traffic. Total commercial traffic volume had to be grouped by single-unit and combination vehicles. Single-unit commercial vehicles were found to be a simple percentage of total volume and, in some instances when only total commercial units were reported, provided the basis for a split between single-vehicle and combination-vehicle traffic.

Vehicle Classification

For the purpose of assessing tolls, the Illinois Tollway has grouped all vehicles into nine classes. However, it was necessary to combine these nine vehicle classes into the six axle classification categories defined at the AASHO Road Test to determine equivalent 18-kip single-axle loadings. The tollway classes and the corresponding AASHO axle groupings and vehicle classifications that BTML used to analyze axle loadings are given below (SV = single vehicle; CV = combination vehicle):

Tollway Class	AASHO Description	AASHO Class
1,7,8	Four-tire SV	1
2	Two-axle/six-tire SV	2
3	Three-axle SV	3
3	Three-axle CV	4
4	Four-axle CV	5
5,6	Five-axle or more CV	6

As determined in the 1968 long-range pavement maintenance program report prepared by BTML, tollway class-7 and class-8 vehicles were grouped into the class-1 axle category because they correspond to AASHO class-1 vehicles except that they are towing a one-axle trailer (class 7) or a two-axle trailer (class 8). The tollway class-3 vehicles included both single and combination three-axle vehicles.

By using the tollway to determine the mix of vehicle classifications, statewide average vehicle classifications were determined from the Illinois Department of Transportation W-4 loadometer tables. By applying these percentages to actual traffic volumes for each pavement section on the tollway, the number and mix of commercial vehicles in each vehicle classification were determined.

Lane Distribution

The distribution of traffic volume by lane was determined directly from field data. Since the commercial vehicles are important in determining axle-load applications, only vehicles in classes 2 through 6 were examined for lane-distribution purposes. For tollway segments that have four lanes--two in each direction--90 percent of commercial travel is assigned to lane 1. For segments that have six lanes or more--three in each direction--98 percent of commercial travel is assigned to the driving lane. These values fall within the general limits suggested in the 1972 AASHTO interim guidelines for lane distribution on four- and six-lane highway facilities.

Axle Loads

At the AASHO Road Test, only loaded vehicles were used to impose a single value of axle load. Moreover, only the number of repetitions of loaded axles was counted. On the tollway, however, there exists a wide range of differing axle-load repetitions. It therefore becomes necessary to convert this distribution of axle load into a uniform axle-loading pattern. Since pavement distress increases exponentially with axle load, it should be noted that the equivalent axle load that represents the distribution will be different from and always greater than the mean axle load.

Individual axle loads for each vehicle type do not vary significantly with respect to time or geographic distribution. Therefore, the Illinois Department of Transportation axle-load information collected at loadometer stations throughout the state is used for summarizing 18-kip single-axle-load equivalencies per 1000 vehicles.

Statewide 18-kip equivalency factors for 1963, 1964, 1965, 1975, and 1977 for each vehicle class were used. A weighted mean equivalency factor was computed for each vehicle class by weighting the factor published for each year by the number of vehicles in that class per year. Loads imposed by class-1 vehicles are negligible compared with classes 2 through 6 and are omitted from the pavement axle-loading analysis.

For each vehicle class, the fraction of trucks was multiplied by the average 18-kip axle load in that class. These values were totaled for all classes to obtain an average 18-kip axle load per truck. This sum was then multiplied by the percentage of trucks in the driving lane to obtain the 18-kip axle loads in that lane per truck in the traffic stream. This result was the multiplied by the percentage of trucks in the traffic stream and by the directional traffic volume to obtain the number of 18-kip single-axle loads in the driving lane. The values obtained for all three periods were summed to obtain 18-kip axle loads for the entire study period.

Figure 6 illustrates an 18-kip single-axle-load history for the Tri-State Tollway between mileposts 0.0 and 6.0.

Future Traffic Loading

Cumulative 18-kip single-axle-load history curves (as illustrated in Figure 6) were used to estimate future axle loadings on each section of the tollway. These values were then used to establish serviceability histories to predict the total axle loadings for each pavement section to reach a TSI of 2.3, the value adopted by the tollway to schedule rehabilitation or overlays.

The more comprehensive the performance history, the more accurate the predicted performance of a pavement. In developing the service-life curves for the tollway system, the rating history consists of five serviceability points. The expected accuracy of projections based on this history will increase with time. Therefore, it is desirable that pavement performance be monitored by obtaining needed data to establish PSI values at regular intervals. This practice will improve the capacity to project future performance in addition to validating existing projections of service life. Further, major modifications in service-life curves may be required in the future to accommodate unanticipated changes in traffic patterns. This is more readily accomplished by using a complete up-to-date history of pavement performance.

For the tollway pavement sections, serviceability indices and traffic data were collected in 1967, 1969, 1971, 1975, and 1979 that provide five actual points on the service-life curve. Since more data that relate serviceability to cumulative 18-kip single-axle loads have become available, it is possible to construct service-life curves based on actual performance histories for each pavement section.

Figure 6. Cumulative axle-load history, Tri-State Tollway, mileposts 0.0-6.0.

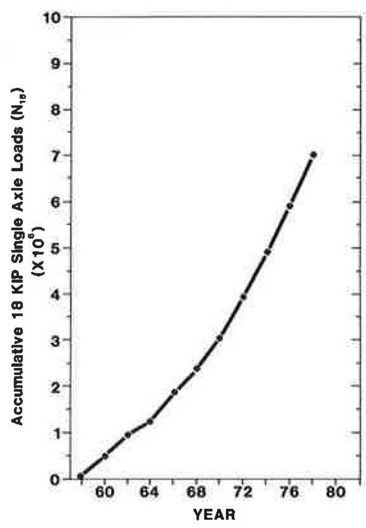
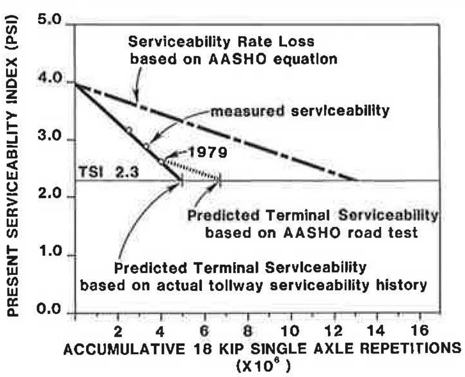


Figure 7. Typical serviceability curve and TSI projection.



SELECTION

The TSI is the point at which the pavement surface will not provide adequate service. The AASHO Road Test data revealed that when the serviceability index is reduced to 1.5, a pavement is completely unserviceable and would require reconstruction.

All previous tollway pavement evaluations have adopted 2.3 as the TSI to schedule rehabilitations or overlay measures. A TSI of 2.3 is retained for continuity of evaluation in this study.

SERVICE-LIFE CURVES

Figure 7 illustrates the service-life curve for a rigid pavement section on the Tri-State Tollway (mileposts 0.0-9.8). (Witczak has derived life curves for all pavement sections, and Figure 7 is typical.) By using both the AASHO Road Test method and actual performance history, times to TSI are determined. The AASHO method indicated that a serviceability value of 2.3 will require three times as many 18-kip single-axle loads as actual tollway serviceability trends indicate. By using the Tri-State Tollway performance data from milepost 0.0 to milepost 9.8, a TSI value of 2.3 will be obtained in two years. Actual serviceability loss on the Tri-State Tollway more closely fits the curve generated by the historical serviceability curves from the tollway. Therefore, the rate of serviceability loss as a function of cumulative 18-kip single-axle loads was derived from the serviceability trends established from 1958 to 1979.

REHABILITATION FORECASTS

The pavement service-life curves for each pavement section, for each direction of travel, and for all three tollways were completed. These curves are based on actual measurements through 1979. Projections from 1979 to a TSI of 2.3 were converted from equivalent 18-kip single-axle loads to time based on projected traffic volume and traffic mix. These data are summarized in Table 2 and provide the basis for the serviceability index.

Project limits are based on additional factors, which include location of toll plazas, pavement sections that have similar structural strengths, significant changes in traffic volume, significant changes in skid resistance, and similar typical pavement cross sections.

The resulting schedule is a 14-year cycle (Figure 8) in which major rehabilitation for all mileage will be performed. The average number of projects to be rehabilitated each year is between five and six; the average length is 6.56 miles. The cumulative percentage of system rehabilitation to be

Table 2. Proposed rehabilitation schedule.

Tollway	Milepost	Direction	PSI (1979)	Projected Year of Rehabilitation
Tri-State	0.00-9.18	NBL	2.64	1982
	9.18-17.44		2.62	1982
	17.44-23.30		2.76	1982
	23.30-28.70		2.78	1982
	28.70-31.50		2.57	1981
	31.50-40.00		2.54	1981
	40.00-46.00		2.69	1984
	46.00-52.50		2.81	1985
	52.50-55.60		2.98	1984
	55.60-63.40		2.91	1984
	63.40-70.00		2.90	1984
	70.00-77.30		3.42	1991
	0.00-9.18	SBL	2.81	1984
	9.18-17.44		2.77	1983
	17.44-23.30		2.76	1982
	23.30-28.70		2.80	1982
	28.70-31.50		2.68	1982
	31.50-40.00		2.65	1981
	40.00-46.00		2.67	1984
	46.00-52.50		2.67	1984
	52.50-55.60		2.74	1983
	55.60-63.40		2.81	1983
	63.40-70.00		2.76	1983
	70.00-77.30		3.43	1991
Edens Spur	48.20-53.30	WBL	3.20	1986
	48.20-53.30	EBL	3.21	1985
Northwest	0.00-2.70	WBL	2.72	1983
	2.70-5.20		2.77	1983
	5.20-10.60		2.63	1982
	10.60-16.60		2.69	1982
	16.60-23.26		2.97	1985
	23.26-33.75		3.04	1988
	33.75-39.21		2.95	1987
	39.21-50.84		3.03	1988
	50.84-54.06		3.05	1988
	54.06-62.71		2.71	1984
	62.71-67.49		2.95	1988
	67.49-74.78		3.00	1989
	74.78-76.31		3.00	1989
	0.00-2.70	EBL	2.72	1983
	2.70-5.20		2.76	1983
	5.20-10.60		2.75	1983
	10.60-16.60		2.77	1983
	16.60-23.26		2.86	1984
	23.26-33.75		2.94	1987
	33.75-39.21		2.86	1986
	39.21-50.84		2.92	1987
	50.84-54.06		2.96	1987
	54.06-62.71		3.05	1988
	62.71-67.49		2.95	1988
	67.49-74.78		3.00	1989
	74.78-76.31		3.00	1989
East-West	59.70-69.00	WBL	3.28	1992
	69.00-82.00		3.43	1994
	82.00-91.66		3.42	1994
	91.66-94.00		3.45	1994
	94.00-107.00		3.24	1991
	107.00-117.00		3.25	1992
	117.00-124.80		3.22	1991
	124.80-128.90		3.32	1992
	128.90-133.55		3.14	1990
	133.55-138.15		2.17	
	138.15-143.80		2.26	
	143.80-149.70		2.99	1988
	149.70-152.00		3.01	1989
	152.00-156.00		2.94	1988
	59.70-69.00	EBL	3.21	1991
	69.00-82.00		3.45	1994
	82.00-91.66		3.37	1993
	91.66-94.00		3.47	1993
	94.00-107.00		3.29	1992
	107.00-117.00		3.38	1993
	117.00-124.80		3.43	1994
	124.80-128.90		3.44	1994
	128.90-133.55		3.12	1990
	133.55-138.15		2.15	
	138.15-143.80		2.28	
	143.80-149.70		2.93	1988
	149.70-152.00		2.95	1988
	152.00-156.00		2.90	1987

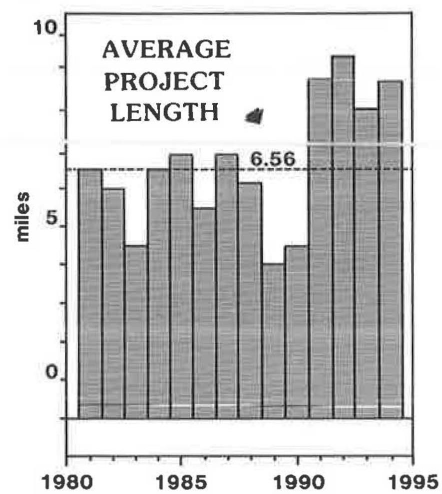
Figure 8. Tollway rehabilitation schedule.

completed over the 14-year cycle and the average project length for each year are illustrated in Figure 9.

PROJECT DESIGN AND REHABILITATION ALTERNATIVES

Selection of rehabilitation type and corresponding project design to achieve the best value possible for funds expended and to provide smooth, safe, and economical pavements is done separately for each project. A study has been done by B. Ratteree of Crawford, Murphy, and Tilly, Inc., Springfield, Illinois, that provides an overview of those steps

Figure 9. Average project length for rehabilitation.



and additional data necessary for the project phase of pavement evaluation and management.

REFERENCE

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