Research Report
KTC-90-4

REVIEW AND ANALYSIS OF PAVEMENT MANAGEMENT PRACTICES IN KENTUCKY

by

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in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
U.S. Department of Transportation

March 1990

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

MILO D. BRYANT
SECRETARY
AND
COMMISSIONER OF HIGHWAYS

WALLACE G. WILKINSON
GOVERNOR

October 4, 1990

Mr. Paul Toussaint
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40602

Subject: IMPLEMENTATION STATEMENT
KYHPR 85-106, "Models and Strategies for Pavement Management in Kentucky"

Dear Mr. Toussaint:

This research study has involved detailed review of the current procedures and activities of the pavement management process in Kentucky. This study has been most helpful in summarizing and describing the state-of-the-art of pavement management in Kentucky. The study has identified and described the areas where the pavement management system is well advanced and functions routinely. The study has also documented areas and procedures that need further development and advancement.

One of the major areas of implementation of this study has been the initiation of other research studies that are addressing areas that were identified in this study as needing further research. One of these studies is entitled "Pavement Deflection Evaluations" (KYHPR 86-109). This study is attempting to develop better pavement behavior models from deflection testing. This information will be very helpful in predicting pavement performance histories for management studies. A second study initiated partly as a result of this study is entitled Life-Cycle Costing of Pavement Systems (KYHPR 88-118). Better life-cycle cost models is essential to effective pavement management.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
KTC-90-4		

4. Title and Subtitle	5. Report Date
REVIEW AND ANALYSIS OF PAVEMENT MANAGEMENT PRACTICES IN KENTUCKY	March 1990
	6. Performing Organization Code
7. Author(s) David L. Allen	8. Performing Organization Report No. KTC-90-4
9. Performing Organization Name and Address KENTUCKY TRANSPORTATION CENTER COLLEGE OF ENGINEERING UNIVERSITY OF KENTUCKY LEXINGTON, KY 40506-0043	10. Work Unit No. (TRAIS) 11. Contract or Grant No. KYHPR-85-106 13. Type of Report and Period Covered: Final
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building Frankfort, KY 40622	14. Sponsoring Agency Code

15. Supplementary Notes

Publication of this report was sponsored by the Kentucky Transportation Cabinet with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

Pavement Management is becoming increasingly more important in an era of limited budgets and aging pavement structures. State Highway Agencies (SHA) are attempting to manage the pavements under their jurisdiction more carefully and economically. All pavement management systems include all or some of the following items as inputs: (1) pavement distress, (2) serviceability or rideability, (3) inventory of the system, (4) structural adequacy, (5) traffic volumes and loadings, and (6) some form of performance history. This report documents Kentucky's present pavement management system. In addition, the duties and goals of the Pavement Management Branch are catalogged and described. Methods for rating pavements are described. The allocation of funds and how this allocation is calculated are described. Methods of determining estimates for rehabilitation needs are also described. A description of the organization and flow of information in the PMS is given in detail. Comparisons are made between Kentucky's PMS and the elements of a pavement management system to be required by the Fedreal Highway Administration in 1993. Kentucky's PMS is well advanced and most of the elements in the Federal Guidelines are already in place or are in some stage of development. Life-cycle costs analysis procedures need to be developed and adopted. Greater use of the present data bases is encouraged.

17. Key Words	18. Distribution Statement
Pavements, Pavement Management, Life-Cycle Costs, Distress Survey, Roughness	Unlimited with approval of Kentucky Transportation Cabinet

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	99	

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

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It is anticipated that no major changes will be initiated immediately as a result of this study. However, this document and its recommendations will serve as guidelines to help focus future development of the pavement management system. Some of the recommendations concerning more objective procedures in performing distress surveys will be implemented as available technology permits.

Sincerely,

O. G. Newman, P.E.
State Highway Engineer

ACKNOWLEDGEMENTS

For their significant contributions toward completion of this report, an expression of appreciation is extended to the following employees of the Kentucky Transportation Cabinet:

Rolands Rizenbergs, Pavement Management Branch,
James Burchett, Pavement Management Branch,
John Dade, Pavement Management Branch,
Gary Sharpe, Division of Design.

Their information, consultation, and advice were invaluable in organizing and compiling the data and information contained herein.

EXECUTIVE SUMMARY

Pavement Management is becoming increasingly more important in an era of limited budgets and aging pavement structures. State Highway Agencies (SHA) are attempting to manage the pavements under their jurisdiction more carefully and economically. All pavement management systems include all or some of the following items as inputs: (1) pavement distress, (2) serviceability or rideability, (3) inventory of the system, (4) structural adequacy, (5) traffic volumes and loadings, and (6) some form of performance history. This report documents Kentucky's present pavement management system. In addition, the duties and goals of the Pavement Management Branch are catalogged and described. Methods for rating pavements are described. The allocation of funds and how this allocation is calculated are described. Methods of determining estimates for rehabilitation needs are also described. A description of the organization and flow of information in the PMS is given in detail. Comparisons are made between Kentucky's PMS and the elements of a pavement management system to be required by the Fedreal Highway Administration in 1993. Kentucky's PMS is well advanced and most of the elements in the Federal Guidelines are already in place or are in some stage of development. Life-cycle costs analysis procedures need to be developed and adopted. Greater use of the present data bases is encouraged. It is also recommended that more personnel will be needed to perform all the duties necessary in the near future.

INTRODUCTION

Transportation systems have developed rapidly during the past several decades and now represent considerable investment of resources. As these facilities age and traffic usage increases, the need for improved management of transportation facilities becomes more essential. The pavement structure is one of the most significant components of the road transportation system and represents a significant cost in providing transportation services. Sound pavement management practices are essential to provide acceptable service through efficient and effective allocation of funding, equipment, personnel, and other resources.

The fundamental objective for pavement management is effective and efficient directing of the various activities that deal with providing and sustaining pavements in a condition acceptable to the travelling public at the least life-cycle cost. The 1986 AASHTO "Guide for Design of Pavement Structures" states that "pavement management in its broadest sense encompasses all the activities involved in the planning, design, construction, maintenance, evaluation, and rehabilitation of the pavement portion of a public works program. A pavement management system (PMS) is a set of tools or methods that assists decision makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a given period of time. Figure 1 illustrates the hypothetical service history of a pavement. Just after construction, the pavement has a high level of serviceability. This level of serviceability decreases as the pavement ages and the damaging effects of climate and fatigue accumulate. Throughout the service history of a pavement, a number of rehabilitation or maintenance schemes could be employed to prevent the serviceability of the pavement from falling below a minimum acceptable level.

Figure 2, from the Pavement Management Guide prepared by the Road and Transportation Association of Canada, shows typical major activities and interactions in a pavement management system. It is included here to illustrate the general flow of information within an effective pavement management program. The development of appropriate methodologies and procedures will vary widely depending upon the specific organizational structure and needs of the transportation organization. In spite of this wide variability in detail from one pavement management system to another, nearly all systems require accumulation of the following information:

1. Observable pavement distresses,
2. Pavement rideability and associated level of serviceability,
3. Pavement deformation characteristics,
    a. Deflections under actual wheel loads,
    b. Dynamic deflections from such devices as the Dynaflect, Road Rater, and the falling weight deflectometer,
    c. Pavement rutting,

4. Pavement fatigue (ESAL's) information determined from
    a. Traffic volumes,
    b. Vehicle loadings,
    c. Traffic distributions,
5. Other pertinent data (skid resistance and safety).

The exchange of information is one of the most important aspects of any pavement management system. There must be a continuing flow of information to other functions and management personnel regarding the performance and effectiveness of design, materials, construction, and maintenance. This flow of information necessarily makes a pavement management program an evolutionary process. Refinements and adjustments may be made as more data become available. In most cases, the pavement management system will become more encompassing and reliable as the size of data banks increases and histories of performance increase. Information derived from pavement management activities may be used at the network level for programming and funding allocation purposes. Similarly, pavement management data may be used to rank and establish priorities for specific projects and for making preliminary project design decisions.

The highway system in Kentucky consists of 70,226 miles. Of this 27,380 miles are under the jurisdiction of the Kentucky Transportation Cabinet. This includes 763 miles of interstate, 633 miles of parkways (toll roads), 3,267 miles of state primary, 8,092 miles of state secondary, 12,171 miles of rural secondary, 2,453 miles of supplemental roads, and approximately 100 miles of other roads. The first centralized efforts to manage this vast system of highways in a more structured, objective manner began in the early 1980's with the creation of the Pavement Management Branch within the Division of Maintenance. Much progress has been made in the last nine years in Kentucky's pavement management system. This is particularly so in the areas of sophistication, reliability, and in the use of the information obtained and distributed by the Pavement Management Branch.

The major objectives of this study were: (A) Document current pavement management practices and identify future needs; (B) Develop models and strategies for pavement management in Kentucky, involving implementation and/or adaptation of the most current equipment and technology available; (C) Determine and/or develop an organizational plan to provide for the most efficient and effective collection and processing of data for use in the development of pavement management recommendations in Kentucky; (D) Develop a means of efficient and effective refinement and revision of pavement management activities as new technologies become available; and (E) The design of computerized data banks for storage and retrieval of data applicable to pavement management needs in Kentucky.

This report completes Objective A. Efforts on Objective B (models and strategies) are being performed under two other research studies. The first study is entitled "Life-

Cycle Costing of Pavements Systems" (KYHPR-88-118), and the second study is entitled "Pavement Deflection Evaluations" (KYHPR-86-109). Objective C also has been addressed in this report. Objective D has not been addressed due to time constraints. Objective E has been partly addressed in this report and part of this objective is being performed under the "Pavement Deflection Evaluations" study. The portion of Objective E that is being developed under the above mentioned study is the data base that will contain all structural evaluation data (pavement deflections).

This report also compares Kentucky's pavement management system with the federally mandated pavement management policy published in the Federal-Aid Highway Program Manual (Transmittal 428, dated March 6, 1989).

ORGANIZATION OF KENTUCKY'S PAVEMENT MANAGEMENT SYSTEM

MAJOR AREAS OF RESPONSIBILITIES IN KENTUCKY'S PMS

Figure 3 illustrates, in a very general way, the major areas of responsibilities for the various divisions within the Kentucky's Department of Highways. The design of pavements for new and reconstructed roadways is the responsibility of the Division of Design. Included in the Division of Design's responsibilities is the use of pavement performance prediction models to develop designs, economic analyses, and optimization of alternate designs. Designs for rehabilitation projects are analyzed in the Division of Design based,in part,on recommendations made by the Pavement Management Branch. Final designs are selected by the Division of Design after consulting with the Department's Pavement Committee.

The Division of Materials provides information on material properties and makes recommendations on suitable mixes. The Division of Planning provides traffic and loading histories, and projections, for pavement designs. The Division of Construction, of course, oversees the building of roads and rehabilitation of older pavements.

The responsibilities of the Pavement Management Branch will be discussed in detail in subsequent sections. However, briefly, the responsibilities of the Pavement Management Branch include system inventory, performance monitoring (this includes roughness surveys, structural testing and analysis, and detailed distress surveys), maintaining all pavement data bases, analyzing and reporting on performance histories, establishing pavement rankings according to needs, analyzing and reporting network conditions, reporting on network trends and needs, identifying projects that need structural rehabilitation, recommending rehabilitation strategies to the Pavement Committee, developing pavement performance databases, forecasting future trends, and providing other administrative units with reports as requested.

The Division of Maintenance is charged with the responsibility of overseeing the routine maintenance activities on all pavements and is responsible for selecting and programming rehabilitation projects for all roads except for Rural secondary roads.

A permanent, standing Pavement Committee comprised of personnel from various divisions of the Department of Highways determines strategies for pavement rehabilitation, restoration, reconstruction and/or resurfacing. The Committee is the focal point for most pavement decisions. The Committee consists of representatives from the Division of Design (Pavement Design Branch), the Division of Specialized Programs (Pavement Management Branch), the Division of Maintenance, and the Division of Materials. The Committee coordinates (through its Chairman) with other divisions (Construction, Planning, etc.) within the Transportation Cabinet and outside agencies (Kentucky Transportation Center, FHWA, AASHTO, etc.) as necessary for pavement concerns.

The Committee reviews the priority listing of projects. The Committee is specifically responsible for reviewing rehabilitation projects for Interstates and Parkways and other road projects where pavements exhibit severe deterioration including rutting, excessive and severe cracking, excessive and/or severe base failures, and thereby require more detailed analyses. The Committee may also review proposed resurfacing projects where the interval between resurfacing has been less than five years. The Division of Design presents results of comparative analyses of alternative strategies to the Pavement Committee for review and concurrence. The Pavement Committee may make recommendations concerning reconstruction strategies.

COMMUNICATION AND INTERACTION WITHIN KENTUCKY'S PMS

As stated previously, the Pavement Management Branch (PMB) is the primary source and repository of information in Kentucky's PMS. Information exchange occurs between the PMB and most of the technical divisions of the Transportation Cabinet, as well as the 12 District Offices, the Federal Highway Administration, the State Highway Engineer's Office, national technical organizations, and research agencies. Figure 4 is a flow chart that illustrates the flow of information to and from the pavement management unit. The number in each block refers to the numbered paragraphs that follow which describes the information that is normally exchanged between these agencies.

1. Design. PMB supplies the Division of Design with the results of structural analysis, the latest pavement condition information, and recommendations on treatments for specific projects. The Division of Design supplies PMB with detailed design information on alternate strategies for specific projects, economic analyses on individual projects, specification requirements, and information on which projects to specify rideability requirements.

2. Maintenance. PMB transmits to the Division of Maintenance information on condition evaluations and results of tests (these include deflection, roughness, and skid resistance). PMB also makes recommendations on resurfacing needs, project rankings, and treatments. Recommendations are presented on the allocation of resurfacing and machine patching monies for the Districts. PMB makes recommendations on the levels of funding for pavement improvements. The Division of Maintenance consults with PMB on rehabitation programs development. The Division of Maintenance also makes special requests of PMB for evaluation's and testing.

3. Materials. PMB provides results of skid tests and performance analyses to the Division of Materials. PMB also provides consultation on surface treatments. PMB receive requests from the Division of Materials for skid testing on specific types of surfaces, and the Division of Materials provides recommendations on applicability of various mixes.

4. Construction. PMB receives requests from the Division of Construction for rideability requirement testing on newly constructed and rehabilitated pavements. Results are transmitted to the Division of Construction when the testing is completed and the results are analyzed. Changes in requirements are proposed by the PMB,or others.

5. District Offices. District Offices provide PMB with a list of pavements the district wishes to be evaluated for the resurfacing program. PMB provides the results of pavement evaluations, and subsequent points ranking the pavements, and recommended treatments. District personnel will provide their priorities, treatment recommendations, and cost estimate.

6. State Highway Engineer's Office (SHE). PMB provides the SHE with pavement condition reports and reports on funding needs for pavement improvements. PMB also provides consultation on project selection and recommended treatments. Advice is also provided on pavement-related policy. PMB also assists the SHE in special analyses and requests.

7. Federal Highway Administration (FHWA). PMB provides FHWA with pavement condition information, justification for rehabilition of pavements on Interstates and the Federal Aid Primary System, and the initial communication of proposed rehabilitation strategies.

8. Research. PMB maintains a close relationship with the Kentucky Transportation Center at the University of Kentucky. Personnel of PMB provide advice and monitors research studies. PMB also provides data to be used in various research studies.

9. Planning. PMB provides updates on pavement condition surveys and systems analyses. It also provides roughness data on the Highway Performance Monitoring System (HPMS) statistical sample sections. Planning provides PMB with traffic data, ESAL data, and system classification data.

10. National Organizations. PMB maintains technical contact with such national organizations as the Transportation Research Board, the National Cooperative Highway Research Program, the American Society for Testing and Materials, and the Strategic Highway Research Program (SHRP).

ORGANIZATION OF THE PAVEMENT MANAGEMENT BRANCH IN KENTUCKY'S PMS

The Pavement Management Branch was organized within the Division of Maintenance in 1981. Shortly thereafter, the unit was moved to the State Highway Engineer's Office under the Assistant State Highway Engineer for Operations. The decision to place the unit at that level allowed for greater and more effective interaction of the Pavement Management Branch with other units within the Transportation Cabinet. In 1987, the unit was moved to the Division of Specialized Programs which is composed of several staff functions. The unit is staffed with three engineers, five technicians, and a secretary shared with another unit. Policy and procedures applicable to the Pavement Management Branch are included in the State Highway Engineer's Guidance Manual (Appendix A).

GOALS AND FUNCTIONS

The concept of service to the highway user has guided development of the pavement management program by focusing efforts on functions that have a clear impact on the highway user. Important pavement management functions are as follows:

- Measure quality of all pavements to assess general conditions and estimate current and anticipated improvement needs.

- Evaluate pavements to select those in need of rehabilitation or restoration and priority rank for programming.

- Assess impacts and recommend changes in programs, practices, policies and specifications affecting condition and performance of pavements.

- Maintain Pavement Database information base for effective communicating and coordinating of pavement related activities within the Department of Highways.

- Provide data, information, and results of analyses to other Transportation Cabinet units whenever necessary.

MAJOR TASKS

Although the major goals have not changed significantly in several years, current major tasks to implement the functions are (latest yearly goals are itemized in Appendix B):

1. Conduct annual roughness surveys of all roads and summarize present condition of pavements by highway system, district, and county. Identify needs for pavement improvements, estimate funding needs, and allocate rehabilitation funds among highway districts on the basis of pavement conditions and other factors. Evaluate the relevance and significance of specific programs, construction procedures, specifications, and other practices. Identify pavements that may need rehabilitation.

2. Perform detailed pavement condition evaluations and analyses, including roughness, skid resistance and deflection testing, and observable distresses. Annually evaluate all Interstate and Parkway pavements and other selected pavements in relation to rehabilitation programs. Select and rank pavements for rehabilitation, recommend treatments and estimate costs.

3. Test for skid resistance and evaluate the performance of various pavement types. Recommend modifications of Departmental guidelines for selection of bituminous surfaces. Perform tests on pavements subjectively identified as being slippery and make recommendations on the basis of Departmental guidelines for de-slicking.

4. Test newly constructed and rehabilitated high-type pavements for conformance with Departmental rideability requirements.

5. Compile and maintain computer files of pavement related information. Summaries of these files, as well as files maintained by others, are included in Appendix C.

TEST METHODS AND PROCEDURES

ROUGHNESS

Roughness measurements are made with six sedans equipped with Mays Ride Meters and on-board microprocessors designed to provide results at the time of testing and to record data for computer processing later. Tests are made at 50 mph and in accordance with ASTM E 1082. Test speed is reduced whenever geometrics of the roadway, posted speed, or traffic congestion prohibited testing at the standard speed. Roads less than 0.4 miles long are excluded. Testing is confined to ambient temperatures above 50 degrees Fahrenheit. The results, in inches per mile, are converted to rideability index (RI). The RI scale ranges from zero to five. Zero means the pavement is too rough to be traveled at a reasonable speed of the road without high risk to the driver, while five means the pavement is perfectly smooth. The RI's may be viewed from rideability standpoint as follows:

Rideability Index	Rideability Assessment
4.0 to 5.0	Very Good Rideability
3.0 to 3.9	Good Rideability
2.0 to 2.9	Fair Rideability
1.0 to 1.9	Poor Rideability
0.0 to 0.9	Very Poor Rideability

RUTTING

Rutting of asphaltic concrete pavements or wear of portland cement concrete pavements are measured with a ruler and 67-inch straightedge which is a sufficient length to span the ruts to obtain an accurate measurement.

SKID RESISTANCE

Skid resistance measurements are made using a pavement friction tester in accordance with ASTM E 274. Pavements are selected for testing if slippery conditions are suspected based on either prior test results or visual condition surveys or when accident data indicate a disproportionate number of wet-pavement accidents. The measurement is expressed as skid number (SN), and the scale ranges from 0 to 100. Tests are made in the left wheel path of each lane at 0.5-mile intervals.

STRUCTURAL EVALUATIONS

Pavement deflection measurements are not obtained routinely. Deflection testing is conducted on pavements where subjective evaluations indicate potential structural inadequacy. Pavement deflection measurements are made with a Model 2000 Road Rater (trailer mounted). The device, even though able to apply much larger dynamic loads (up to peak-to-peak of 5,500 lb.), is used to obtain measurements at peak-to-peak of 600 lb., 1,200 lb., and 2,400 lb. at a frequency of 25 Hz. The static load is 3,500 lb. Falling weight Deflectometer tests are also available through the Kentucky Transportation Center as is an additional Road Rater (Model 400).

Evaluation of asphaltic concrete pavements utilizes elastic layer concepts to determine, for each test location, the theoretical deflection basin that best matches the measured deflection basin. Pavement behavior is expressed as the effective thickness of crushed stone, the effective thickness of reference quality asphaltic concrete (modulus of elasticity of 480 ksi) and a subgrade modulus.

These values are used in combination with the design fatigue estimated from traffic projections to determine thicknesses of bituminous overlay to meet projected design ESAL's for each test location. Computed overlay thicknesses for the test locations are analyzed statistically to determine the 80th percentile overlay thickness requirement for the project length.

Structural evaluations of rigid pavements are more subjective and procedures are still evolving. Limited analysis to date involves relative comparisons of deflection measurements for one slab versus another slab. Additionally, the efficiency of load transfer has been estimated by comparing deflection basins for midslab versus deflection basins at a joint (or major crack) where the load is applied to one side of the joint but deflection measurements are obtained on both sides of the joint or crack.

OBSERVABLE DISTRESSES AND CONDITIONS

Cracking, base failures, faulting, raveling, spalling, and out-of-section are subjectively evaluated for Interstates and Parkways in terms of extent and severity. For other roads, edge failures are also included. Appearance of pavements is assessed from the perspective of the highway user in terms of good to very poor. Extent of pavement patching is considered only for Interstates and Parkways because prevailing practice on other roads is to do full-width, long-segment patching that must be considered as a capital improvement. Symptoms of distress are subjectively evaluated and are defined in terms of demerit points.

Interstates and Parkways

Pavements are visually inspected to assess conditions according to six elements and assigned condition points (demerits) as follows:

	EXTENT			SEVERITY			
	FEW	TO	EXTENSIVE	SLIGHT	TO	SEVERE	MAXIMUM
Cracking	3	to	18	3	to	13	31
Base Failures (Faulting)	3	to	9	3	to	9	18
Raveling-Wear (Spalling)	2	to	6	2	to	6	12
Out-of-Section	2	to	6	2	to	6	12
Patching	2	12	12				12
Appearance	Fair to Very Poor (3 to 15)						15
							100

Distresses and conditions are noted in both directions of travel by driving at reduced speed on the pavement and slowly on the shoulder for short intervals. The vehicle is stopped as necessary to inspect the pavement and to measure rut depths.

Other Roads

Pavements are visually inspected to assess conditions according to six elements and assigned condition points (demerits) as follows:

	EXTENT			SEVERITY			
	FEW	TO	EXTENSIVE	SLIGHT	TO	SEVERE	MAXIMUM
Cracking	1	to	6	1	to	4	10
Base Failures (Faulting)	1	to	3	1	to	3	6
Raveling-Wear (Spalling)	0.6	to	2	0.6	to	2	4
Out-of-Section	1	to	3	1	to	3	6
Edge Failures	0.6	to	2	0.3	to	1	3
Appearance	Fair to Very Poor (1 to 5)						5
							34

Distresses and conditions are first noted during roughness testing in both directions of travel. Pavements are then traversed again, if necessary, at a slower speed, and, where feasible, slowly on the shoulder for short intervals. The vehicle may be stopped as necessary to inspect the pavement and to measure depths of ruts or wear.

REHABILITATION STRATEGIES

GENERAL

Current practice for resurfacing asphaltic concrete pavements involves leveling and wedging and application of a 1-inch bituminous surface course. Structurally adequate pavements which have rutted to a depth of 3/8-inch or more may be milled to minimize leveling and wedging requirements and to improve rideability. Structurally adequate pavements may also be milled as much as 1 inch prior to overlaying to maintain shoulder or curb heights. Thicker overlays are recommended on the basis of subjective assessments and deflection analyses. Overlays of 2 inches or more (two pavement courses -- surface and binder) are considered thick overlays.

Extensive maintenance or restoration of rigid pavements has typically not been performed. The prevailing practice of overlaying rigid pavement, except for Interstates and Parkways, involves leveling and wedging with asphaltic concrete and overlaying with a 1-inch bituminous surface course. Thick overlays (4 to 8 inches) have been placed on Interstate and Parkway pavements in an attempt to minimize thermal expansion of the portland cement concrete slabs and thereby minimize reflective cracking. The practice of breaking the existing rigid pavement into 18- to 24-inch fragments, seating the fragments, and overlay with 5 1/2 or more inches of asphaltic concrete has been used extensively on Interstate and Parkways. This treatment (first used in 1982) has been successful in controlling reflective cracking. Other rehabilitation practices for rigid pavements have involved installing edge drains, resealing joints, and diamond grinding surfaces. Full-depth and partial-depth portland cement concrete patching also is being done to extend the life of some pavements.

DE-SLICKING

Guidelines for selecting slippery pavements prescribe levels of skid resistance and benefit/cost requirements for pavements to qualify for de-slicking. Those guidelines state, in part, that roads (other than Interstates) having ADT's between 1,000 and 10,000 qualify for de-slicking when the skid number (SN) is less than 26 or SN is 26 to 32 and the benefits (accident reductions) and costs associated with de-slicking result in a benefit/cost ratio above 2. All Interstates and roads having ADT's above 10,000 vehicles per day qualify when the SN is 28 or lower or the SN is 29 or higher and cost associated with de-slicking results in a benefit/cost ratio above 2.

Guidelines for selecting slippery pavements for consideration for de-slicking are included in Appendix A (Exhibit 40-15-3).

SELECTING BITUMINOUS SURFACING COURSES

Performance and suitability of pavements have been analyzed to establish the Cabinet's selection guidelines for bituminous surface courses, which specify surface courses to be used for various traffic volume and travel speed levels. These are listed in Appendix D.

PAVEMENT CONDITION--INTERSTATE AND PARKWAY

EVALUATIONS

Data regarding pavement and roadway sections are stored on discs and a form (Appendix A, Exhibit 40-15-1) is automatically printed for all routes according to construction termini. Data include location, construction and design information, traffic volumes, etc. The form provides for entry of demerit points associated with the various evaluation elements and results of roughness, skid resistance, and rut-depth measurements. The form also provides for entry of recommended treatment and ranking if the pavement needs rehabilitation, and assessment of shoulder and guardrail conditions.

NEEDS ESTIMATE AND PRIORITY RANKING

Pavements on interstates and Parkways in need of rehabilitation are identified each year from pavement condition evaluations. These evaluations along with historic rideability data and, since 1981, yearly pavement condition evaluations (Figure 5) provide a basis for estimating when other pavements may need rehabilitation. Pavements judged as needing rehabilitation are ranked in order of conditions. Pavements are ranked according to RI level, change in RI with time, deterioration (demerit points) from condition surveys, increase in deterioration (demerit points) with time, severity of rutting, and results of deflection testing. Pavements ascertained as needing rehabilitation later are tabulated by year through the next several years. Rehabilitation remedies and costs are estimated for each pavement. Costs are accumulated to quantify funding needs and for projections of programming needs.

ALLOCATION OF FUNDS

Allocation of funds for pavement rehabilitation of Interstates , Parkways, and other high-type facilities is based on demonstrated need. Those pavements which are judged in greatest need are given the highest priority. For interstates, the 4-R federal monies apply; however, pavement rehabilitation projects must now compete with other than pavement improvements. Priority rankings may be subjectively modified in consideration of other factors not related to relative conditions of the pavements.

PAVEMENT CONDITION-- STATE PRIMARY, STATE SECONDARY, AND SUPPLEMENTAL ROADS

NEED ESTIMATES

Detailed pavement condition evaluations are not performed on all pavements. Rideability indexes, however, are obtained for all state-maintained pavements. Analyses of rideability index, average daily traffic volumes, and subjective assessments of the need for resurfacing have indicated that need for resurfacing are associated with some critical RI (Table 1). Pavements at or below critical RI's, based on traffic volumes, are considered to be in poor condition and may require rehabilitation. Current needs are estimated by identifying pavements having RI's at or below the critical level and totaling the mileage. The critical RI's are not sufficiently precise to conclude that pavements so identified require rehabilitation, but these pavements are selected for visual inspection the following year. Mileages estimated as needing rehabilitation now or in the near future are tabulated by year and by system. Average costs for resurfacing are applied to the mileages and total funding needs are estimated for use in budget requests.

EVALUATIONS AND PRIORITY RANKING

Rideability data are provided to each highway district to aid in their selection of pavements for detailed evaluations by the Pavement Management Branch. The selections are reviewed and a final listing of projects is mutually agreed upon. Additional pavements, selected by the Pavement Management Branch primarily on the basis of RI's at or below critical levels, or requested by others are added. The evaluation scheme is based on a maximum of 100 rating points incorporating the following:

1. Distress and Condition Survey -- maximum 34 points

2. Rideability -- RI = 3.1 (1 point) to 1.4 or lower (26 points)

3. Rutting -- 1/4 inch (3 points) to 5/8 inch or greater (10 Points)

4. Skid Resistance -- SN = 36 (1 point) to 24 or lower (13 points, adjusted according to traffic volume)

5. Traffic Volume -- ADT = 401 (1 point) to 7,501 or higher (12 points)(8,951 for 4- lane roadways)

6. Travel Speed -- 40 mph (1 point) to 55 mph (5 points)

Demerit points applicable to various rating elements are cited on a rating form (Appendix A, Exhibit 40-15-2). Distribution of points is linear for rideability and skid resistance but curvilinear for all other elements.

The total points from the evaluations are used to rank pavements within each highway district. Raters indicate on the evaluation form specific rehabilitation needs. Raters also provide information on width and type of existing pavement, extent of patching, shoulder characteristics, and use of roadway for industrial haul. Completed forms are forwarded to each highway district office for information and use in assigning priority rankings, recommended treatments, and estimated costs. District recommendations are reviewed by the Pavement Management Branch and statewide rankings are assigned. Ultimately, the forms, along with explanations of variances with District rankings and recommended treatments, are submitted to the Division of Maintenance for preparation of the annual resurfacing program.

ALLOCATION OF FUNDS

Bituminous Resurfacing Program

State-funded resurfacing program monies are allocated to the highway districts on the basis of lane-miles of roads, cost of bituminous surface course materials, and conditions of pavements in each district. Pavement conditions in each district are characterized in terms of difference in RI's between measured values and critical values. The RI of each homogeneous pavement section is deducted from the critical RI assigned for the particular traffic volume and is known as the pavement condition index (PCI). The PCI difference at 15 percent of the pavement mileage in the poorest condition in each District is determined. The largest negative PCI identifies the District having the poorest pavements. Conversely, the largest positive value identifies the highway district having the best pavements. A modifying factor permits the extent to which pavement conditions influence allocations to be varied. A factor of zero would completely remove pavement condition from influencing the allocations. On the other hand, as the factor is increased, highway districts with the poorer pavements would receive proportionately larger allocations.

Each year the percentage of poorer pavements used in characterizing pavement conditions is examined in light of funds budgeted. When the budget is large, a percentage higher than 15 percent may be selected. Also, several modifying factors are used to generate sets of allocation figures; those are reviewed from the standpoint of minimum and maximum allocations to any highway district. The concern is to assure a competitive paving industry in all highway districts and yet to assure that excessive allocations may not overburden the industry in any district.

The allocation formula is unique because it incorporates condition of pavements along with miles of roads maintained and cost of bituminous materials. From its first use in 1982, it has been well accepted. This acceptance stems from recognition of differences between districts and that an equitable allocation of funds is essential.

Complete equalization in pavement conditions statewide is not sought because traffic loading, subgrade conditions, climate, terrain, etc. distinguishes one District from another and significantly affects pavement performance. The intent, however, is to achieve, in time, more equal conditions without unduly draining the state's resources.

Machine Patching

Historically, allocations to the districts for machine patching have been based on lane miles maintained and perceived needs. District managers administered the program and, in many instances, patching was done not only to maintain pavements at some reasonable level of service, but to achieve general improvements. These full-width, short-length (sometimes long-length) patches were often unwarranted, usually unsightly, too often had poorer rideability, and were more costly than equal length's of pavement resurfaced.

Beginning in 1986, efforts have been made to base patching allocations on pavement conditions in each district and to adjust patching to conform to and be compatible with the resurfacing program. Limited patching of the worst segments of pavements improve condition and extend life. However, continued, extensive patching results in quality that is not desired by the highway user and, instead, the pavement may warrant resurfacing. Pavements likely to be resurfaced next year should not be extensively patched. Pavements likely to need resurfacing within two to three years should not be extensively patched if possible and, if necessary, perhaps resurfacing should be done sooner.

When budgets for improvement (patching plus resurfacing) are small, more money must be spent on patching. In fact, with a very small budget, only patching may be feasible. With a large budget, less money needs to be spent on patching.

PAVEMENT CONDITION--RURAL SECONDARY ROADS

Rural Secondary Roads are under the jurisdiction of the Department of Rural and Municipal Aid and a report is provided for use in their pavement management activities. In general, the report includes rideability and estimated, general condition of pavements by county, district, and statewide. The report also cites trends in conditions and resurfacing needs (miles and dollars). The appendix of that report contains information for the 8,000 pavement sections in the state.

COMPARISON OF KENTUCKY'S PAVEMENT MANAGEMENT SYSTEM WITH FEDERALLY MANDATED POLICY ON PAVEMENT MANAGEMENT

On March 6, 1989, the Federal Highway Administration published Transmittal 428 of the Federal-Aid Highway Program Manual. This transmittal presents FHWA's Pavement Management and Pavement Design Policies. State highway agencies must be in compliance with this policy on or before March 6, 1993. The general statement of this policy is "each State Highway Agency (SHA) shall have a pavement management system (PMS) that is acceptable to FHWA and is based on concepts described in American Association of State Highway and Transportation Officials publications including its 1985 'Guidelines on Pavement Management'." The following paragraphs are a section-by-section comparison of the policy statement with Kentucky's pavement management system. The following material printed in the number paragraphs was taken directly from Transmittal 428.

4. <u>POLICY</u>

4.a. Pavement Management System. Each State Highway Agency (SHA) shall have a pavement management system (PMS) that is acceptable to FHWA and is based on concepts described in American Association of State Highway and Transportation Officials publications including its 1985 "Guidelines on Pavement Management."

4.a.(1) Background. For many years SHAs have been providing well-designed and constructed pavements, proper maintenance, and timely rehabilitation. Managing these activities in the past was difficult but did not involve many of the acute problems that now prevail. Rising costs, reduced resources, increased utilization of the system, needs that far exceed revenues, and a changing emphasis from system expansion to system preservation and rehabilitation are issues which highway administrators and engineers must address. A systematic approach to managing pavements is needed if the tremendous investment in today's highway network is to be protected and if every available highway dollar is to be maximized. A PMS provides the data, analysis capability, and products which give SHA decision makers key information with which to address these needs.

COMMENT In the 1960's and 1970's, road roughness and skid resistant surveys were made on a regular basis on the major highways throughout the state. In the past decade, Transportation Cabinet personnel have been increasingly aware of the importance of data collection and analyses on the inventory and condition of the highways under their jurisdiction. The present pavement management system in Kentucky is the result of an evolutionary process that has developed concurrently with the awareness of the need for such an information and management system. To date, no one particular document specifies in detail a step-by-step procedure of the pavement management system in Kentucky. This is largely because almost every administrative division of the Transportation Cabinet participates, to some degree, in the pavement management process. This is evident by the previous discussion on the flow of information within the pavement management system, and is illustrated by Figure 3. The present system provides voluminous data and analyses capability, which are absolutely vital for a viable pavement management system.

4.a.(2) Scope and Purpose. A PMS is a systematic approach to providing highway administrators and engineers with the types of information needed to effectively and efficiently manage their highway pavements. It includes the collection, processing, analysis, and reporting of data on pavement sections. The analysis and reporting capabilities of a PMS are directed towards identifying current and future needs, developing rehabilitation programs, priority programming of projects and funds, and providing feedback on the performance of pavement designs, materials, rehabilitation techniques, and maintenance levels.

COMMENT The present scope of Kentucky's PMS covers, to some degree, all aspects of a pavement management system. Data are collected, analyses are made, reports are prepared, and estimated funding needs are addressed. (Each of these items will be discussed later in greater detail.) Feedback is often done on a more informal basis, particularly in the areas of the effectiveness of maintenance strategies, materials performance, and design life. There is no formal method of feedback on the design process. The effectiveness, constructability, and workability of designs usually are not reported.

4.a.(3) Coverage

4.a.(3) (a) The SHA's PMS shall cover all Rural Arterial (Interstate, Other Principal Arterials and Minor Arterials) and Urban Principal Arterial (Interstate, Other Freeways and Expressways, and Other Principal Arterials) routes under its jurisdiction. The expansion of a SHA's PMS to include all rural and urban arterials, regardless of jurisdiction, is desirable. The development of a local PMS for pavements under local jurisdiction is also desirable.

COMMENT Data collection, reporting, and analysis include all roads under the state's jurisdiction. This includes the Interstate and Parkway System's, Federal-Aid Primary, Federal-Aid Secondary, Rural Secondary, and Supplemental Roads. Rural and urban arterials that are not under state jurisdiction presently are not included in the PMS. A number of local governments (cities and counties) in Kentucky have in recent years implemented to some degree a pavement management program. The Kentucky Transportation Center has assisted a number of local governments in this process. In one case (Lexington, Kentucky), The Transportation Center helped to develop the computer software, developed distress survey manuals, and trained personnel in pavement management procedures. One of the major differences between a local pavement management system and one used by a state agency is the local system usually relies heavily on visual distresses, whereas Kentucky's system relies heavily on ride quality.

4.a.(3) (b) Maximum benefits can be achieved from PMS when it includes all roadways under the jurisdiction of an agency. This provides for full network-level performance and trend information which would not otherwise be available. It is feasible to design various levels of sophistication and complexity into a PMS based on the relative level of management commitment and importance of the roadway section. For example, certain data may be collected visually for lower-order systems, but require some degree of objective measurement for higher-level systems.

COMMENT Various levels of sophistication are presently used in the PMS, particularly in the area of data collection. The Interstate and Parkway Systems are surveyed annually, more detailed information is collected, and more in-depth analyses are performed on the data. Only selected pavements on other systems are evaluated in detail each year. The types of data collected for the various systems have been discussed earlier in this report.

4.a.(4) Content

4.a.(4) (a) Certain key elements are in all effective PMSs. These elements must be tailored to address the characteristics of the organizational structure, available resources, decision making process, pavement network, and environment within the State. These key elements include:

4.a.(4) (a)1 Inventory - An accounting of the physical features of the roadway network is essential as a framework for the collection, storage, and retrieval of pavement information. Basic data items typically include lengths, number of lanes, widths, surface type, functional classification, shoulder etc. Expanded information on pavement structure material types and thicknesses, construction quality, and dates of major work including maintenance activities (i.e., project history data) can also be a valuable feature of an inventory since significant additional analysis and performance feedback data is possible.

COMMENT Kentucky's inventory system is extensive. Included in the data are location, length, number of lanes, surface type, year of construction or rehabilitation and system classification. The Interstate and Parkway inventory also includes pavement and DGA thicknesses, any rehabilitation treatment, and the presence of pavement edge drains, joint spacing, type of shoulder, and contractor.

4.a.(4) (a)2 Condition Survey - A measurement of the condition of the PMS roadway network from which the change over time can be determined. The four major measurements which are typically included in a PMS survey are: (a) ride (or roughness), (b) distress, (c) structural adequacy, and (d) surface friction. Ride and distress are often the two major parameters in a calculated "condition index" used in many PMSs, while structural adequacy and surface friction can be used as priority modifiers and aids to first-cut strategy selection for budgeting purposes. Distress data collection is usually separated by roadway type into at least two classes: asphalt and concrete. A number of different distress types have been used in PMSs, including various types of cracking, rutting, patching, joint condition, spalling, pumping, etc. The details and extent of distress data collection will be highly dependant on PMS scope and the characteristics of the State's roadways, environment, etc.

COMMENT Kentucky's condition survey is usually a "windshield" survey conducted at low speed with periodic stops to make rutting measurements. Most of the distresses that are cataloged are broad-category or "lumped" distresses that do not describe the cause or nature of the distress (example evaluation sheets are shown in Appendix A). Although this system is quicker, it is difficult for the designer or engineer to ascertain the cause of the distress. Kentucky's distress survey appears to be partly dependent upon the experience of the individual performing the rating. Those presently rating pavements have many years of experience and reproducibility is very good. However, it is questionable if data from a less experienced rater would correlate well with data from the experienced rater. Structural adequacy and surface friction data are not collected for all sections, but are collected only in special cases.

4.a.(4) (a)3 Traffic Data - Pavement loading data are a key element of a PMS which enters into analysis of pavement performance, deterioration rates, etc. Traffic data, necessary to calculate cumulative loads, is discussed more fully in paragraph 4b (1).

COMMENT Traffic will be discussed in a later section.

4.a.(4) (a)4 Database Systems - An effective, automated system for the storage and retrieval of roadway inventory, condition, and traffic data is a critical feature of successful PMSs. The PMS database can be considered as a resource for all functional elements of an SHA dealing with pavements, and is the source of data used in analyses and production of PMS products. A means of linking data to physical locations should be integral to the design of a database system, as this can provide for significant additional capabilities through correlations to other data sources maintained by an SHA; such as accidents, bridges, railroad crossings etc. The SHA is encouraged to incorporate its maintenance management system into the PMS.

COMMENT Five large data bases are maintained by the Pavement Management Branch. Information contained in these data bases are listed in Appendix C. These data bases may be easily accessed. Data bases maintained by others are used as needed. All data are located by highway milepoint. Highway milepoints are marked in the field by metallic numbers mounted on metal posts.

4.a.(4) (a)5 Highway Performance Monitoring System (HPMS) - Due to the similar data needs, coordination should be encouraged between a SHA's PMS and HPMS activities as they relate to pavement data items in the "HPMS Field Manual."

COMMENT There are over 2700 HPMS sample sections in Kentucky. Approximately 70 individual items of information are required for input into HPMS for each sample section. These include layer thickness or structural number, AADT, pavement type, geometry, traffic stream characteristics, drainage characteristics and other more detailed information. However, soil information and maintenance history are not included. HPMS is capable of summarizing present condition, performance and deficiencies, forecasting needs, predicting future conditions and performance under different scenarios, analyze investment strategies, and estimate user's costs. Some of the models used by HPMS include travel projection model, pavement deterioration model (based on AASHTO's structural number and a national average), capacity calculation model, improvement type simulation model, cost estimation model, improvement prioritization model, traffic density distribution model, traffic composition model, vehicle operation simulation model, composite index (sufficiency rating), and uses cost model. The HPMS data set is not used for pavement management purposes. Pavement roughness data are provided by PMP for all HPMS sample sections. Other data for HPMS are collected on a sample basis. The HPMS sample section seldom corresponds with a specific inventory section for pavement management. Thus, it is difficult to directly utilize HPMS data for some pavement management inquires. In addition, the HPMS pavement deterioration model does not correlate with Kentucky's experience in pavement deterioration (this was determined by comparing with Kentucky's thickness design curves). Therefore, it does not appear that HPMS can be directly implemented for pavement management purposes.

4.a.(4) (a)6 Data Analysis Capability - Effective manipulation of the information in the PMS database to produce useful input to decision makers is probably the most important of the PMS components. Capabilities in the areas of traffic analysis, network trends, project programming, project ranking and project strategy selection are useful ingredients. These procedures provide key information to SHA top management and is therefore a valuable resource to all types of pavement-related decision processes.

COMMENT Because the data are presently available, much of the analysis described above may and is already being performed. Project analysis and project ranking, system analysis, distress analysis, analysis by District, and funding needs are just some of the analyses that are now being performed. Some of the ways the results of these analyses are presently being presented are illustrated in Appendix E. However, there are many more ways the data presently available may be analyzed to provide SHA administrators and planners with vital information on future trends. It should be emphasized again that the Pavement Management Branch issues reports annually on each of the highway systems detailing all the data and analyses for that particular system.

4.a.(5) Products. Products and benefits from a PMS can be realized by many different types of groups both within and outside of the SHA. Examining the products of a PMS is one of the best measures of the benefits of the system. Some of the products that should be part of an acceptable PMS are:

4.a.(5) (a) For outside groups such as legislators and the public:

4.a.(5) (a)1 Status reports on overall trends and conditions; and

4.a.(5) (a)2 Analysis of future performance given specified budgets; and needed funds for desired performance levels (i.e., objective answers to the implications of lower funding levels and/or lower standards).

4.a.(5) (b) For SHA Management:

4.a.(5) (b)1 Comprehensive, comparative assessment of current and expected future network condition and needs;

4.a.(5) (b)2 Proposed single - and multi-year programs (i.e., prioritized listings) for meeting rehabilitation/reconstruction needs;

4.a.(5) (b)3 Reports on relative needs among different systems, areas of the State, etc.;

4.a.(5) (b)4 More accurate assessment of the cost effectiveness of various rehabilitation and reconstruction strategies; and

4.a.(5) (b)5 Impacts and costs of different program scenarios.

4.a.(5) (c) For SHA Technical/Engineering Staff:

4.a.(5) (c)1 Improved communication among planning, design, construction, maintenance, materials, and research on pavement issues through the consistent PMS database;

4.a.(5) (c)2 More accurate and complete information on "what's out there" when initiating project strategy selection and pavement design; and

4.a.(5) (c)3 More extensive pavement performance records over a period of years, which can be used to conduct evaluations of materials, designs, etc.

COMMENT The Pavement Management Branch issues the following annual reports.

1. Condition of Interstates,
2. Condition of Parkways,
3. Condition of the State Primary, State Secondary, and Supplemental Roads,
4. Condition of Rural Secondary Roads, and
5. Pavement Condition Evaluations for Resurfacing Program.

These reports and various memorandums are used by the State Highway Engineer and other management personnel to determine system needs and funding levels, Examples of tabular information and figures from these reports and memorandums are included in APPENDIX E.

4.a.(6) Implementation and Monitoring

4.a.(6) (a) The SHA's PMS shall be operational within a reasonable period of time, not to exceed 4 years from the effective date of this regulation. It is envisioned that many States will have to implement a PMS on a staged basis, putting the components of the system into operation as each is developed. It is not expected that analysis capabilities which require detailed historic pavement performance information, such as multi-year programming, be operational within this time frame since the necessary data may not be sufficient. These capabilities will develop and improve as the condition database grows.

4.a.(6) (b) The FHWA field offices will monitor the States' implementation and assess progress and adequacy on the basis of periodic reviews. The reviews will assess the PMS primarily on the quality of the data collected, the products being produced and their use in strengthening the States's pavement program.

COMMENT Kentucky's pavement management system is well advanced beyond the stage of those used in many states today. The majority of the elements described in Transmittal 428 are addressed in some capacity, or are in various stages of development.

4.b. General Pavement Design Considerations. The SHA's pavement design procedures should include consideration of traffic, roadbed soils, reliability analysis, drainage, shoulder structure, environment, economic analysis, pavement performance, and materials of construction. Based on recent research efforts and noted pavement design weaknesses, SHAs are encouraged to give special attention to the following six items in designing new, reconstructed, or rehabilitated pavements.

4.b.(1) Traffic

4.b.(1) (a) Accurate cumulative load (normally expressed as 18 kip equivalent single axle loads or ESALs) estimates are extremely important to structural pavement design. Load estimates should be based on representative current vehicle classification and truck weight data and anticipated growth in heavy truck volumes and truck weights. Representative current traffic data should be obtained using a statistically valid procedure for obtaining count, classification, and weight data comparable to the procedure recommended in the FHWA "Traffic Monitoring Guide." Vehicle classification data on the number and types of trucks is essential to the estimation of cumulative loads during the design period and should be given special emphasis. Weight information should be obtained using weigh-in-motion (WIM) equipment since this data is more representative than data obtained using static scales. States should purchase and implement the use of automatic vehicle classification and WIM systems as soon as possible to improve the current base traffic data from which to forecast future truck volumes and loads.

COMMENT The Division of Planning currently obtains the following information.

a. Vehicle Classifiers (AVC)
21 permanent locations and continues counts
350 locations counted 48 hours each on a 3 year cycle

b. Volume
Every year Interstate
Every 3 years HPMS sites (2300)
Rest on 6 year cycle

c. Weighing - WIM

90 locations on 3 year cycle - 48 hours
7 SHRP sites annually - 78 hours
Static - Interstate - 11 locations 48 hours quarterly

4.b.(1) (b) When forecasting future loadings, SHA's should, at a minimum, make forecasts for two truck classes: trucks up to 4-axle combination and trucks with 5-axles or more. Changes in load factors should also be monitored and forecasted. The forecasting procedures should consider past trends and future economic activity in the area. A traffic data collection and forecasting program that identifies the most important truck types and the changes in numbers and weights of these truck types during the ~~design period should provide realistic load estimates.~~

COMMENT Kentucky uses as many as 13 classes of vehicles to forecast future ESAL's (this includes pickup trucks and automobiles). A recent research study conducted for the Transportation Cabinet proposed a comprehensive traffic prediction model for Kentucky that provides for detailed growth factors. Some of the parameters that determine these growth factors include population, personal income, fuel prices, vehicle registrations, functional classification, vehicle-miles, and highway miles. Portions of this model are presently being implemented.

4.b.(2) Reliability Analysis. The use of the reliability concept provides a rational approach for evaluating the probability that a pavement section will perform as designed over the performance period. A reliability analysis should include a method for accounting for chance deviation in performance caused by variation in construction, environment, traffic estimates, and lack of fit errors in the design equations. Ideally, estimation of the components of chance variations should be based on design, construction and environmental conditions similar to the project site. Pavement performance probability distributions are generally normal. As a result, the incremental cost of achieving increased reliability significantly increases as the reliability level goes up. Therefore, the selection of an appropriate level of reliability should be based on a careful weighing of the incremental cost against the risk associated with premature distress. The SHAs are encouraged to become familiar with the reliability concept and how it can be applied in the design of pavement structures.

COMMENT Kentucky's present pavement design system does not provide for reliability directly. However, preliminary results from a research study presently being conducted (KYHPR-88-125, "Pavement Design Parameters for Kentucky Conditions") indicate that for Present Serviceability Indicies of 2.5 or less, Kentucky's design system provides a reliability of 85 to 95 percent. However, for Present Serviceability Indices of 3.0 or greater, the reliability appears to vary with ESAL's (90 percent at 10^4 ESAL's to approximately 50 percent at 10^6 ESAL's). These results are only preliminary, however, and the study is continuing.

4.b.(3) Drainage. Free water that enters and collects within undrained pavements is a primary cause of premature and continuing pavement damage. A number of recently completed research efforts that included evaluation of performance and maintenance costs confirm that providing adequate pavement drainage is highly cost-effective over the long term. The SHAs are encouraged to perform a drainage analysis for each new, rehabilitated, or reconstructed pavement structure. Designs should provide for methods to minimize the potential for reduced service life due to saturated structural layers. Methods include subsurface drainage, joint and crack sealing, roadside drainage and the use of moisture insensitive materials.

COMMENT In the last decade, Kentucky has placed great emphasis on pavement drainage for new and rehabilitated pavements. Hundreds of lane-miles of pavement edge drains have been installed on Interstate and Parkway pavements. Free-draining granular bases are now being constructed, and the Department of Highways is committed to the design and construction of many more miles of these bases. Cross drains are also being used in many applications on new construction to intercept water travelling downgrade under the pavement structure.

4.b.(4) Shoulder Structure. Recent studies demonstrate that structurally adequate shoulders improve both mainline pavement and shoulder performance. The SHAs are encouraged to use paved shoulders where conditions warrant. Shoulders should be structurally capable of withstanding wheel loadings from encroaching truck traffic. On urban freeways or expressways, strong consideration should be given to constructing the shoulder to the same structural section as the mainline pavement. This will allow the shoulder to be used as a temporary detour lane during rehabilitation or reconstruction. The SHAs are also encouraged on new and reconstructed pavement projects to investigate the advantage of specifying that the shoulder be of the same materials as the mainline, particularly for high-volume roadways. Constructing shoulders of the same materials as the mainline facilitates construction, reduces maintenance costs, and improves mainline pavement performance.

COMMENT Guidelines for Design of Highway Pavements are presently under the review and implementation stage in the Department of Highways. The guidelines state that paved shoulders are the preferred option. The guidelines also recommend that the mainline pavement be constructed two feet wider on the outside shoulder to provide better edge support for the pavement.

4.b.(5) Economic Analysis (Life Cycle Cost). The concept of life cycle costing is an important pavement management and design tool. Selection of a pavement design only because it has the lowest initial cost can lead to serious future pavement problems. Since pavements are long term public investments, it is appropriate to consider all the costs that occur throughout their lives. While the analysis will identify the alternative with the least life cycle cost, available funding may not permit its selection. The selection of an alternative should take into account the results of the life cycle cost analysis, but these results must be weighed against the needs of the entire system. While the least cost alternative for one highway section may be total reconstruction, it might be so expensive that other sections could not receive timely rehabilitation and thus might require more costly repairs in the future.

COMMENT An abbreviated method of life-cycle cost analysis has been conducted in the past on selected projects, primarily on Interstate highways. A research study entitled "Life-Cycle Costing Analysis of Pavements" (KYHPR-88-118) is presently being conducted to develop a life-cycle cost analysis procedure for Kentucky. It is anticipated the results of that study will be implemented to assist in making in-depth economic analyses of many pavement projects in the future.

4.b.(6) Material Properties. Material properties have a major impact on pavement design and performance. The design process should consider the following: the properties and related performance characteristics of available materials; new materials and practices which may be available that can contribute to extended pavement life; and the constructability and maintainability of the specified materials or processes.

COMMENT New materials and practices are continuously being investigated in an attempt to improve service life. Some of the items that are often used and studied include different types and configurations of pavement drains, various geotextiles, asphalt modifiers and/or additives, various types of aggregates, various gradations of asphalt mixtures, subgrade stabilization, and various construction techniques.

4.b.(6) (a) Quality Assurance/Quality Control. Increased truck weights, axle loads, and tire pressures, as well as stiffer truck suspension systems and new axle configurations, have created the need for emphasis on the design and construction of high quality pavements to prevent premature rutting and stripping of asphalt pavements and pumping of concrete pavements. Appropriate mix design, specifications, and construction procedures need to be established for materials, construction, and maintenance, so that design parameters and assumptions will be met. Quality Assurance/Quality Control processes need to be established for the processing and production of materials, construction inspection, and maintenance operations to assure that the assumed pavement performance period will be attained.

COMMENT Kentucky Standard Specifications for Road and Bridge Construction (current edition is 1988) form the basis for quality control of construction. Standard Specifications are supplemented by Special Provisions and Special Notes that clarify, or in some cases, supersede the Standard Specifications. Testing procedures for all materials are documented in the Division of Materials' manual entitled "Kentucky Methods". These published methods ensure uniform testing procedures at testing laboratories throughout the state, and promote repeatability of results. In addition, the Division of Maintenance maintains a "Field Operations Guide" in an effort to promote efficient, economical, and uniform maintenance operations.

4.b.(6) (b) Resilient Modulus (M_R). The resilient modulus (M_R) has been used by many highway engineers and researchers and was included in the 1986 "AASHTO Guide for Design of Pavement Structures" (1986 Guide) as the definitive property to characterize materials for pavement design. It is a measure of a material's modulus of elasticity under repeated loading increments. It closely represents the pavement behavior when subjected to a moving wheel load and can be used in mechanistic analysis of multi-layer systems for predicting pavement distress and performance. The SHAs are encouraged to become familiar with procedures for determining resilient modulus and how it can be applied in the design of pavement structures.

COMMENT The Kentucky Flexible Pavement Design Procedure and also the Rigid Pavement Design Procedure are mechanistic-empirical. Mechanistic-empirical indicates the model for pavement behavior was derived from some theoretical model and then calibrated against observed pavement performance. In Kentucky's case, the models of pavement behavior were derived from elastic layer concepts and correlated with field performance in Kentucky. Additional correlations with the AASHO Road Test have been used for verification. Elastic moduli have been used for development of Kentucky's pavement design procedures. Current elastic moduli for pavement design are 480 ksi for asphaltic concrete and 4,200 ksi for Portland cement concrete pavement. Subgrades were characterized by elastic moduli for the development of the pavement design procedures and converted to CBR by dividing by 1500. Thus, it is believed feasible to utilize resilient modulus of subgrades with Kentucky's current pavement design procedure. The limiting strain criterion also can be applied when using material with elastic moduli that are different from those used for the current pavement design procedure. Additionally, the resilient modulus test has been used on selected construction projects as a referee test to judge the quality of a particular asphaltic concrete mixture. resilient moduli have been used on a limited number of projects where special materials were being used to refine the thickness design of flexible pavements.

4.c. Pavement Design - New and Reconstructed Pavements. Each SHA shall have a process that is acceptable to FHWA for the type selection and design of new and reconstructed pavement structures. The type selection process shall include an engineering and economic analysis for alternate designs. The analysis period selected shall be the same for all alternates being considered.

COMMENT A copy of Kentucky's guidelines for design of highway pavements is included in Appendix F. The comments that follow will frequently refer to that document.

4.c.(1) Pavement Type Selection

4.c.(1) (a) Each SHA shall have a pavement type selection process for the design of new or reconstructed pavements. The analysis period selected should include an initial pavement structure performance period, plus at least one rehabilitation operation. Appendix B of the 1986 Guide provides excellent guidance on the content of a pavement type selection process. The SHAs are encouraged to include in the pavement type selection process those principal and secondary factors listed in Appendix B. The selection of pavement type is not an exact science, but a process in which engineering judgments are made on both the type of factors included and the values assigned to each. The FHWA field offices will determine the adequacy of the SHA pavement type selection procedures through periodic reviews.

COMMENT As stated previously, research is currently being conducted to develop a detailed life-cycle cost procedure to assist the designer and administrator in selecting the most cost effective alternative. Life-cycle costing procedures have already been initiated on a limited scale, however, it is expected at the conclusion of the current research study that a more comprehensive procedure will be adopted. Additionally pavement type selection is related to other considerations such as historical pavement performance, initial cost versus available budget, locally available materials, and site specific and regional considerations.

4.c.(1) (b) The FHWA does not encourage the use of alternate bids to determine the pavement type. In those rare instances where the use of alternate bids is considered, the SHA's engineering and economic analysis of the pavement type selection process should clearly demonstrate that there is no clear cut choice between two or more alternatives having equivalent designs. Equivalent design implies that each alternative will be designed to perform equally over the same performance period without subsequent rehabilitation during this period. The use of planned rehabilitation is not allowed when evaluating alternate bids. Equal performance is intended to include similar life-cycle costs. For example, a 12-year design requiring frequent maintenance is not considered equal in performance to a 12 -year design requiring very little maintenance, even though initial costs are identical.

COMMENT Alternate bids presently are utilized only for state funded projects as these alternate bids typically involve a rigid pavement alternative, a maximum aggregate base alternative, and a maximum bituminous alternative.

4.c.(2) Methods of Pavement Design. Each SHA shall have procedures for the design of new or reconstructed pavements. The SHA may use the design procedures outlined in the 1986 Guide or they may use other pavement design procedures that by past performance or supported by research are satisfactory for the pertinent conditions. The FHWA field offices will conduct periodic reviews to determine the acceptability of the SHA's pavement design procedures. Project-by-project pavement design checks will not be required. However, using the SHA's accepted procedures, the FHWA should review a number of project pavement designs each year to ensure that the SHA is following these procedures.

COMMENT Kentucky's method of flexible pavement design is a mechanistic-empirical method. The original thickness design curves (1949 and modified in 1959) were based upon empirical data. These design procedures have been modelled using principles of layer linear elastic theory. The 1981 edition of Kentucky's thickness design curves use the tensile strain at the bottom of the asphalt layer and the compressive strain at the top of the subgrade as the governing criteria for failure. A 1987 version of the curves uses work strain as the governing criterion. The 1987 version is currently being reviewed by pavement design staff for potential implementation.

4.d. Pavement Design - Rehabilitated Pavements. Each SHA shall have a pavement rehabilitation selection process that is acceptable to FHWA and that includes identification of candidate solutions and a methodology for structural design. For pavements approaching terminal serviceability and exhibiting significant structural deficiencies, the process shall include procedures for making an engineering and economic analysis of alternative rehabilitation strategies. These alternative rehabilitation strategies should include both reconstruction and rehabilitation alternatives. It is essential that rehabilitation projects be properly engineered in order to obtain the goal of achieving the best return possible for the money expended. It is recognized that it may not be necessary to provide alternatives or a detailed economic analysis of alternatives for all rehabilitation projects. If an existing pavement structure is sound and the cost to restore serviceability is minor when compared to the cost for a new pavement structure or major rehabilitation, an engineering and economic analysis of alternative actions may not be necessary. In general, for all major rehabilitation projects, each of the following steps should be followed to properly analyze and design the project.

4.d.(1) Project Evaluation

4.d.(1) (a) Obtain the necessary available information to evaluate the performance and establish the condition of the in-place pavement with regard to traffic loading, environmental conditions, and material strength. A pavement's historical condition data, obtained from the PMS, can provide good initial information.

COMMENT Traffic loading information is collected and processed by the Division of Planning. Variations in pavement design on the basis of environmental considerations and material strengths are considered by the Division of Design in the development of final pavement designs. Historical pavement condition data are collected and maintained by the Pavement Management Branch, and are supplied to the Pavement Design Branch in the form of annual reports on pavement conditions and more detailed trends of pavement condition information once the specific project has been identified for rehabilitation.

4.d.(1) (b) Before developing appropriate rehabilitation alternatives, it is important that the type of pavement distress be identified and the factors causing the distress determined. This need is often overlooked when considering rehabilitation strategies. The tools to perform project failure analysis such as coring, trenching, and measuring deflection are well known, but need to be emphasized.

COMMENT A research report entitled "Interim Guidelines for Design of Highway Pavements" (Report No. KTC 89-1), published by the Kentucky Transportation Center, recommends under Section VIII, Item B, (Thickness Designs for Overlays) that the "pavement condition may be determined on the basis of (a) visual condition surveys, (b) pavement rideability analyses, or (c) pavement deflection analyses. Structural overlay thickness designs for flexible pavements currently are determined on the basis of an effective thickness approach, wherein the effective thickness is determined from deflection measurements. There are other methods of determining overlay thickness requirements as are outlined in the 1986 AASHTO Guide for Design of Pavement Structures. Overlay thickness requirements simply are the result of determining the thickness requirements for a new pavement and subtracting the effective thickness or remaining life of the existing pavement. The remaining life of a pavement may be estimated by non-destructive testing (NDT), by accumulation of traffic, by the time approach which relies heavily on historical condition information, and by the serviceability approach which is related to the change in serviceability (a functional deterioration) of the pavement. The various procedures all have their strengths and weaknesses which are discussed in the 1986 Guide. Additionally there are variations in addressing the NDT, serviceability, and the visual condition approach. The Kentucky NDT approach expresses pavement condition in the form of effective thicknesses of reference quality material. An alternate approach involves expressing pavement behavior as effective layer moduli for the constructed pavement layers. The effective thickness approach seems to work well for relatively thin bituminous overlays (less than 3-4 inches). However, the limiting strain approach used in the development of Kentucky's pavement design procedures may be used for overlay design if existing layer moduli are known from either destructive or non-destructive testing. Additionally, pavement distress information can be valuable in assessing the cause of pavement deterioration. Current procedures for pavement conditions are done by windshield surveys. This has been quite effective in ranking the various pavements on the basis of observable distress. However, the combined distress identification approach sometimes does not appear sensitive enough to differentiate causes of distress. Additional distress identification and/or coring and destructive testing may be in order for some projects. This area needs further attention.

4.d.(1) (c) Feasible alternatives should address the causes of the deterioration, be effective in repairing the existing distress, and prevent the premature reoccurrence of the distress.

4.d.(2) Project Analysis

4.d.(2) (a) Perform an engineering and economic analysis on candidate strategies. The engineering analysis should consider the traffic loads, climate, materials, construction practices, and expected performance. The economic analysis should consider service life, initial cost, maintenance costs, and future rehabilitation requirements, including maintenance of traffic costs.

4.d.(2) (b) Select the best rehabilitation alternative. Although the economic analysis results are important in selecting the preferred alternatives, budget constraints and engineering judgment should also be considered in selecting the best alternative for a particular project.

COMMENT Feasible alternatives are developed to address traffic loads, climate, available materials, construction practices and past performance. Maintenance of traffic also is considered when evaluating the feasibility of proposed alternates. Proposed rehabilitation alternates are reviewed by a Pavement Committee involving representatives of the Divisions of Design, Materials, Maintenance, and Specialized Programs (Pavement Management Branch). The Division of Design, in consultation with the Pavement Management Branch, the Division of Materials, and the Division of Maintenance, develops alternate rehabilitation strategies. Economic analyses are conducted by the Division of Design. Currently, economic analyses involve initial costs and simplified life-cycle cost analyses. As was discussed earlier, a comprehensive life-cycle costing research study is underway and is anticipated to result in refined economic analyses of pavement designs. The results of economic analyses are presented to the Pavement Committee and a final decision regarding strategy is developed. The Division of Design then finalizes the proposed rehabilitation design.

4.d.(3) Project Design

4.d.(3) (a) Sufficient testing, both destructive and non-destructive, should be conducted to verify the assumptions made during the alternative comparison. A new distress survey should be considered if the original survey was not 100 percent of the project, or was not completed within a year of the time the project is scheduled to go to contract.

COMMENT Rather than conduct sufficient testing to verify design assumptions made during development of rehabilitation alternatives, it appears that rehabilitation alternates should be custom designed to fit site specific conditions rather than relying on policy prescribed rehabilitation design and then adjusting on the basis of site specifics. The Pavement Management Branch collects initial pavement distress information and deflection tests which form the basis for their recommendations for rehabilitation alternatives. The Division of Design may request additional testing and/or conduct additional analyses for finalization of rehabilitation strategies.

4.d.(3) (b) In addition to the surface indicators, it is essential that the final design consider and address all factors causing the distress. Such factors as structural capacity, subgrade support, surface and subsurface drainage characteristics need to be considered and provided for in the final design.

4.d.(3) (c) Once a rehabilitation alternative is selected, the project should be designed using appropriate engineering techniques. There are a number of publications available to guide the selection of these engineering techniques. The FHWA's "Pavement Rehabilitation Manual," and training course "Techniques for Pavement Rehabilitation: provided excellent guidelines. There are also a number of excellent guides available from the asphalt and concrete industries.

4.d.(4) Project Implementation. It is important that the intent of the design be well documented in the project plans and specifications so as to provide both the contractor and the construction engineering personnel a clear and concise project proposal. In addition, adequate communication should be maintained between the design and construction engineers to reinforce the intent of the design and provide feedback on project constructability and performance so that timely evaluation can be made of the selected rehabilitation alternative and its appropriateness. The performance information should also be included as a part of the SHA's PMS. The lack of good performance data on pavement rehabilitation techniques has been one of the weaker points in the rehabilitation process. Increased emphasis should be placed on developing basic performance data that is not presently available on a rehabilitation technique.

4.e. Safety. Each project involving construction of a pavement shall have a skid resistant surface. Pavement rehabilitation and reconstruction projects shall also incorporate other cost-effective opportunities to enhance safety as required by 23 CFR 625.2.

4.e.(1) The SHAs should be encouraged to provide for skid resistant surfaces on all projects, regardless of funding source. New pavement surfaces constructed with Federal funds shall have skid resistant properties suitable for the needs of the traffic. New pavement surfaces which are financed by others on projects where a skid resistant surface was previously constructed with Federal funds are expected to have skid resistant properties suitable for the needs of the traffic. Pavement performance histories and existing skid data should be analyzed to ensure that the materials, mix designs, and construction techniques used are capable of providing a satisfactory skid resistant surface over the expected performance period of the pavement. Each SHA's skid accident reduction program should include a systematic process to identify, analyze, and correct hazardous skid locations. The same procedures and quality standards used in construction should be used in maintenance operations.

COMMENT Kentucky has developed guidelines for selection of bituminous surface based on skid resistance performance under various traffic speed and travel spped conditions. The guidelines have been approved by FHWA and are being applied to all projects. The guidelines are prerated in Appendix D.

4.e.(2) Pavement rehabilitation and reconstruction projects are to be developed and accomplished in a manner which considers and includes appropriate safety improvements. The scope of the needed pavement improvement should be considered when determining the type of improvements that are feasible, prudent, and practical. Minor safety improvements may be appropriate for pavement rehabilitation projects while significant geometric upgrading may be appropriate for pavement reconstruction projects.

4.e.(3) Even though pavement resurfacing typically enhances safety by addressing problem areas such as rough pavements, poor surface drainage, low skid resistant qualities, etc., resurfacing alone does not fulfill the congressional intent that 3R/4R projects enhance highway safety. Other cost-effective roadway safety improvements must also be considered.

4.e.(4) Plans and specifications for proposed pavement rehabilitation and reconstruction projects should include items to minimize disruption and ensure adequate protection of the motorists and workers within the construction work zone, in accordance with the provision of 23 CFR 630, Subpart J and 23 CFR 635.125.

CONCLUSIONS

The growth and evolution of Kentucky's pavement management system has been rapid in the past decade. In the author's opinion, Kentucky's pavement management system is well advanced beyond the stage of those used in many states today. The majority of the elements described in Transmittal 428 are addressed in some capacity, or are in various stages of development.

Development of more refined economic analysis procedures are in progress. The major portion of this development is the description and integration of remaining-life models into the procedures. Also some form of user costs models and maintenance costs models need to be established. Presently, it appears that maintenance cost data may be difficult to obtain. This is partly because major maintenance on any particular facility is often considered to be spot resurfacing in the form of machine patching. It is anticipated that a user cost model will be one that has already been developed by other researchers and will be modified to reflect Kentucky's needs.

There is a tremendous amount of data presently available in the data bases that are maintained by the Pavement Management Branch. It appears these data could be utilized more fully if other administrative units within the Transportation Cabinet had easy access to the information. Each unit could then perform any analysis that might be needed.

A major deficiency in Kentucky's pavement management system appears to be the lack of a formal feedback mechanism. There needs to be some type of formal feedback mechanism developed wherein the impact of changing policies, design procedures, maintenance procedures, and new materials are followed. The Pavement Committee discussed earlier and the Design Guidelines may be the appropriate mechanism to facilitate the feedback process.

A review of data and reports from the PMS on Kentucky's machine patching program indicates considerable tonnage is being used by maintenance personnel for (what appears to be) structural patching. It is suspected that much of this is accomplished without updated distress or rideability surveys or consultation with pavement management personnel. Structural patching for long stretches of pavement dramatically changes the pavement condition rating, and this activity hinders the proper functioning of a central pavement management system.

Roughness measurements are presently made with a "response-type" measurement system. This system measures the response of the vehicle to the irregularities of the pavement surface. Consequently, the measurements are highly dependent upon the reaction and condition of the vehicle's suspension system. This necessitates frequent recalibration of the system for wear and other changes in the suspension system. A more direct method of measuring roughness is needed (one that is independent of the vehicle).

Another area which bears some discussion involves the area of visual distress identification and determination of causes of distress. The current method involves a windshield survey, and involves identification of pavement distress in seven general areas: (1) cracking, (2) base failures, (3) raveling, spalling or wear, (4) out-of-section, (5) patching, (6) appearance, and (7) pavement rutting. The rating procedure has served Kentucky well for the past several years and results in realistic rankings of pavement projects on the basis of extent and severity of observable distress. The major shortcoming of this procedure appears to be that the rating process does not readily lend itself to an identification of the causes of the distress. As referenced in the FHWA pavement policy statement and other literature concerning pavement rehabilitation, the identification of the causes of pavement distresses are critical for the development of alternate rehabilitation strategies. While if is not perceived necessary to specifically identify the cause of distress for ranking of pavements, it is concluded that final design of rehabilitation alternatives should address not only the distress but also the cause of the distress.

RECOMMENDATIONS

It is recommended that a formal procedure for feedback to the Pavement Management Branch be established.

The present pavement rating system is somewhat subjective, and different individuals may rate the same pavements slightly differently (although presently most pavements are rated by experienced personnel and results are very consistent). Consequently, it is recommended that a more automated system be introduced (when reliable systems are available) to remove the possibility of greater variability that could be produced by less experienced raters. In addition, a greater volume of data could be obtained in less time, and at less risk to personnel when using an automated system. The technology of these systems has advanced rapidly in the last few years, producing highly reliable data at reasonable cost.

It is recommended that research and development on life-cycle costing procedures, including the associated models, continue, and eventually be adopted.

FUTURE

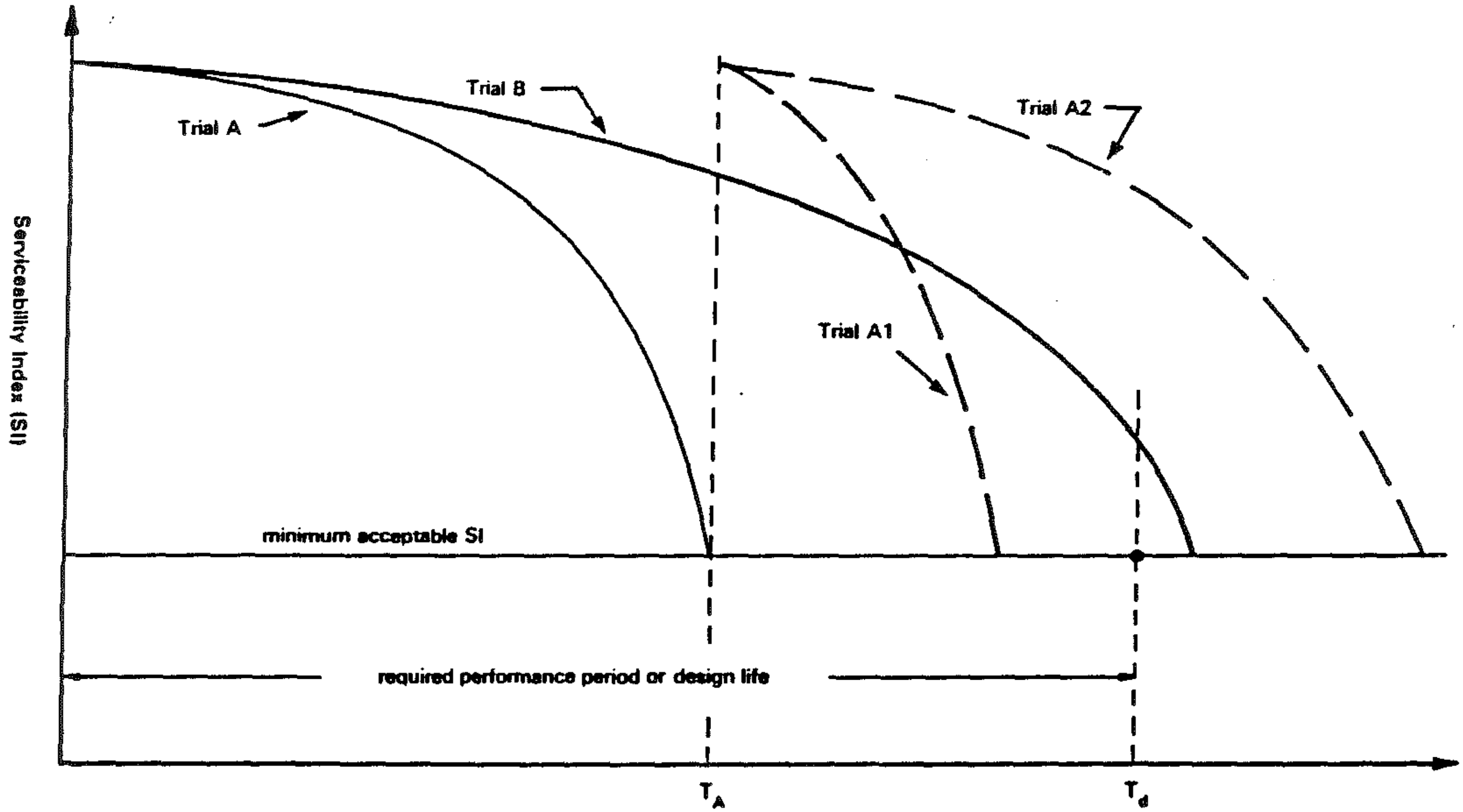
Most of the present operating system will be applicable many years into the future. However, improvements will continue to be made in the system. More data and more history will be available, making the analyses and projections more reliable. Better statistical and performance models will undoubtedly become available. These also will produce greater reliability. Research will continue to be stressed to determine more efficient ways to obtain data, to store and retrieve data, and to utilize data.

TABLE 1

RIDEABILITY INDEXES AND CORRESPONDING PAVEMENT CONDITION INDEXES
FOR ESTIMATING GENERAL CONDITION OF PAVEMENTS

ADT	RIDEABILITY INDEX (PAVEMENT CONDITION INDEX)		
	POOR CONDITION	FAIR CONDITION	GOOD CONDITION
Above 8000	*2.7(0.0) or lower	2.8(0.1) to 3.1(0.4)	3.2(0.5) or higher
6201- 8000	2.6(0.0) or lower	2.7(0.1) to 3.0(0.4)	3.1(0.5) or higher
4401- 6200	2.5(0.0) or lower	2.6(0.1) to 3.0(0.5)	3.1(0.6) or higher
2701- 4400	2.4(0.0) or lower	2.5(0.1) to 2.9(0.5)	3.0(0.6) or higher
1501- 2700	2.3(0.0) or lower	2.4(0.1) to 2.8(0.5)	2.9(0.6) or higher
1101- 1500	2.2(0.0) or lower	2.3(0.1) to 2.8(0.6)	2.9(0.7) or higher
901- 1100	2.1(0.0) or lower	2.2(0.1) to 2.7(0.6)	2.8(0.7) or higher
701- 900	2.0(0.0) or lower	2.1(0.1) to 2.7(0.7)	2.8(0.8) or higher
601- 700	1.9(0.0) or lower	2.0(0.1) to 2.6(0.7)	2.7(0.8) or higher
501- 600	1.8(0.0) or lower	1.9(0.1) to 2.6(0.8)	2.7(0.9) or higher
401- 500	1.7(0.0) or lower	1.8(0.1) to 2.5(0.8)	2.6(0.9) or higher
301- 400	1.6(0.0) or lower	1.7(0.1) to 2.5(0.9)	2.6(1.0) or higher
201- 300	1.5(0.0) or lower	1.6(0.1) to 2.4(0.9)	2.5(1.0) or higher
1- 200	1.4(0.0) or lower	1.5(0.1) to 2.4(1.0)	2.5(1.1) or higher

*Critical RI's



Time or Accumulated Traffic

T_A = Life of Design Trial A
T_d = Design Life Desired

Trial A and Trial B are competing design alternates.
Trial A1 and Trial A2 are competing rehabilitation strategies.

Figure 1. Idealized Service History of a Typical Pavement (from the 1986 AASHTO "Guide for Design of Pavement Structures")

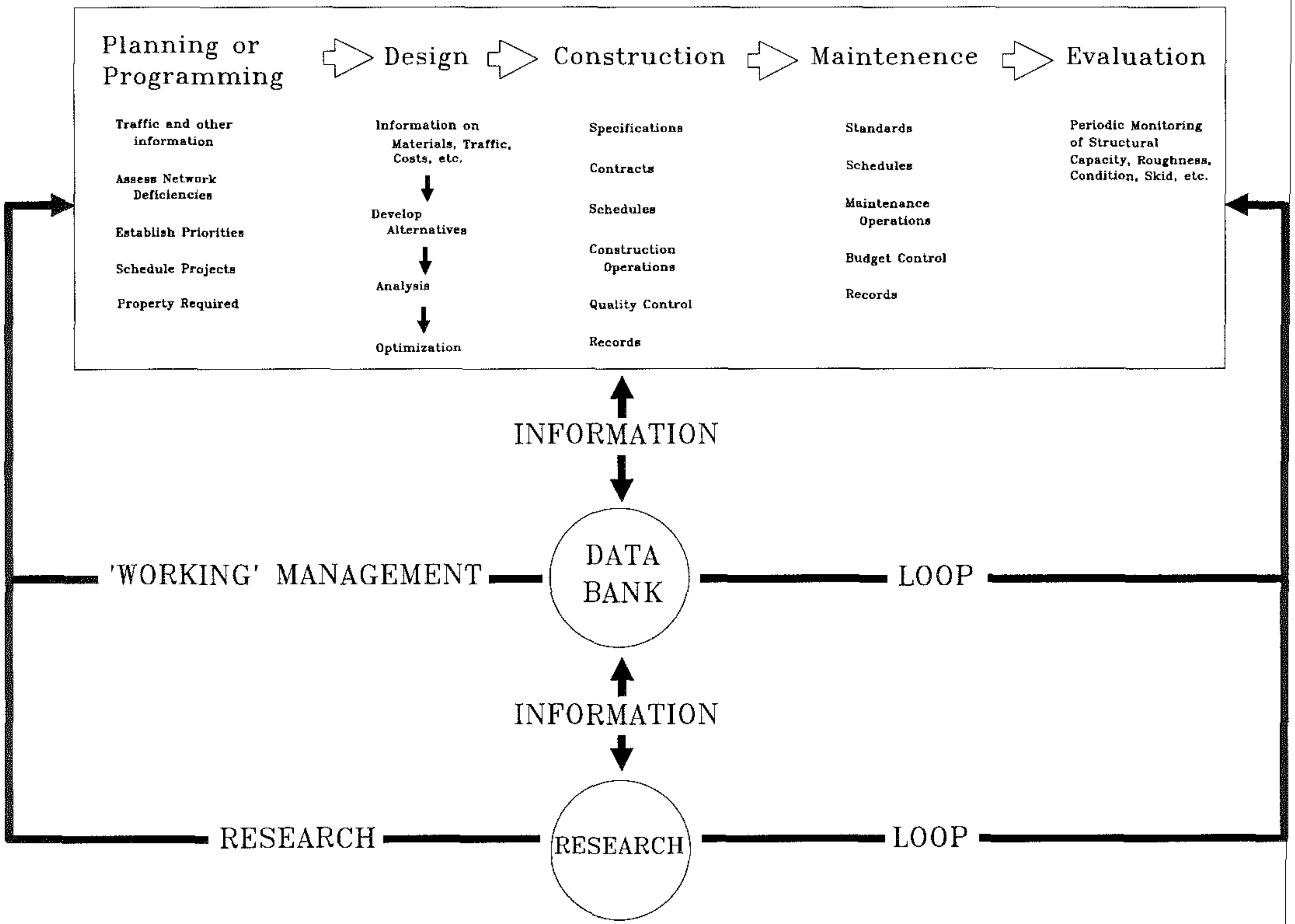


Figure 2. Major Activities of a Pavement Management System (from the Pavement Management Guide prepared by the Road and Transportation Association of Canada).

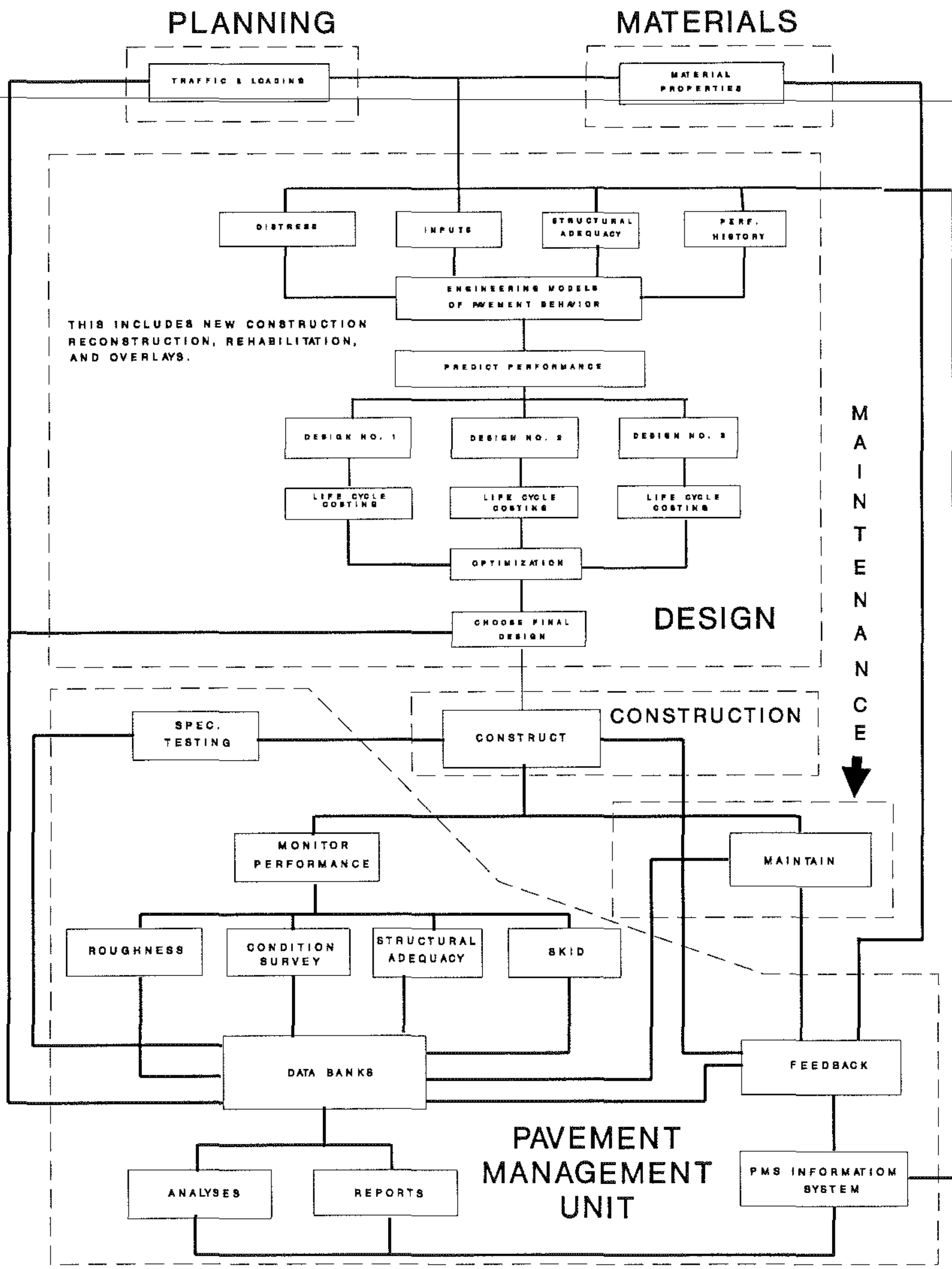


Figure 3. Flowchart of Kentucky's Pavement Management System.

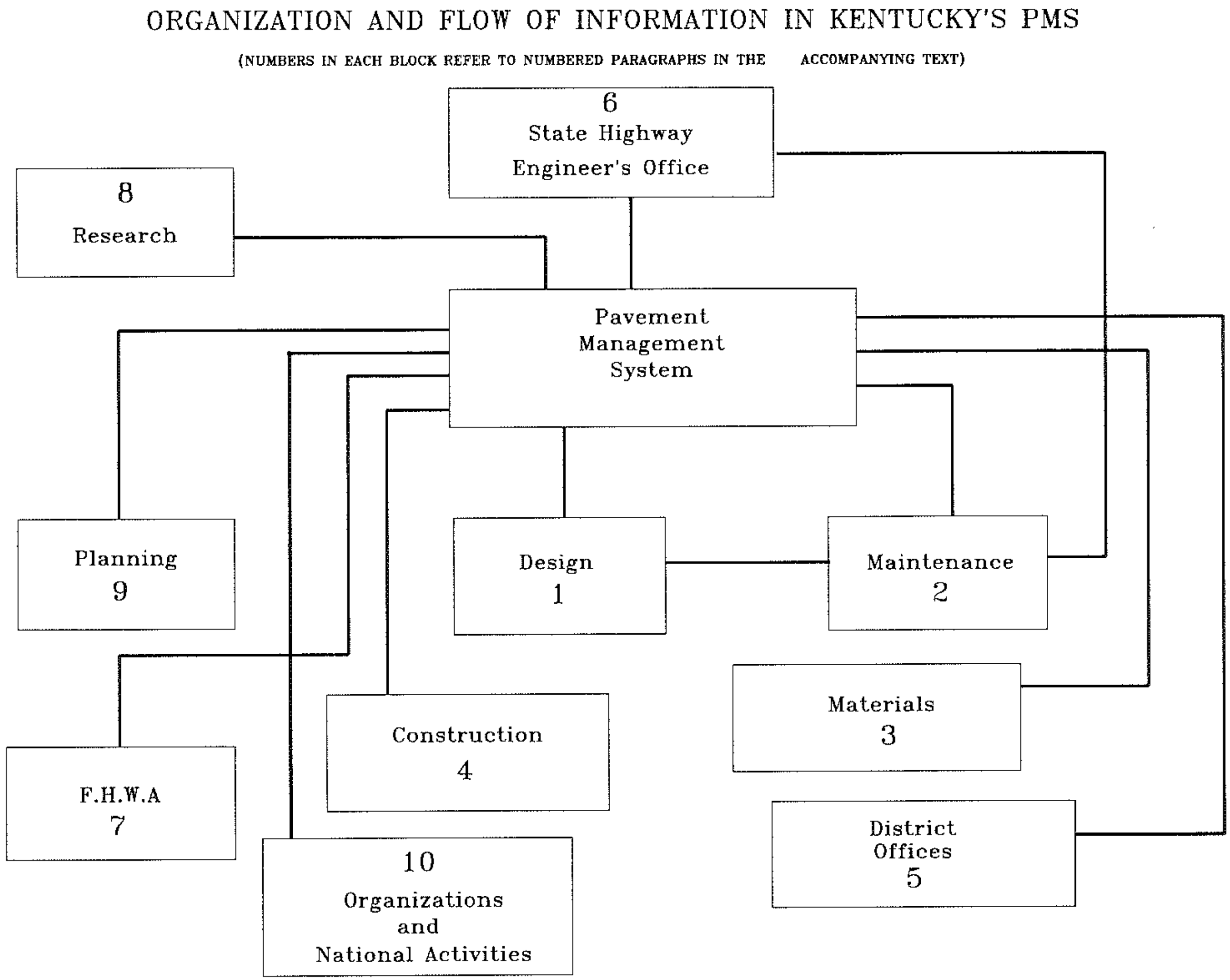


Figure 4. Organization and Flow of Information in Kentucky's Pavement Management System.

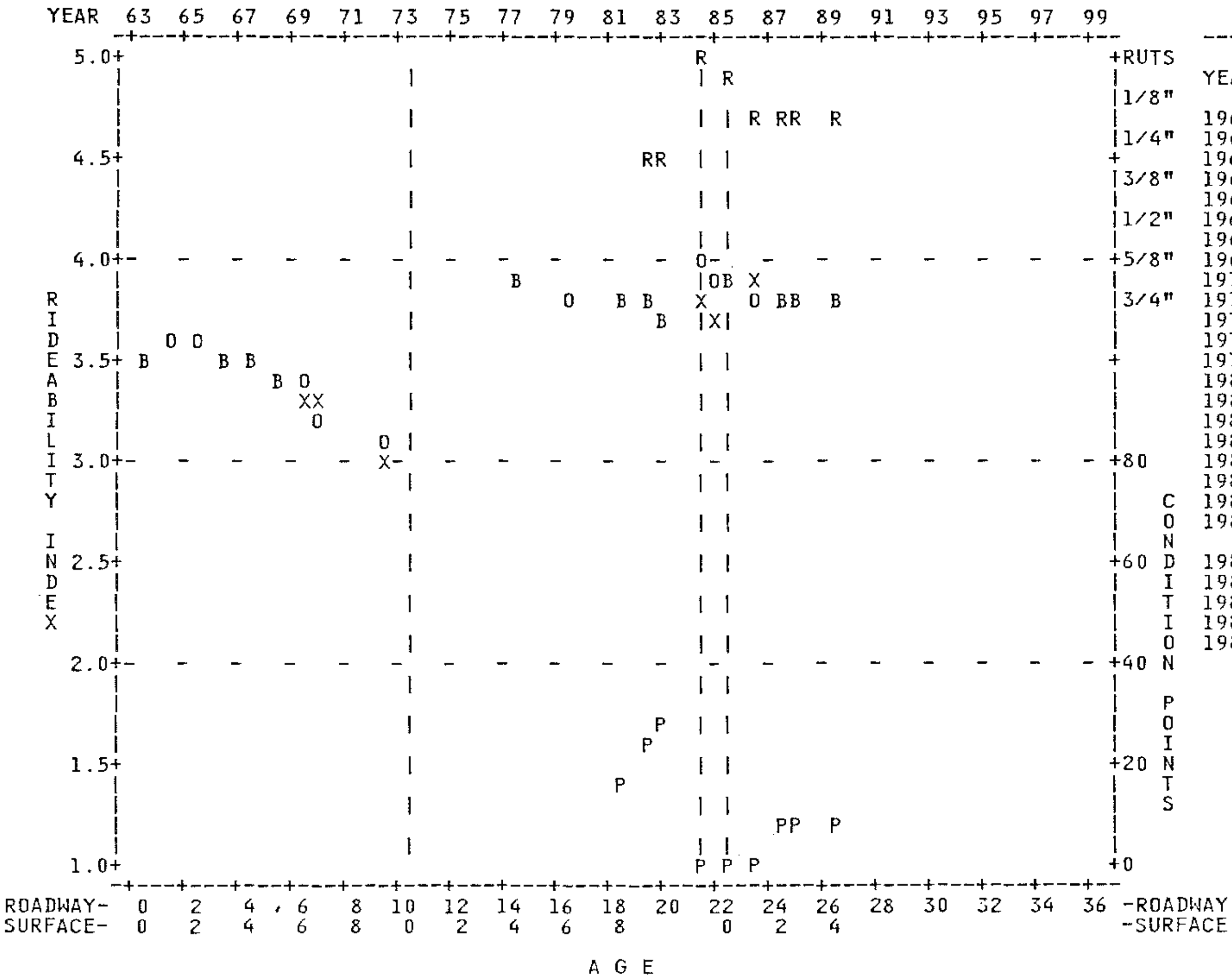
ROAD NO: I 64 DIRECTION: WEST COUNTY: CLARK DISTRICT: 7

ROAD NAME: Lexington - Ashland

FROM: MP 89.48 Fayette County Line
TO: MP 94.23 KY 1958

O = OUTER LANE
X = INNER LANE
B = BOTH LANES

P = CONDITION POINTS
# = INDEX & POINTS
R = RUT (@ = INDEX & RUT)



YEAR	-- RI -- OUT	INN	CONDITION POINTS	ADT
1963	CONSTRUCTED		- AC	
1963	3.5	3.5		8950
1964	3.6			6190
1965	3.6			10600
1966	3.5	3.5		10200
1967	3.5	3.5		10170
1968	3.4	3.4		11500
1969	3.4	3.3		13700
1970	3.2	3.3		12560
1972	3.1	3.0		13400
1973	RESURFACED		- AC	
1977	3.9	3.9		15300
1979	3.8			14600
1981	3.8	3.8	17.6	15200
1982	3.8	3.8	23.0	16300
1983	3.7	3.7	27.0	19100
1984	MILLED		- AC	
1984	RESURFACED		- AC	
1984	4.0	3.8	0.0	18900
1985	3.9	3.7		19400
1985	SURFACED - OGFC		SURFACE	
1985	3.9	3.9	1.0	19400
1986	3.8	3.9	1.6	20400
1987	3.8	3.8	7.0	22080
1988	3.8	3.8	7.0	21900
1989	3.8	3.8	8.0	22200

Figure 5. Plot of Rideability Indices, Condition Points and Ruts.

APPENDIX A

STATE HIGHWAY ENGINEER'S GUIDANCE MANUAL
CHAPTER ON PAVEMENT MANAGEMENT

CHAPTER 40-15

PAVEMENT MANAGEMENT

40-15.0100 GENERAL

The Department of Highways is required to provide and sustain pavements in a condition acceptable to the traveling public at the least life-cycle cost. To assist in discharging this responsibility, the Department shall develop and maintain a Pavement Management System which is to be an established, documented procedure treating the pavement management activities in a systematic and coordinated manner. Pavement management activities include planning, budgeting and programming, design, construction, monitoring, maintenance, research, etc. The Pavement Management System is to include at least the following six essential elements structured to serve decision-making responsibilities at various levels:

(1) Pavement condition survey;

(2) Data base: pavement, roadway, traffic, etc., information;

(3) Analysis scheme;

(4) Decision criteria;

(5) Implementation procedure;

(6) Feedback mechanism or procedures.

40-15.0200 POLICY

The responsibility to develop and maintain a Pavement Management System shall be with the Pavement Management Branch within the Division of Specialized Programs, under the Assistant State Highway Engineer for Administration and Research.

The Pavement Management Branch shall consult with engineering divisions and highway districts in identifying needs and objectives in pavement management; assimilate information and data on pavements and roadways; and disseminate information, data and reports throughout the Department.

The Pavement Management Branch shall be primarily responsible for the identification, evaluation and ranking of pavements for improvements; determination of present conditions; forecasting future conditions and needs; devising allocation formulas for distribution of pavement improvement funds; and assessing impact of programs, practices, policies and specifications on pavement conditions.

40-15.0300 PROCEDURES

.0310 General Condition of Pavements - The Pavement Management Branch will test for roughness each year all state-maintained roads. For pavements on other than interstate and parkway roads, rideability criteria will be applied to these data to characterize pavement conditions and to estimate mileage in need of improvement now and in the future. For interstate and toll roads, in addition to testing for roughness, each pavement section will also be assessed each year for rutting, skid resistance, visually discernible distresses, and changes in conditions over time. These data will be used to characterize pavement conditions and to determine mileage in need of improvement now and in the future. Reports on conditions will be prepared and distributed throughout the Department.

.0320 Identification, Evaluation and Ranking of Pavements for Improvements

.0321 Interstate and Parkway Roads - All interstate and parkway road pavements will be evaluated each year on the basis of rideability, skid resistance, rutting, visually discernible distresses, structural condition, and changes in conditions over time. Pavements in need of improvement will be ranked according to condition and types of improvements to be applied will be recommended. The Pavement Condition Evaluation forms (Exhibit 40-15-1) will be forwarded to the Division of Maintenance for review, priority ranking and scheduling for improvements. Copies of forms will also be provided to highway districts and divisions of Design and Materials.

.0322 Other Roads (Resurfacing) - The Pavement Management Branch will provide highway districts with tabulations of pavements most likely in need of resurfacing and request a list of pavements for evaluation. Districts will identify and provide to the Pavement Management Branch a list of pavements in poorest condition.

The Pavement Management Branch will evaluate pavements recommended by the districts and also pavements selected by the Division of Maintenance and Pavement Management Branch staff. Evaluations will consist of visual condition survey, rideability, rutting and skid resistance and points (demerits) will be assigned to each rating element cited on the Pavement Condition Evaluation form, TC 71-103, (Exhibit 40-15-2).

40.15.0300 PROCEDURES (Cont.)

The total point scores will be used to rank pavements in each district. After review of evaluation results, the districts will enter their priority ranking of pavements, recommended treatment, and cost estimate, and then return the forms to the Pavement Management Branch.

The Pavement Management Branch will enter statewide rankings based on points and forward the completed forms to the Division of Maintenance for preparing the annual resurfacing program. Copies of the completed evaluation forms will also be provided to the districts.

The Pavement Management Branch, in consultation with the Assistant State Highway Engineer for Operations and Division of Maintenance, will allocate each year resurfacing funds to the districts based on a formula which includes lane-miles of roads, cost of bituminous materials, condition of pavements in the district, and a multiplication factor for moderating the effect of pavement condition.

A report summarizing results of evaluations will be prepared each year by the Pavement Management Branch and submitted to the Assistant State Highway Engineer for Operations and Division of Maintenance.

.0330 Skid Resistant - The Pavement Management Branch will when requested, conduct tests, search accident report files and perform analysis to identify pavements qualifying for deslicking according to "Guidelines for Selecting Slippery Pavements for Consideration for Deslicking" (Exhibit 40-15-3). The qualifying pavements will be submitted and considered for deslicking or posting of warning signs by the Division of Maintenance and the districts.

Experimental and other pavement surfaces of interest may be tested. The Pavement Management Branch, in consultation with the Divisions of Materials, Maintenance, Construction, and Design will ascertain performance of surfaces and recommend surfaces that provide adequate skid resistance.

.0340 Rideability Requirement for New Surfaces - The Division of Design will identify projects with rideability requirements for new surfaces and inform the Pavement Management Branch for verification. The Districts will request the Division of Construction to schedule testing. The Division of Construction, in turn, will request the Pavement Management Branch to conduct necessary tests and report the results on the Rideability Test Report Form TC 63-43A,(Exhibit 40-15-4).

40.15.0300 PROCEDURES (Cont.)

The Pavement Management Branch will tabulate results of all tests on new surfaces and issue each year a report on quality of workmanship and recommend any needed changes in rideability requirements as well as possible application of rideability requirements to broader range of surface improvements.

.0350 Structural Condition of Pavements - After consulting with the Division of Maintenance and others, the Pavement Management Branch will determine pavements in need of structural analysis, coordinate and perform deflection tests to determine structural condition of pavements, and recommend overlay thicknesses as needed. The expected axle loads for structural analysis will be obtained from the Division of Planning. Reports on findings will be supplied to the Divisions of Maintenance and Design and to the district in which the pavements are located.

EXHIBIT 40-15-1

0989

PAVEMENT CONDITION EVALUATION FORM
INTERSTATE AND PARKWAYS

ROAD NO: I 64 ROAD NAME: Lexington - Ashland

COUNTY: CLARK DISTRICT: 7

FROM: Fayette County Line MP: 89.48
TO: KY 1958 MP: 94.23

ADT(89): 22200 LENGTH: 4.75

CONSTRUCTED NOV 63 DGA: 15 INCHES CBR: 5

CONTRACTOR FOR AUG 85 ACTION: Eaton

DATE	ACTION	PAVEMENT INCHES	PAVEMENT TYPE	SURFACE TYPE	REMARKS
NOV 63	CONSTRUCTED	7.5	AC		
OCT 73	RESURFACED	2.5	AC		
SEP 84	MILLED	-0.5	AC		
SEP 84	RESURFACED	2.75	AC		2.25" WB
AUG 85	SURFACED			OGFC	

VISUAL CONDITION SURVEY

(DEMERIT POINTS)	MAXIMUM EXT	MAXIMUM SEV	EB EXT	EB SEV	EB SUM	WB EXT	WB SEV	WB SUM
CRACKING	18	13			0			0
BASE FAILURES - FAULTING	9	9			0			0
RAVELING - WEAR SPALLING	6	6	4	3	7	4	3	7
OUT OF SECTION	6	6			1			1
PATCHING	12				0			0
APPEARANCE	__	15			0			0
>---- TOTAL ---->	51	49			8			8

REMARKS: ______

GUARDRAIL: POOR FAIR (GOOD) SHOULDER: AC : POOR FAIR (GOOD)

NUMBER OF LANES: 4

	EB INN	EB OUT	WB INN	WB OUT
PREVIOUS RI (88):	3.7	3.8	3.8	3.8
RI:	3.8	3.7	3.8	3.8
DECREASE IN RI:	-	.1	0	0
RUTTING (INCHES): Varies up to 1/2"		5/16		3/16
SKID NUMBER:				

RECOMMENDATIONS: OVERLAY MILL GRIND YEAR: ______

OTHER ______

RATERS: RIZENBERGS BURCHETT [illegible] DATE: 10/12/89

REMARKS: ______

RANKING

Transportation Cabinet
Department of Highways
Specialized Programs

EXHIBIT 40-15-2 (Front) TC 71-103
Rev. 3/88

PAVEMENT CONDITION EVALUATION FORM

trict: 1	County: Crittenden	Route No: US 641	Road Name: Marion-Princeton

m: (MP 6.750) 0.278 Mi S of Chapel Hill Road To: (MP 7.494) US 60

ıgth: 0.744	Width: varies	Project No: MP-028-0641-006-008	System: SP

CONDITION SURVEY

	EXTENT: Few		EXTENT: Intermediate		EXTENT: Extensive		SEVERITY: Slight		SEVERITY: Moderate		SEVERITY: Severe	POINTS
cking	1 2 (3)		4	5	6		1	1.5	2	(3)	4	6
ıe Failures (Faulting)	1	1.5	(2)	2.5	3		1	(1.5)	2	2.5	3	3.5
ıeling (Spalling)	.6	.9	1.3	(1.6)	2		.6	.9	1.3	1.6	2	3.4
ıe Failures	.6	.9	1.3	1.6	2	(.2)	.3	.4	.6	.8	1	.2
: of Section	1	(1.5)	2	2.5	3		(1)	1.5	2	2.5	3	2.5
ɔearance		Fair - 1 (2)		Poor - 3 4			Very Poor - 5					2
											Subtotal	17.6

RIDEABILITY	N/E: 1.65 S/W: 1.81	RI 1.6	23.0
RUTTING	N/E: S/W:	Depth 3/8(UP TO 1")	6
SKID RESISTANCE		SN NO Points x Factor ___ x ___	0
TRAFFIC VOLUME		AADT 5040 (88)	9
TRAVEL SPEED		MPH 35	0
Raters: Rizenbergs, P.E. / Crossfield		Total	55.6
Date: 10/14/89		Points Ranking	1

ROADWAY CHARACTERISTICS

ɔC AC (AC/PCC)
(urbs & Gutters .194 - 7.494) Manholes Inlet Boxes
Shoulders High ____ Low ____
Width varies
Type AC
Industrial Haul Type ____
Patching (Percent) ____

CO RECOMMENDATIONS

Improvement Needed? (Yes) Marginal No
Type: (Resurface (AC)) Other ____
Preparation: Leveling & Wedging (Percent) 30
Milling (in.) ____ Other ____
Other: Mill ruts at stoplight by State Forces

STATEWIDE RANKING: 10

DISTRICT RANKING: 1

Preparator: David Madison

DISTRICT RECOMMENDATIONS

Cost Estimate: $22,839

Treatment Code: 1 - B - I

Remarks: ____

RIDEABILITY

RI	Points
3.1	1
3.0	2.5
2.9	3.9
2.8	5.4
2.7	6.9
2.6	8.4
2.5	9.8
2.4	11.2
2.3	12.7
2.2	14.2
2.1	15.7
2.0	17.2
1.9	18.6
1.8	20.1
1.7	21.6
1.6	23.0
1.5	24.5
1.4 or lower	26.0

Rating	
5 – 4	Very Good
4 – 3	Good
3 – 2	Fair
2 – 1	Poor
1 – 0	Very Poor

III. RUTTING

Inches	Points
1/4	3
3/8	6
1/2	8
5/8 or higher	10

IV. SKID RESISTANCE

SN	Points
36	1
35	2
34	3
33	4
32	5
31	6
30	7
29	8
28	9
27	10
26	11
25	12
24 or lower	13

TRAFFIC VOLUME

POINTS	2-Lane AADT	4-Lane AADT	MULTIPLICATION FACTOR FOR SKID RESISTANCE POINTS
1	401 - 800	401 - 850	0.1
2	801 - 1,250	851 - 1,300	0.18
3	1,251 - 1,700	1,301 - 1,800	0.26
4	1,701 - 2,250	1,801 - 2,400	0.35
5	2,251 - 2,850	2,401 - 3,100	0.46
6	2,851 - 3,500	3,101 - 3,800	0.58
7	3,501 - 4,200	3,801 - 4,650	0.71
8	4,201 - 4,950	4,651 - 5,600	0.84
9	4,951 - 5,750	5,601 - 6,600	1.0
10	5,751 - 6,600	6,601 - 7,700	1.0
11	6,601 - 7,500	7,701 - 8,950	1.0
12	7,501 or higher	8,951 or higher	1.0

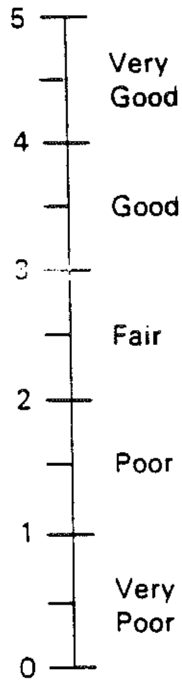
TRAVEL SPEED

MPH	POINTS
40	1
45	1.5
50	3
55	5

RIDEABILITY

RI	Points
3.1	1
3.0	2.5
2.9	3.9
2.8	5.4
2.7	6.9
2.6	8.4
2.5	9.8
2.4	11.2
2.3	12.7
2.2	14.2
2.1	15.7
2.0	17.2
1.9	18.6
1.8	20.1
1.7	21.6
1.6	23.0
1.5	24.5
1.4 or lower	26.0

Rating



III. RUTTING

Inches	Points
1/4	3
3/8	6
1/2	8
5/8 or higher	10

IV. SKID RESISTANCE

SN	Points
36	1
35	2
34	3
33	4
32	5
31	6
30	7
29	8
28	9
27	10
26	11
25	12
24 or lower	13

TRAFFIC VOLUME

POINTS	2-Lane AADT	4-Lane AADT	MULTIPLICATION FACTOR FOR SKID RESISTANCE POINTS
1	401 - 800	401 - 850	0.1
2	801 - 1,250	851 - 1,300	0.18
3	1,251 - 1,700	1,301 - 1,800	0.26
4	1,701 - 2,250	1,801 - 2,400	0.35
5	2,251 - 2,850	2,401 - 3,100	0.46
6	2,851 - 3,500	3,101 - 3,800	0.58
7	3,501 - 4,200	3,801 - 4,650	0.71
8	4,201 - 4,950	4,651 - 5,600	0.84
9	4,951 - 5,750	5,601 - 6,600	1.0
10	5,751 - 6,600	6,601 - 7,700	1.0
11	6,601 - 7,500	7,701 - 8,950	1.0
12	7,501 or higher	8,951 or higher	1.0

TRAVEL SPEED

MPH	POINTS
40	1
45	1.5
50	3
55	5

EXHIBIT 40-15-3

KENTUCKY DEPARTMENT OF HIGHWAYS
GUIDELINES FOR SELECTING SLIPPERY PAVEMENTS
FOR CONSIDERATION FOR DE-SLICKING

justification and proposed implementation of these guidelines is contained tached Justification and Implementation of Proposed Guidelines for Slippery Pavements for De-Slicking.

HIGH VOLUME ROADS --- All Interstates; Other roads with ADT above 10,000

A. Skid number of 28 or lower; or
B. Skid number of 29 or higher and benefit/cost ratio greater than 2

MEDIUM VOLUME ROADS --- Roads with ADT of 4,000 to 10,000

A. Skid number of 25 or lower; or
B. Skid number of 26 to 32 and benefit/cost ratio greater than 2

MEDIUM LOW VOLUME ROADS --- Roads with ADT of 1,000 to 4,000

A. Skid number of 25 or lower and, if applicable more than 30 percent wet-pavement accidents; or
B. Skid number of 26 to 32 and benefit/cost ratio greater than 2

LOW VOLUME ROADS --- Roads with ADT below 1,000

A. Skid number of 25 or lower and benefit/cost ratio greater than 2

STATE HIGHWAY ENGINEER DATE: 2/4/86

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
DEPARTMENT OF HIGHWAYS

TC 63-43A
Rev. 7/86

POSAL CODE NO.: ______ DISTRICT NO.: ______

ING DATE: ______ CH NO.: ______

RIDEABILITY TEST REPORT

I. NO.: ______ ROUTE: ______ COUNTY: ______

ATION: FROM ______ MI. PT. ______

TO ______ MI. PT. ______

IMENTS: ______ LENGTH: ______

UESTED BY: PROJECT ENGINEER ☐ DISTRICT OFFICE ☐ DIV. OF CONST. ☐ CONTRACTOR ☐

NAME: ______

COMMENTS: ______

DATE: ______ DATE R I NEEDED: ______ REQUIRED R I: ______

PAVEMENT: AC ☐ PCC ☐ OR COMPOSITE ☐ OTHER ☐ ______

KNESS: DGA ______ PCC ______ AC SURF. ______ BASE ______ BINDER ______ OGFC ______

. PREP.: MILL ______ IN. SCRATCH COURSE ______ IN. LEVEL & WEDGE ______ IN.

OTHER ______

PAVEMENT: NEW CONSTRUCTION ☐ OVERLAY ☐ BREAK & SEAT W/OVERLAY ☐

KNESS: DGA ______ PCC ______ AC SURF. ______ BASE ______ BINDER ______ OGFC ______

DESIGN EAL: ______ CBR: ______ ADT: ______

DATE: ______ DEGREES F.: ______ WEATHER: ______

ED BY: ______ SURFACE TYPE: ______

CHARTS TO: ______ DATE: ______

OSE OF TEST: CHECK ☐ ACCEPTANCE ☐ AFTER CORRECTIONS ☐ OTHER ☐

IMENTS: ______

RIDEABILITY INDEX

MILEPOINT	DIR/LANE	TEST NO. 1	TEST NO. 2	TEST NO. 3	AVERAGE	PASSED

ILTS VALIDATED BY: ______ DATE: ______

APPENDIX B

TYPICAL ANNUAL GOALS AND TASKS FOR PAVEMENT MANAGEMENT

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

MILO D. BRYANT
SECRETARY
AND
COMMISSIONER OF HIGHWAYS

WALLACE G. WILKINSON
GOVERNOR

MEMORANDUM

TO: B. S. Siria, P.E.
Director
Division of Specialized Programs

FROM: R. L. Rizenbergs, P.E.
TEBM for Pavement Management
Division of Specialized Programs

DATE: January 18, 1990

SUBJECT: Pavement Management's Major Goals for 1990

1. Test for roughness about 50 pavements for conformity to rideability requirements.

2. Evaluate condition of about 700 pavements (2,500 miles) for the 1991 Resurfacing Program. Also, visit each district office to share the results and to discuss various pavement management matters.

3. Evaluate condition of all Interstate pavements (760 miles).

4. Evaluate condition of all Parkway pavements (630 miles).

5. Test for skid resistance about 200 pavements.

6. Prepare and communicate recommendations on Interstate pavement improvements involving 4-R projects.

7. Update computer files on road system classification, project termini, year of resurfacing or construction, pavement type, and traffic volume.

8. Prepare a report on condition of Interstate pavements evaluated in 1989, including an updated listing of improvement needs through 1994.

9. Prepare a report on condition of Parkway pavements evaluated in 1990, including an updated listing of improvement needs through 1995.

10. Prepare a report on results of testing for conformity to rideability requirements in 1989.

11. Prepare a report on condition of State Primary, State Secondary, and Supplemental Road pavements in 1989.

12. Prepare a brief report on condition of Rural Secondary Road pavements in 1989 in District 7, 9 and 10.

13. Test for roughness 2,340 HPMS sample sections, including 480 on roads not maintained by the Department.

14. Test for roughness pavements on State Primary Roads (3,200 miles), State Secondary Roads (8,000 miles), and Supplemental Roads (2,500 miles).

15. Test for roughness pavements on Rural Secondary Roads (12,200 miles).

The proposed major goals for 1990 are very ambitious but may be achievable with available staff. Success, however, is always contingent upon weather, equipment and vehicle breakdowns, availability of full staff, and assignment of other work or tasks. Most of the listed work items have to be accomplished. The main flexibility is in roughness testing. Of least importance would be the complete testing of Rural Secondary Roads. Here again we propose to begin with testing of all roads in as many counties as possible. If later in the year it appears that we cannot complete testing all the roads, Rural Secondary Roads would be deleted. A tentative schedule for various activities is attached.

Search for new or improved methods, procedures, and equipment will continue in order to improve efficiency and reliability in testing, data processing and analysis.

Please let me know whether the proposed goals and priorities for 1990 meet with your approval. Additional information or explanation, of course, will be provided if desired.

Attachments

RLR:jwh

c: A. R. Romine
G. W. Asbury
Cy Layson
Pavement Management Staff

TENTATIVE WORK SCHEDULE FOR 1990

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
PAVEMENT CONDITION EVALUATION												
Resurfacing Program						—	—	—				
Parkways & Interstates									—	—	—	
ROUGHNESS TESTING												
Parkways & Interstates							—	—				
MP & RS Systems & HPMS Sections			- -	- -	—	—	—	—	—	—	- -	
Rideability Requirement	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
SKID TESTING												
Surface Types & Resurfacing Program								—	—			
DEFLECTION TESTING												
Interstates, Parkways, & Other Roads							- -	- -	- -			
EQUIPMENT REPAIR	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
EQUIPMENT CALIBRATION												
Roughness					—							
Skid Resistance						—						
DATA PROCESSING & ANALYSIS												
Roughness	—	—						- -	- -	- -	- -	—
Skid Resistance										- -	- -	- -
Deflection	—							- -	- -	- -	- -	- -
INFORMATION ACQUISITION AND PROCESSING												
Pavement, Roadway, & System	- -	- -	- -	- -	- -							- -
SUMMARIES AND REPORTS												
Interstate	—											
Parkway												—
MP System		—	—									
Resurfacing Program							- -	- -	- -	- - —	—	
RS System			—	—								
Rideability		—										
4-R INTERSTATE & OTHER PROJECT	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

----- Intermittent Activity

APPENDIX C

COMPUTERIZED DATA FILES FOR PAVEMENT MANAGEMENT

NAME - Official Orders for State Primary Road System

SIZE - 6,000 records, 50 columns each

CONTENTS EACH RECORD

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
District	Integer	2	Highway District No. (1-12)
County	Integer	3	County No. (1-120)
Route Prefix	Character	2	(US, KY I, etc.)
Route No.	Integer	4	Assigned Route No.
Route Suffix	Character	1	(blank, A, E, W, C, etc.)
Lower Milepoint	Real	7	Section Termini-Beginning
Upper Milepoint	Real	7	Section Termini-Ending
Cardinal Direction	Integer	1	Code for Direction of Road
State Aid	Integer	1	Code for State Primary Classification of Road

PAVEMENT MANAGEMENT COMPUTER FILES

NAME - Pavements Constructed or Resurfaced by Year

SIZE - 5,000 records for years 1979 and earlier
400 records for each year after 1979

CONTENTS EACH RECORD

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
District	Integer	2	Highway District No. (1-12)
County	Integer	3	County No. (1-120)
Route Prefix	Character	2	(US, KY I, etc.)
Route No.	Integer	4	Assigned Route No.
Route Suffix	Character	1	(blank, A, E, W, C, etc.)
Lower Milepoint	Real	7	Section Termini-Beginning
Upper Milepoint	Real	7	Section Termini-Ending
No. Lanes	Integer	1	No. of Traffic Lanes
Direction Restriction	Integer	1	Code for Direction(s) Applicable
Pavement Type	Integer	2	Code for Pavement Surface
Pavement Code	Integer	1	Code for Pavement Type
Action Code	Character	1	Code for Type of Action to Pavement
Action Date	Integer	4	Month and Year of Action

PAVEMENT MANAGEMENT COMPUTER FILES

NAME - Roughness Data File

SIZE - 300,000 records each year, 50 columns each

CONTENTS EACH RECORD

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
District	Integer	2	Highway District No. (1-12)
County	Integer	3	County No. (1-120)
Route Prefix	Character	2	(US, KY I, etc.)
Route No.	Integer	4	Assigned Route No.
Route Suffix	Character	1	(blank, A, E, W, C. etc.)
Lower Milepoint	Real	7	Section Termini-Beginning
Upper Milepoint	Real	7	Section Termini-Ending
Vehicle	Integer	2	Vehicle Used for Testing
Test Date	Integer	6	Month, Day, Year of Test
Direction Code	Integer	1	Code for Cardinal or Non-Cardinal Direction of Test
Direction	Integer	1	Code for Direction of Test
Lane	Integer	1	Lane of Test
Rideability Index	Real	5	Pavement Rideability Index
Pavement Type	Integer	1	Type of Pavement
Date Sequence	Integer	1	Instances of Testing That Year
Latest Test	Integer	1	Code to Indicate Last Instance of Test That Year

PAVEMENT MANAGEMENT COMPUTER FILES

NAME - Annual Average Daily Traffic

SIZE - 16,000 records, 50 columns each

CONTENTS EACH RECORD

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
District	Integer	2	Highway District No. (1-12)
County	Integer	3	County No. (1-120)
Route Prefix	Character	2	(US, KY I, etc.)
Route No.	Integer	4	Assigned Route No.
Route Suffix	Character	1	(blank, A, E, W, C, etc.)
Lower Milepoint	Real	7	Section Termini-Beginning
Upper Milepoint	Real	7	Section Termini-Ending
Direction Restriction	Integer	1	Code for Direction(s) Applicable
ADT	Integer	6	Traffic Volume
Year	Integer	2	Year of Count

PAVEMENT MANAGEMENT COMPUTER FILES

NAME - Interstate and Parkway Historic Data

SIZE - 10,000 records, 100 columns each

CONTENTS

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
ALL RECORDS			
Route Prefix	Character	3	
Route No.	Integer	4	Assigned Route No.
Cardinal Direction	Integer	1	Code for Direction of Road
Lower Milepoint	Real	7	Section Termini-Beginning
Upper Milepoint	Real	7	Section Termini-Ending
County	Integer	3	County No. (1-120)
ROADWAY RECORD			
No. of Lanes	Integer	2	No. of Traffic Lanes
DGA Thickness	Integer	2	Thickness Granular Base
CBR	Integer	2	Soil Support for Design
Joint Spacing	Character	4	Value or Statement (var or none)
Shoulder Type	Integer	1	Code for AC or PCC

INTERSTATE AND PARKWAY HISTORIC DATA (Continued)

PAVEMENT RECORD EACH ACTION

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
Surface Sequence	Integer	1	1 - Constructed, 2 - Next Action
Date	Integer	6	Date of Action
Action	Integer	2	Code for Type of Action
Thickness	Real	5	Pavement Thickness Each Action
Pavement Type	Integer	1	Code for Pavement Type
Surface Type	Integer	2	Code for Pavement at Surface
Contractor	Character	35	Name of Contractor for Action

CONDITION RECORD EACH YEAR

Rideability Index (each lane)	Real	3	Measured Rideability Index
Date	Integer	6	Date of Rideability Test
Rut	Integer	2	Rut Depth in Increments of 1/16"
Condition Points	Real	4	Total Points from Condition Evaluation
Surface Age	Real	5	Age of Pavement Surface
ADT	Integer	6	Traffic Volume for Year of Test

PAVEMENT MANAGEMENT COMPUTER FILES

NAME - Pavement Evaluated for Resurfacing Program

SIZE - 600 records per year

CONTENTS EACH RECORD

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
Proposed By	Character	3	Evaluation Proposed by (District or CO)
District	Character	2	Highway district No. (1-12)
County	Character	12	Name of County
Route No.	Character	10	Assigned Route No. (KY 1111B)
Road Name	Character	30	Name of Road
From	Character	50	Starting Point of Evaluation
To	Character	50	Ending Point of Evaluation
Length	Numeric	6	Length of Section
Width	Character	6	Pavement Width
Project No.	Character	20	Unified Project Number
System	Character	4	State Classification
Cracking Extent	Numeric	3	Extent of Cracking of Pavement
Cracking Severity	Numeric	3	Cracking Severity
Cracking Total	Numeric	4	Total Points for Cracking
Base Failure Extent	Numeric	3	Extent of Base Failures in Pavement
Base Failure Severity	Numeric	3	Severity of Base Failures
Base Failure Total	Numeric	4	Total Points for Base Failures
Raveling Extent	Numeric	3	Extent of Raveling of Pavement
Raveling Severity	Numeric	3	Severity of Raveling
Raveling Total	Numeric	4	Total Points for Raveling

PAVEMENTS EVALUATED FOR RESURFACING PROGRAM (Continued)

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
Edge Failures Extent	Numeric	3	Extent of Edge Failures
Edge Failures Severity	Numeric	3	Severity of Edge Failures
Edge Failures Total	Numeric	4	Total Points for Edge Failures
Out Section Extent	Numeric	3	Extent of Out of Section
Out Section Severity	Numeric	3	Severity of Out of Section
Out Section Total	Numeric	4	Total Points for Out of Section
Appearance	Numeric	4	Points for Appearance of Pavement
Sub Total	Numeric	4	Sub Total of Points
Rideability North/East	Character	4	Rideability North/East Direction
Rideability South/West	Character	4	Rideability South/West Direction
Ride	Numeric	4	Points for rideability
Ruts North/East	Character	4	Ruts in North/East Direction
Ruts in South/West	Character	4	Ruts in South/West Direction
Ruts	Numeric	4	Points for Ruts
Skid	Character	2	Skid Number of Pavement
Points	Numeric	2	Points Pertaining to Skid Number
Factor	Numeric	4	Multiplication Factor of Skid Points
Skid Points	Numeric	4	Skid Points
Traffic Volume	Numeric	5	Traffic Volume (ADT)
Traffic Points	Numeric	4	Points due to ADT
Speed	Numeric	2	Travel Speed
Speed Points	Numeric	4	Points due to Travel Speed
Total Points	Numeric	4	Total of all Points
Co-Ranking	Numeric	3	Pavement Ranking by Central Office
Raters	Character	30	Name of Evaluators

PAVEMENTS EVALUATED FOR RESURFACING PROGRAM (Continued)

NAME	DATA TYPE	FIELD WIDTH	NARRATIVE
Date	Date	8	Date of Evaluation
Roadway Char	Character	10	Type of Pavement
Curb	Character	30	Curb and Gutter Section
Shoulder High/Low	Character	11	Shoulder High/Low
Shoulder Width	Character	5	Shoulder Width
Shoulder Type	Character	20	Type of Shoulder
Industrial Haul	Character	8	Type of Industrial Haul on Road
Patching	Character	3	Percent of Patching of Pavement
Resurface	Character	8	Resurface Recommendation
Other - 1	Character	20	Other Recommendations
Leveling/Wedging	Character	3	Percent Leveling and Wedging
Milling	Character	6	Milling in inches
Other - 2	Character	10	Other Recommendations
Statewide Ranking	Numeric	3	Statewide Ranking of Pavement
District Ranking	Numeric	3	Ranking by District
Preparer	Character	20	Name of Preparer of District Recommendation
Cost	Numeric	7	Estimated Cost
Treatment	Character	10	Type of Treatment
Remarks	Character	120	Remarks by district
Overlaid	Character	4	If Pavement Overlaid That Year
Letting Date	Date	8	Date of Letting Contract
Award Date	Date	8	Award Date of Contract
Award Price	Numeric	7	Award Price of Contract
Completion Date	Date	8	Date of Completion of Work

PAVEMENT MANAGEMENT COMPUTER FILES

NAME - Pavements Tested for Structural Analysis

SIZE -

CONTENTS EACH RECORD

Under Development

APPENDIX D

GUIDELINES FOR SELECTION OF BITUMINOUS SURFACE COURSES

GUIDELINES FOR SELECTION OF BITUMINOUS SURFACE COURSES

CATEGORY	TRAVEL SPEED (MPH)	SURFACE COURSE
I.	**All Interstate Roads**	
		Bituminous Concrete Surface, Class A or Class K
II.	**High Volume Roads -- Roads with ADT of 6,000 and higher**	
	A. 50 or higher	Bituminous Concrete Surface, Class A, Class K, or Sand Asphalt, Type II
	B. Below 50	Bituminous Concrete Surface, Class I (40% polished-resistant aggregate required)
III.	**Medium Volume Roads -- Roads with ADT between 3,000 and 6,000**	
	A. 45 or higher	Bituminous Concrete Surface, Class I (40% polished-resistant aggregate required)
	B. Below 45	Bituminous Concrete Surface, Class I (20% polished-resistant aggregate required)
IV.	**Medium Low Volume Roads -- Roads with ADT between 1,500 and 3,000**	
	A. 45 or higher	Bituminous Concrete Surface, Class I (20% polished-resistant aggregate required)
	B. Below 45	Bituminous Concrete Surface, Class I (No restrictions on aggregate type)
V.	**Low Volume Roads -- Roads with ADT below 1,500**	
	All	Bituminous Concrete Surface, Class I (No restrictions on aggregate type)

OTHER SURFACES - Considered on a project to project basis
Bituminous Concrete Surface, Class N

Note 1. Traffic volumes shown are for two lane roadways. For four lane roads, determine the equivalent two lanes volume for the shoulder or outside lanes from the attached chart.

Note 2. Lower category surface may apply when the project quantity of the wearing course is less than 500 tons.

Note 3. Stage construction or special mixtures may be specified for roadways where pavements may develop significant rut depth.

Note 4. Exceptions to these guidelines may be made with the approval of the State Highway Engineer in special cases when warranted by design, materials, or traffic consideration.

APPROVED: [signature] DATE: 5-27-88
State Highway Engineer

APPROVED: [signature] DATE: 10-16-88
Federal Highway Administration

APPENDIX E

TYPICAL PRODUCTS FROM PAVEMENT MANAGEMENT

TABLE C-1. PAVEMENT IMPROVEMENT NEEDS IN 1989

ROAD (COUNTY)	LOCATION	LENGTH (MILES)	PAVEMENT TYPE	DIR.	CONDITION RI	CONDITION RUT (inches)	CONDITION POINTS	RECOMMENDED TREATMENT (REMARKS)
I-24 (McCracken)	From: MP 10.32, Island Creek Bridge To: MP 13.80, 0.5 mi. E. of Clark River	3.48	OGFC/AC	EB WB	3.6 3.5	9/16 9/16	10 11	Mill & 3 1/2" AC overlay (FHWA approved & FY 1990 funded)
I-24 (McCracken)	From: MP 13.80, 0.5 mi. E. of Clark River To: MP 16.16, US 68	2.36	OGFC/AC	EB WB	3.6 3.8	3/4 3/4	19 18	Mill & 3 1/2" AC overlay (FHWA approved & FY 1990 funded)
I-24 (McCracken-Marshall)	From: MP 16.16, US 68 To: MP 22.04, 0.1 mi. W. of Howard Rd.	5.88 (Westbound)	OGFC/AC	WB	3.5	5/8	27	Mill & 2 1/2" AC overlay
I-24 (Marshall)	From: MP 26.56, US 62 To: MP 27.55, Cypress Creek Bridge	0.99	AC	EB WB	3.4 3.4	5/8 9/16	10 9	Mill & 1" AC inlay of outside lanes (211 Account funded)
I-24 (Marshall)	From: MP 27.55, Cypress Creek Bridge To: MP 29.14, Tennessee River Bridge	1.59	OGFC/AC	EB WB	3.4 3.5	1/2 9/16	22 16	Mill & 1" AC inlay of outside lanes (211 Account funded)
I-24 (Livingston)	From: MP 29.54, Tennessee River Bridge To: MP 30.55, KY 453	1.01	AC	EB WB	3.7 3.8	3/4 5/8	10 15	Mill & 1" AC inlay of outside lanes (211 Account funded)
I-64 (Jefferson)	From: MP 0.72, Ohio River Br. To: MP 1.34, Beginning of structure	0.62	PCC	EB WB	2.5 2.4	- -	63 65	Replace with 11" PCC (FHWA approved & FY 1990 funded)
I-64 (Jefferson)	From: MP 1.97, End of structure To: MP 2.06, Beginning of structure	0.09	AC/PCC	EB WB	2.6 2.3	- -	41 47	Replace with 11" PCC (FHWA approved & FY 1990 funded)
I-64 (Jefferson)	From: MP 2.25, End of structure To: MP 3.26, Beginning of structure	1.01	PCC	EB WB	2.4 2.2	- -	20 20	Replace with 11" PCC (FHWA approved & FY 1990 funded)

Figure E1. From Report on Condition of Interstate Pavements in 1989; January 1990.

TABLE C-1. PAVEMENT IMPROVEMENT NEEDS IN 1989 (Continued)

ROAD (COUNTY)	LOCATION	LENGTH (MILES)	PAVEMENT TYPE	DIR.	CONDITION RI	CONDITION RUT (inches)	CONDITION POINTS	RECOMMENDED TREATMENT (REMARKS)
I-64 (Jefferson)	From: MP 8.20 To: MP 9.46, 0.85 mi. W. of Cannons Ln.	1.26	PCC	EB WB	1.9 2.4	- -	39 43	Break, seat & AC overlay
I-64 (Franklin-Woodford)	From: MP 57.90, US 60 To: MP 65.27, KY 341	7.37	PCC	EB WB	3.2 2.9	- -	43 42	Install edge drains (FY 1990 funded)
I-64 (Woodford-Scott-Fayette)	From: MP 65.27 To: MP 73.30 EB & MP 74.60 WB, I-75	8.68	PCC	EB WB	2.6 2.8	- -	55 50	Install edge drains (FY 1990 funded)
I-75 (Whitley)	From: MP 20.20, 0.1 mi. S. of KY 3000 To: MP 21.88, Beginning of AC overlay	1.68 (Northbound)	PCC	NB	2.8	-	51	Break, seat & AC overlay (FY 1990 funded)
I-75 (Laurel)	From: MP 28.85, US 25E To: MP 34.40	5.55 (Southbound)	PCC	SB	2.8	-	18	Diamond grind surface of all lanes (FHWA approved & FY 1990 funded)
I-75 (Laurel)	From: MP 34.40 To: MP 40.70, KY 80	6.30	PCC	NB SB	2.9 2.9	- -	31 19	Diamond grind surface of all lanes (FHWA approved & FY 1990 funded)
I-75 (Kenton)	From: MP 184.72, I-275 To: MP 187.90	3.18	AC/PCC	NB SB	2.9 2.7	- -	69 67	Replace with 13" PCC (FHWA approved plus add lanes to MP 187.05)
I-264 (Jefferson)	From: MP 0.00, I-64 To: MP 0.48	0.48	AC/PCC	EB WB	2.7 2.7	- -	15 13	Replace with 11" PCC on 4" DGA & 4" drainage blanket (FHWA approved & FY 1990 funded)
I-264 (Jefferson)	From: MP 7.18, 0.2 mi. W. of US 31W To: MP 7.90, 0.18 mi. W. of KY 1931	0.72	PCC	EB WB	1.9 0.9	- -	43 38	Replace with PCC

Figure E1. (continued)

TABLE C-1. PAVEMENT IMPROVEMENT NEEDS IN 1989 (Continued)

ROAD (COUNTY)	LOCATION	LENGTH (MILES)	PAVEMENT TYPE	DIR.	CONDITION			RECOMMENDED TREATMENT (REMARKS)
					RI	RUT (inches)	POINTS	
I-265 (Jefferson)	From: MP 25.50, I-64 To: MP 26.64, 0.2 mi. S. of US 60	1.14	PCC	NB SB	2.2 2.5	- -	65 67	Break, seat & AC overlay (FY 1990 funded)
I-275 (Kenton)	From: MP 0.00, I-75 To: MP 0.62 EB MP 1.09 WB	0.86	CRCP	EB WB	1.7 1.7	- -	* *	Replace with 11" PCC (FHWA approved & FY 1990 funded)
I-275 (Kenton-Boone)	From: MP 1.09 To: MP 4.06, 0.09 mi. W.(CW) of KY 212	2.97 (Westbound)	CRCP	WB	2.2	-	*	Crush & 9" PCC overlay (FHWA approved & FY 1990 funded)
I-275 (Campbell)	From: MP 73.55, Ohio River Bridge To: MP 75.39, Three Mile Road	1.84	PCC	EB WB	2.8 2.3	- -	9 11	Repair, diamond grind & joint seals (FHWA approved & FY 1990 funded)
I-275 (Campbell)	From: MP 75.39, Three Mile Road To: MP 77.55, Licking River Bridge	2.16	PCC	EB WB	2.3 2.4	- -	26 26	Repair, diamond grind & joint seals (FHWA approved & FY 1990 funded)
I-275 (Kenton)	From: MP 82.48, US 25 To: MP 83.58, 0.2 mi. E. of I-75	1.10 (Eastbound)	PCC	EB	1.9	-	48	Replace with 11" PCC (FHWA approved & FY 1990 funded)
I-275 (Kenton)	From: MP 83.58, 0.2 mi. E. of I-75 To: MP 83.78, I-75	0.20	CRCP	EB WB	1.5 2.0	- -	* *	Replace with 11" PCC (FHWA approved & FY 1990 funded)

Figure E1. (continued)

TABLE C-1. PAVEMENT IMPROVEMENT NEEDS IN 1989 (Continued)

ROAD (COUNTY)	LOCATION	LENGTH (MILES)	PAVEMENT TYPE	DIR.	CONDITION			RECOMMENDED TREATMENT (REMARKS)
					RI	RUT (inches)	POINTS	
I-471 (Campbell)	From: MP 0.00, US 27 To: MP 5.48, Ohio River Bridge	5.48	PCC	NB	1.4 to 2.9		9 to 26	Repair, diamond grind & joint seals
				SB	1.6 to 2.8		9 to 27	(FHWA approved & FY 1990 funded)

TOTALS**:
12.37 miles -- Overlay AC pavements
3.24 miles -- Overlay PCC pavements with AC (break & seat)
1.49 miles -- Overlay PCC pavements with PCC (crush)
8.32 miles -- Replace with PCC
9.48 miles -- Restore PCC pavements (repair, grind & joint seals)
9.08 miles -- Diamond grind surfaces
16.05 miles -- Edge drains

* Not evaluated
** Length divided by two if one direction only

Figure E1. (continued)

TABLE C-1. CONDITION RANKING OF PAVEMENTS IN NEED OF OVERLAYING IN 1989

COND. RANKING	PARKWAY (COUNTY)	LOCATION	LENGTH (MILES)	PAVEMENT TYPE	DIR.	CONDITION			RECOM. TREATMENT
						RI	RUT (inches)	POINTS	
1	Pennyrile (Hopkins-Webster)	From: MP 53.57, 0.5 mi. S. of KY 138 To: MP 61.75, 1.3 mi. N. of KY 370	8.18 (Southbound)	PCC	SB	2.5	-	62	Break, Seat & AC Overlay
2	Western Kentucky (Grayson)	From: MP 90.08, 0.5 mi. W. of Dog Cr. Rd. To: MP 95.15, 0.05 mi. W. of KY 185	5.07 (Eastbound)	PCC	EB	2.8	-	64	Break, Seat & AC Overlay
3	Green River (Warren)	From: MP 7.10, 0.3 mi. S. of US 231 To: MP 17.80, 0.4 mi. S. of Butler Co. Ln.	10.70	AC	NB SB	3.4 3.3	1/2 3/8	63 58	Mill & 2 1/2" AC Overlay
4	Mountain (Wolfe)	From: MP 36.00, Powell Co. Line To: MP 43.20, Beg. of AC Pavement	7.20 (Eastbound)	PCC	EB	2.9	-	65	Break, Seat & AC Overlay
5	Western Kentucky (Hardin)	From: MP 123.44, KY 84 To: MP 130.95, Rhudes Cr. Br.	7.51 (Eastbound)	AC	EB	3.3	3/8	57	Mill & 1" AC Overlay
		TOTAL*:	10.22 PCC 14.47 AC						

Length divided by two if one direction only.

Figure E2. From Report on Condition of Parkway Pavements in 1989; November 1989.

TABLE 10. ROAD MILES ASSOCIATED WITH ESTIMATED PAVEMENT CONDITIONS IN EACH DISTRICT FOR STATE PRIMARY, STATE SECONDARY, AND SUPPLEMENTAL ROADS.

		TOTAL TESTED				POOR CONDITION				FAIR CONDITION				GOOD CONDITION			
	PAVED ROAD MILES	ROAD		AVERAGE		ROAD		AVERAGE		ROAD		AVERAGE		ROAD		AVERAGE	
DISTRICT	ADT > 100	MILES	%	AGE	ADT	MILES	%	AGE	ADT	MILES	%	AGE	ADT	MILES	%	AGE	ADT
1	1283	1262	98.4	8.6	2310	114	8.9	****	3350	328	25.5	****	2380	841	65.5	7.2	2150
2	1485	1448	97.5	7.8	3220	150	10.1	****	5290	478	32.2	9.2	2960	857	57.7	7.2	3020
3	1036	1028	99.2	9.3	2350	27	2.6	10.5	5380	274	26.5	13.4	2640	734	70.9	7.9	2120
4	1362	1358	99.7	8.7	2230	74	5.4	17.1	3400	387	28.4	13.5	1960	901	66.1	6.3	2250
5	885	871	98.4	6.9	6910	107	12.1	****	14190	230	26.0	9.1	8020	548	62.0	6.1	5000
6	966	958	99.1	5.7	2800	185	19.2	7.4	5870	352	36.5	7.5	1950	429	44.4	3.9	2180
7	1070	1064	99.5	6.3	5610	103	9.6	11.4	10390	258	24.1	8.2	4910	709	66.3	5.0	5170
8	1079	1065	98.7	8.6	2120	70	6.5	****	2940	276	25.5	13.7	2030	734	68.0	6.7	2090
9	989	980	99.1	6.9	2470	183	18.5	9.7	2790	233	23.5	10.0	1890	573	58.0	5.1	2600
10	935	923	98.7	7.1	1750	217	23.2	10.2	2120	335	35.8	8.2	1710	383	41.0	4.6	1580
11	1012	978	96.7	6.6	2790	129	12.8	7.8	3690	375	37.0	9.8	2370	508	50.2	4.1	2890
12	985	977	99.2	5.3	3440	422	42.8	6.9	3370	298	30.3	5.9	2930	265	26.9	2.5	4120
ALL	13088	12912	98.7	7.4	3100	1781	13.6	9.0	4690	3825	29.2	10.1	2830	7482	57.2	5.9	2870

Figure E3. From Report on Pavement Conditions of State Primary, State Secondary, and Supplemental Roads; May 1989.

TABLE 13. ROAD MILES AT VARIOUS PAVEMENT CONDITION LEVELS IN EACH DISTRICT FOR STATE PRIMARY, STATE SECONDARY, AND SUPPLEMENTAL ROADS.

	PAVEMENT CONDITION INDEX	DISTRICT												
		1	2	3	4	5	6	7	8	9	10	11	12	ALL
	> 1.9	-	1	-	7	2	-	-	-	-	2	-	-	12
	1.9	1	2	5	5	-	-	6	1	2	-	-	-	21
B	1.8	7	4	3	6	1	-	-	14	4	3	5	-	47
E	1.7	7	13	13	11	1	-	2	18	8	4	2	-	80
T	1.6	9	24	12	11	5	1	6	21	8	22	4	2	126
T	1.5	34	31	18	24	5	9	5	31	21	7	11	2	196
E	1.4	40	41	46	49	21	16	17	61	20	28	13	5	356
R	1.3	72	50	81	99	20	17	41	91	49	56	13	11	599
	1.2	98	59	90	105	38	57	66	81	67	43	22	7	732
C	1.1	104	76	124	111	46	44	42	130	65	59	48	18	868
O	1.0	112	127	97	142	60	45	80	105	99	60	39	23	988
N	0.9	133	145	113	136	63	74	118	110	107	83	100	44	1226
D	0.8	119	178	52	133	78	67	117	89	134	65	90	82	1205
I	0.7	113	133	101	115	79	99	101	67	91	76	112	87	1175
T	0.6	85	103	73	89	64	78	125	58	42	75	82	75	950
I	0.5	67	105	67	86	60	106	84	45	57	64	91	59	891
O	0.4	57	99	42	80	71	69	71	36	37	65	72	84	783
N	0.3	44	46	37	53	63	54	46	45	45	27	61	55	575
	0.2	31	57	26	31	43	43	42	19	16	39	61	63	472
	0.1	30	34	14	16	47	45	19	17	26	23	40	47	357
	0.0	32	30	10	10	28	36	18	6	18	15	30	44	276
	-0.1	11	25	4	14	14	26	16	3	22	22	36	38	230
	-0.2	16	21	2	5	14	13	13	9	13	27	16	47	196
P	-0.3	9	13	2	10	11	14	10	6	12	12	11	26	137
O	-0.4	8	11	1	2	10	11	13	5	5	15	14	25	119
O	-0.5	6	7	1	2	6	7	10	1	9	11	4	22	85
R	-0.6	8	9	-	-	6	5	3	2	3	10	3	17	68
	-0.7	4	4	-	2	8	6	2	1	9	7	5	22	71
C	-0.8	10	3	1	2	3	5	1	1	3	5	5	12	51
O	-0.9	3	5	1	1	5	5	1	1	6	1	3	17	49
N	-1.0	9	2	-	1	1	3	2	-	2	1	5	3	28
D	-1.1	1	3	-	-	-	4	1	-	2	-	1	11	24
I	-1.2	-	2	-	-	2	7	1	-	2	2	4	9	31
T	-1.3	8	1	-	-	2	2	-	6	-	-	2	5	27
I	-1.4	-	2	-	-	-	2	1	-	1	1	-	2	9
O	-1.5	-	1	-	-	4	-	2	-	2	3	-	1	14
N	-1.6	-	2	-	-	1	1	-	-	-	3	-	6	13
	-1.7	-	1	-	-	-	2	-	-	-	1	2	4	11
	-1.8	-	-	-	-	2	4	-	-	-	1	-	1	7
	-1.9	-	-	-	-	-	1	-	-	-	1	-	5	7
	<-1.9	2	1	-	1	1	4	-	1	2	2	2	2	18
	> 0.0	1164	1327	1014	1310	765	824	987	1039	896	802	866	664	11658
	<=0.0	127	144	23	52	120	158	93	45	111	139	144	319	1474
	ALL	1290	1471	1037	1362	886	981	1080	1083	1006	941	1010	983	13132

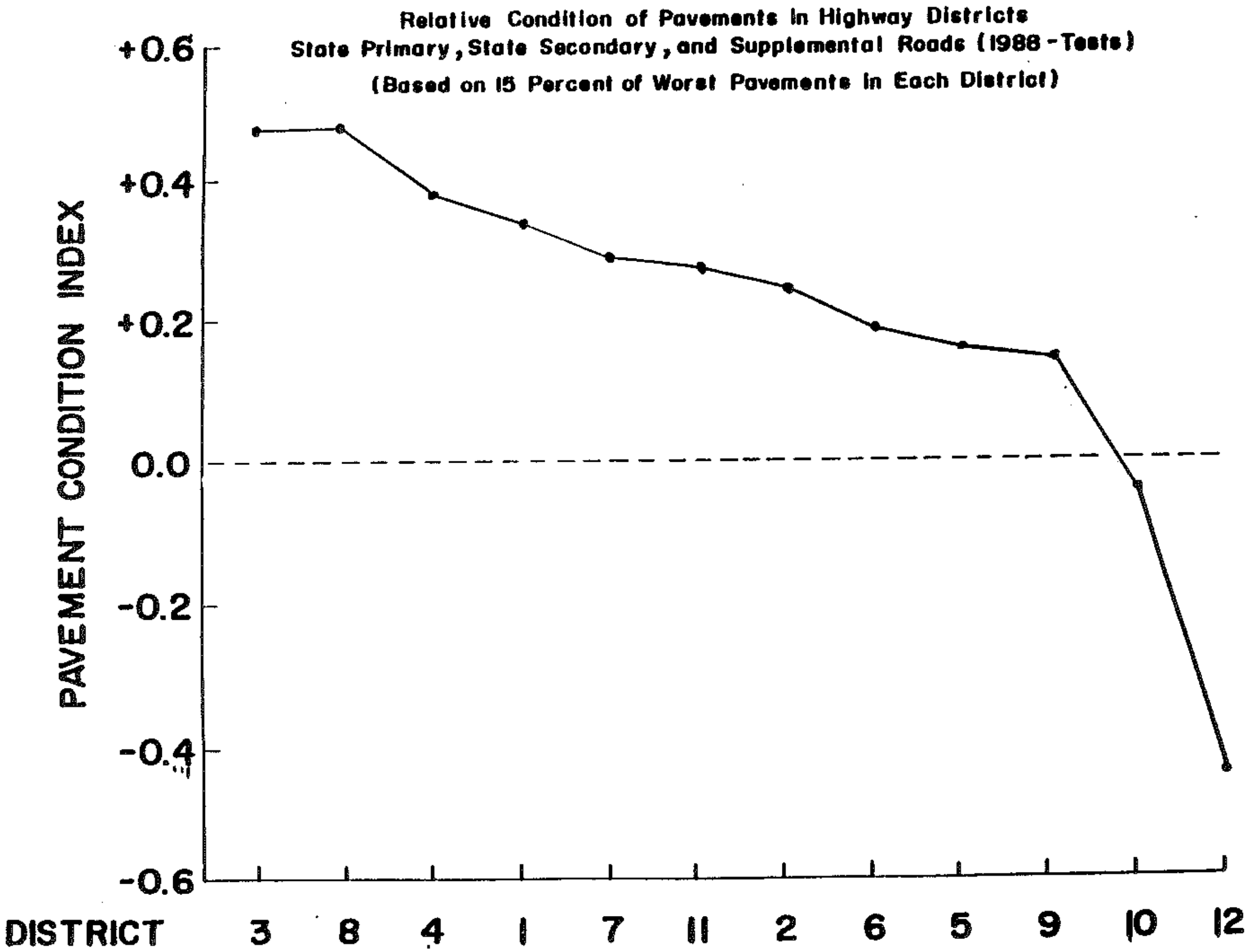


Figure E5. From Memorandum; Proposed Allocation of Funds to Highway Districts; 1990 Resurfacing Program; October 31, 1989.

TABLE 3

ALLOCATION OF MONIES TO DISTRICTS
(Based on $33.0 Million Budget and Condition Multiplication Factor of 0.35)

DISTRICT	ALLOCATION FACTOR	% DIFF FROM 1/12 BUDGET 1988	1989	1990	THOUSANDS OF DOLLARS ALLOCATION	IDENTIFIED NEED	REMAINING NEED*	% FUNDING OF IDENTIFIED NEED
1	0.0824	14.2	22.1	-1.1	2,720	2,720	0	100
2	0.1047	-5.2	-5.8	25.6	3,450	4,270	820	81
3	0.0559	-62.6	-28.2	-32.9	1,840	2,290	450	80
4	0.0909	-8.8	-49.8	9.0	3,000	3,260	260	92
5	0.0724	-7.3	0.8	-13.2	2,390	5,070	2,680	47
6	0.0806	-9.8	23.5	-3.3	2,660	3,510	850	76
7	0.0885	-2.2	22.3	6.2	2,920	3,030	110	96
8	0.0757	-5.5	-41.0	-9.2	2,500	2,790	290	90
9	0.0885	20.0	15.9	6.2	2,920	3,310	390	88
10	0.0476	7.3	-22.6	-42.9	1,570	1,570	0	100
11	0.0765	-4.9	5.7	-8.1	2,530	3,250	720	78
12	0.1364	64.8	57.0	63.6	4,500	7,670	3,170	59

*Identified need minus allocation

Figure E6. From Memorandum; Proposed Allocation of Funds to Highway Districts; 1990 Resurfacing Program; October 31, 1989.

TABLE IV

ESTIMATED UNMET DISTRICT NEEDS

DISTRICT	MILES							
	1984	1985	1986	1987	1988	1989	1990	1991
1	170	170	140	140	110	100	90	70
2	250	250	210	150	130	120	90	70
3	50	70	70	60	80	80	60	30
4	150	160	130	110	80	90	80	60
5	180	210	150	140	110	100	80	40
6	270	280	230	210	200	120	90	50
7	220	220	160	130	120	100	80	60
8	180	200	150	120	90	80	70	60
9	230	250	230	200	190	110	70	20
10	200	220	180	150	100	70	70	60
11	250	260	210	180	120	110	80	30
12	550	560	540	470	420	370	290	210
TOTAL	2,700	2,850	2,400	2,060	1,750	1,450	1,150	760
CHANGE: (From Previous Year)		+150	-450	-340	-310	-300	-300	-390
MILES RESURFACED:	570	330	900	980	960	890	1,070	1,190

Figure E7.

TABLE 1. Quantity of Bituminous Patching Materials for MP System Since FY 1979-80*
(In Thousands of Tons)

DISTRICT	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	TOTAL	AVERAGE TONS/LANE MILE/YEAR	BUDGETED 89-90
1	43.8	41.3	37.5	20.0	26.1	12.2	23.4	35.9	25.7	21.5	287	9.8	25.0
2	40.6	36.9	51.0	24.1	19.8	22.7	34.4	40.9	26.6	27.1	324	9.8	23.1
3	27.3	17.4	23.2	13.2	13.9	18.2	21.6	24.8	23.9	14.7	199	9.2	17.0
4	42.6	22.6	14.8	12.4	23.0	20.7	29.7	31.5	23.4	12.5	234	8.0	19.4
5	16.5	20.4	25.3	31.4	21.0	19.0	25.1	20.1	12.2	7.6	198	9.0	9.6
6	24.0	15.8	19.9	12.1	17.5	14.7	19.2	16.6	20.6	11.2	172	8.2	12.8
7	11.1	18.3	15.8	9.9	11.1	13.4	16.2	11.6	14.6	8.3	131	5.4	13.6
8	29.4	27.7	26.0	13.6	14.1	22.7	30.5	23.0	20.6	9.1	217	9.3	9.1
9	29.9	24.9	38.6	28.5	29.9	19.7	31.8	25.7	26.3	14.4	269	12.3	22.8
10	66.6	75.5	82.5	53.1	62.0	28.2	51.3	32.2	24.8	12.8	489	24.4	15.8
11	26.0	33.1	28.7	29.1	27.7	20.7	36.7	20.9	20.9	10.6	254	12.2	14.5
12	34.0	33.0	70.0	35.7	26.9	25.0	42.0	34.5	28.4	16.0	345	16.4	17.9
TOTAL	392	367	433	283	293	237	362	318	268	166	3,119 (Average 312)	10.8	201
MILES												(Average)	
Patched**:	576	540	637	416	431	349	532	468	394	244	4,587	(459)	295
Resurfaced:	633	584	1,100	843	721	573	326	896	978	957	7,611	(761)	886 (1989)
Total:	1,209	1,124	1,737	1,259	1,152	922	858	1,364	1,372	1,201	12,198	(1,220)	1,181
Resurfacing Cycle (years):	11.4	12.3	7.9	11.0	12.0	15.0	16.1	10.1	10.1	11.4		(11.3)	11.7

* Excludes pothole patching quantities

** Based on pavement width of 21 feet and thickness of 1 inch (680 tons/mile)

Figure E8. From Memorandum; Bituminous Patching of Pavements; Suggested District Allocations for FY 1990 -91; January 25, 1990.

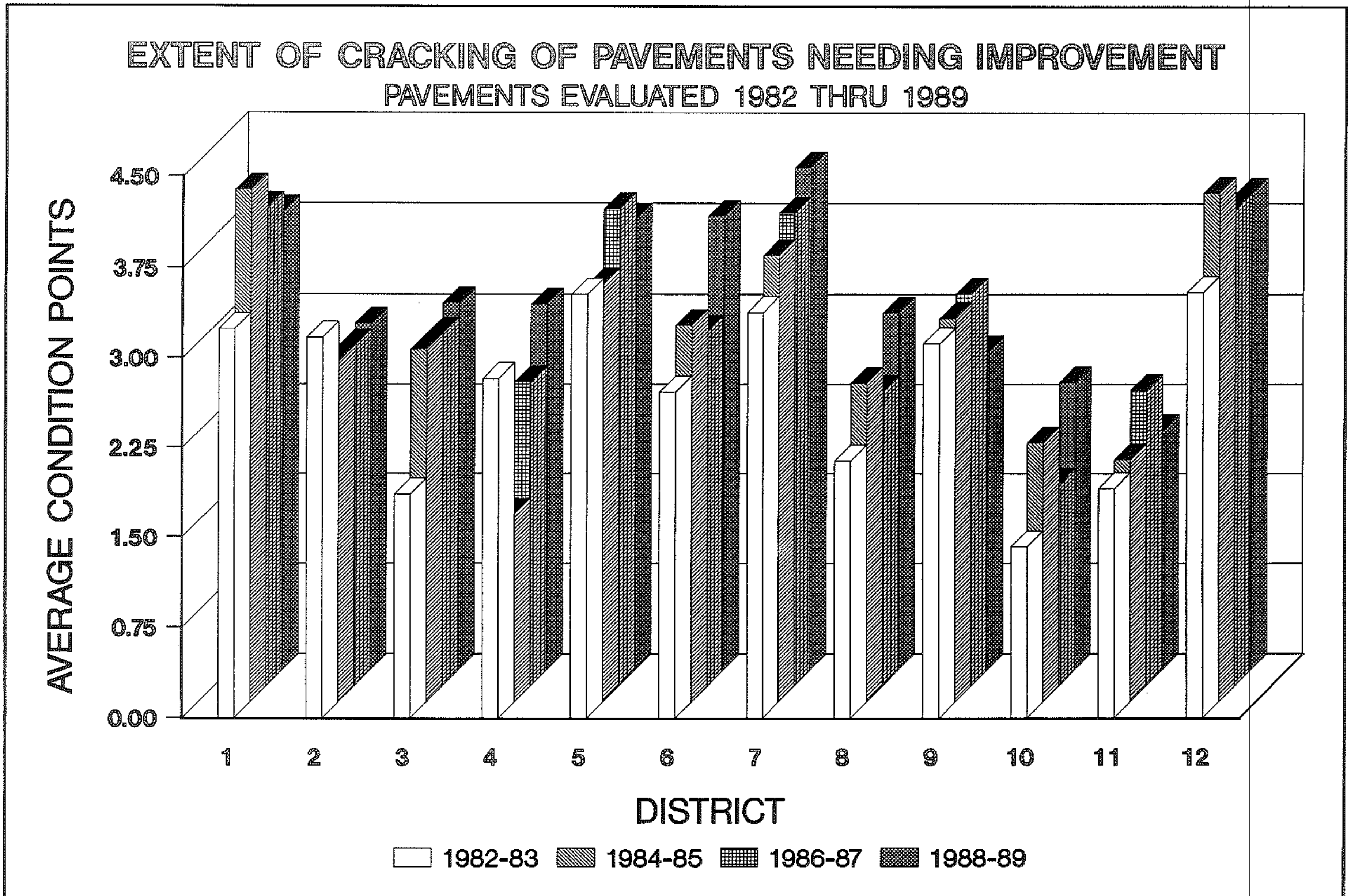

EXTENT OF CRACKING OF PAVEMENTS NEEDING IMPROVEMENT
PAVEMENTS EVALUATED 1982 THRU 1989
AVERAGE CONDITION POINTS
4.50
3.75
3.00
2.25
1.50
0.75
0.00
1
2
3
4
5
6
7
8
9
10
11
12
DISTRICT
1982-83
1984-85
1986-87
1988-89

Figure E9.

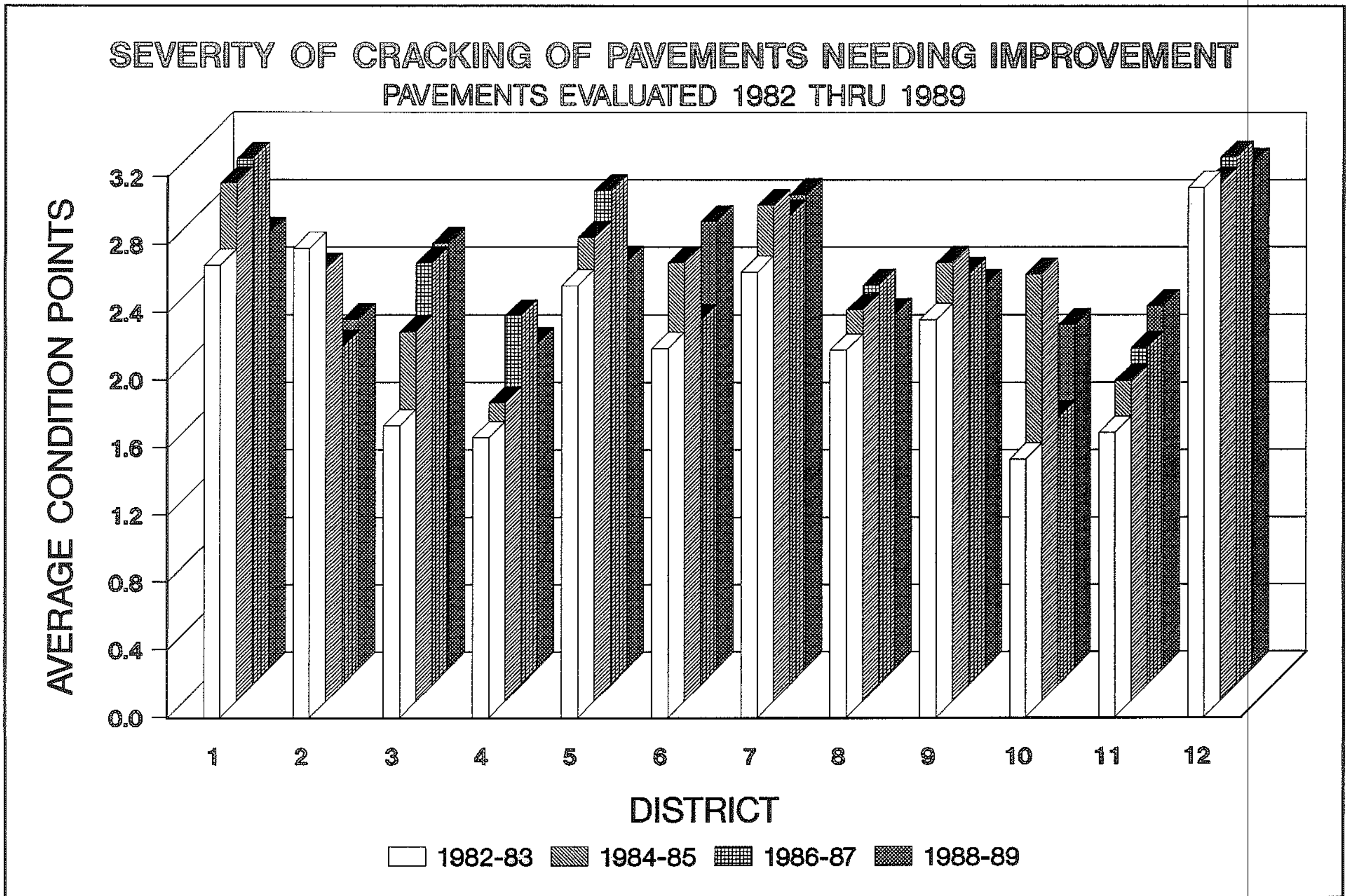

SEVERITY OF CRACKING OF PAVEMENTS NEEDING IMPROVEMENT
PAVEMENTS EVALUATED 1982 THRU 1989
AVERAGE CONDITION POINTS
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
1
2
3
4
5
6
7
8
9
10
11
12
DISTRICT
1982-83
1984-85
1986-87
1988-89

Figure E10.

APPENDIX F

GUIDELINES FOR DESIGN OF HIGHWAY PAVEMENTS IN KENTUCKY

DRAFT

IMPLEMENTATION PLAN

GUIDELINES FOR DESIGN OF HIGHWAY PAVEMENTS IN KENTUCKY

I. ROLES AND RESPONSIBILITIES

A. NEW CONSTRUCTION AND RECONSTRUCTION

1. Pavement Type Selection
Pavement type selection for new and reconstructed pavements is the responsibility of the Division of Design (Pavement Branch). Pavement type selection is made on the basis of the following considerations:

   (a) Performance history of various pavement types,
   (b) Initial costs,
   (c) Life-cycle costs,
   (d) Local paving materials and/or conditions,
   (e) Pavement shoulder considerations,
   (f) Administrative and regional considerations.

   Life-cycle cost analysis procedures currently are being researched to identify critical aspects of life-cycle cost analyses in Kentucky. Simplified life-cycle costing procedures involving only life-cycle costs of construction alternatives are in place. Research continues for refinement of life-cycle cost analyses to include maintenance costs, user costs, refined salvage values and estimates of remaining life.

2. Thickness Design
Pavement thickness determination for new, reconstructed, and rehabilitated pavements is the responsibility of the Division of Design (Pavement Branch). The Division of Specialized Programs (Pavement Management Branch) conducts deflection tests on selected pavements and may make recommendations for overlay thicknesses for bituminous overlays of existing bituminous pavements on the basis of deflections testing. At the request of the Division of Design and others, the Pavement Management Branch also conducts deflection testing of rigid pavements, composite pavements and other pavements.

B. PAVEMENT REHABILITATION, RESURFACING, RESTORATION, AND RECONSTRUCTION

1. Identification of Projects
The identification of potential projects for pavement rehabilitation, restoration, reconstruction and/or resurfacing is the responsibility of the Division of

Maintenance and the Division of Specialized Programs (Pavement Management Branch).

2. Selection of Projects
The selection of projects for programming for pavement rehabilitation, resurfacing, restoration, and reconstruction is the responsibility of the Division of Maintenance. The Division of Maintenance, with the assistance of the Division of Specialized Programs (Pavement Management Branch) develop listings of annual priority needs for resurfacing, restoration, rehabilitation, and reconstruction projects. The listings may include preliminary strategy recommendations.

3. Pavement Committee
(a) Listings of proposed projects for pavement rehabilitation, restoration, and reconstruction are reviewed by a Pavement Committee. The Pavement Committee is the focal point for pavement decisions in the Transportation Cabinet.

(b) The Pavement Committee consists of representatives from the following:
Division of Design (Pavement Branch)
Division of Maintenance
Division of Materials
Division of Specialized Programs (Pavement Management Branch)

(c) The Pavement Committee coordinates application of experimental materials in the pavement area. Examples of experimental features include: additives for bituminous pavements (fibers, polymers), modified mixture designs, special construction procedures, etc.

(d) Members of the Pavement Committee and representatives of the Division of Construction and the Specification Branch (Division of Specialized Programs) form a committee for development of guidelines for bituminous surface type selection.

(e) The Pavement Committee coordinates with other divisions (Construction, Planning, etc.) within the Transportation Cabinet and outside agencies (Kentucky Transportation Center, FHWA, AASHTO, etc.) as necessary.

4. Pavement Performance Information
The Division of Specialized Programs (Pavement Management Branch) is responsible for collection and maintenance of pavement performance data necessary for determining effective pavement rehabilitation, resurfacing, restoration and reconstruction strategies. Pavement performance information collected and maintained by the Pavement Management Branch includes:

i. Inventory
ii. Pavement Condition Survey (Visual Distress) Data
iii. Pavement Rideability Data
iv. Deflection Testing Data
v. Rutting Data
vi. Skid Resistance Data

C. PROJECT DEVELOPMENT

1. New Construction

Procedures for project development for new construction including roadway reconstruction is described in the Design Guidance Manual. The Division of Design is responsible for the development of construction plans, and for the preparation and assembly of plans and or proposals for new construction and reconstruction projects.

2. Resurfacing

For purposes of these guidelines, pavement resurfacing projects shall be defined as those projects wherein the total thickness of bituminous material to be placed is less than or equal to 2 inches.

Project development procedures for resurfacing projects are as follows:

(a) The Division of Maintenance in cooperation with the Pavement Management Branch is responsible for the identification of projects requiring bituminous resurfacing and for determination of priority listing for resurfacing projects.

(b) The Pavement Committee will not routinely review or meet concerning resurfacing projects excepting for proposed resurfacing projects for Interstate and Parkways.

(c) The Division of Maintenance prepares estimates for proposed resurfacing treatments and project termini for submission to the Division of Design. The Division of Design is responsible for preparation and assembly of proposals and/or plans for resurfacing projects.

3. Pavement Rehabilitation and Reconstruction Projects

For purposes of these guidelines, pavement rehabilitation shall be defined as those activities undertaken to restore serviceability and to extend the service life of an existing facility. This may include partial recycling of the existing pavement structures, placement of additional materials (overlays), and other work necessary to return an existing pavement section, including shoulders to a condition of structural and/or functional adequacy. Thick bituminous overlays shall be defined as those overlays where the total thickness of overlay exceeds 2 inches or where more than 2 courses of bituminous material is placed. Pavement rehabilitation project also will typically address the upgrading of guardrail, and/or the extension of drainage pipes, modifications of pipe headwalls, or replacement of existing pipe headwall with specialized drainage boxes for purposes of upgrading the safety and geometric features of the roadway to more closely approach current standards.

Pavement reconstruction is herein defined as construction of the equivalent of a new pavement structure. This usually involves complete removal and replacement of the existing pavement structure.

(a) Interstate Pavement Rehabilitation/Reconstruction and other Federally Funded Pavement Rehabilitation/ Reconstruction Programs

The Division of Maintenance in cooperation with the Pavement Management Branch is responsible for identification of Interstate highway pavements requiring rehabilitation and/or reconstruction and for preparation of priority listings. The Pavement Management Branch conducts pavement condition surveys, measures rut depths, performs rideability tests, and deflection tests. The Pavement Management Branch summarizes the information and results of analyses and makes preliminary recommendations regarding treatments and makes preliminary estimates of costs. This information is transmitted to the Division of Design (Pavement Branch) and the Pavement Committee.

The Division of Design evaluates (where appropriate) alternate treatments and strategies and reports results and recommendations to the Pavement Committee. Alternate rehabilitation strategies are discussed by the Pavement Committee and a rehabilitation/reconstruction strategy selected.

Details for the rehabilitation/reconstruction designs are completed by the Division of Design (Pavement Branch) and submitted to the FHWA for review and concurrence. Included in the submission will be detailed typical sections for pavement rehabilitation/reconstruction, design information and where applicable data necessary to support the proposed pavement rehabilitation or reconstruction design, a statement of other alternatives considered, and an analysis or documentation of why various alternates were rejected. Analyses of alternatives may include: historical performances of various alternates where appropriate, initial costs, life-cycle cost information where available and appropriate, pavement shoulder considerations, locally available paving materials, and other administrative and regional considerations. A summary of pavement condition analyses including pavement rideability data, pavement distress information and deflection data also will be submitted to FHWA in support of the proposed pavement rehabilitation alternate. The results of meetings and discussions of the Pavement Committee will be documented and submitted by memorandum report to the Division of Design for inclusion in project records and for submission to the Federal Highway Administration where appropriate. The Division of Design is responsible for preparation of plans and/or proposals.

4. Parkway and Primary Pavement Rehabilitation Programs

The Division of Maintenance in cooperation with the Pavement Management Branch is responsible for the identification of Parkway and Primary System pavements requiring pavement rehabilitation or reconstruction and for preparation of priority listings for pavement rehabilitation/ reconstruction. The Pavement Management Branch conducts pavement condition surveys, measures rut depths, performs rideability, skid resistance, and deflection testing. The Pavement Management Branch summarizes rideability, condition (distress) survey information and may make preliminary recommendations regarding treatments. This information is transmitted to the Division of Design (Pavement Branch) and the Pavement Committee.

The Division of Design evaluates alternate treatments strategies and reports results and recommendation to the Pavement Committee. Alternate rehabilitation strategies will be discussed by the Pavement Committee the rehabilitation/reconstruction strategy selected.

Final details for the rehabilitation/reconstruction design are completed by the Division of Design (Pavement Branch). The Division of Design is responsible for preparation of plans and/or proposals.

II. DESIGN PERIODS

The design period (life) is variable depending upon the use and functional classification of the facility.

A. DESIGN PERIOD FOR NEW AND RECONSTRUCTED PAVEMENTS

	RURAL	URBAN
ARTERIALS	20 YEARS	25 YEARS
NON-ARTERIALS	15 YEARS	20 YEARS

B. DESIGN PERIOD FOR PAVEMENT REHABILITATION

	RURAL	URBAN
ARTERIALS	10 YEARS	12 YEARS
NON-ARTERIALS	8 YEARS	10 YEARS

The design period for overlays and other pavement rehabilitation strategies may be modified for special circumstances wherein site specific conditions require either a reduced or extended design life.

1. The minimum design life is 5 years
2. The maximum design life is 30 years

C. DESIGN EQUIVALENT SINGLE AXLELOADS (ESAL's)

Design ESAL's are computed by the Division of Planning for the specific design period using current load equivalency factors and procedures for computation of ESAL's. Currently, those procedures are described in Kentucky Transportation Center Research Reports:

1. UKTRP 81-17, UKTRP 81-20 (Load Equivalency Factors)
2. UKTRP 84-30, UKTRP 85-30 (ESAL Computation)

III. CHARACTERIZATION AND TREATMENT OF SUBGRADE MATERIALS

A. Current pavement thickness design procedures are based on California Bearing Ratios (CBR's) determined by the current Kentucky method (KM64-501) for CBR testing.

B. DESIGN SUBGRADE STRENGTH

1. The design subgrade strength is determined by the Division of Materials, by consultants, or from deflection test results.

2. The design CBR for new and reconstructed pavement projects is selected as the laboratory CBR by Kentucky Method KM64-501, current edition for the weakest soil most likely to be encountered in the subgrade.

3. The design CBR is recommended by the Division of Materials or by consultants. The testing agency (Division of Materials or consultants) is responsible for collection of a sufficient number of samples to adequately evaluate the design bearing capacity of the subgrade material.

4. The design CBR may be estimated by the Division of Design for minor projects such as bridge replacement, detours, short pavement replacement sections and overlays wherein it may not be practical to obtain the required subgrade soil samples or other tests necessary for determination of design subgrade strengths.

5. Deflection tests may be used to estimate design subgrade strengths for overlay projects.

C. SUBGRADE MODIFICATION

1. Subgrade modification is considered for all subgrade soils with design CBR 6 or less.

2. The typical method of subgrade stabilization is by chemical treatment using either lime or portland cement.

   a. Lime (hydrated or quicklime) is typically used if the Plasticity Index (PI) for the subgrade soil is greater than or equal to 20 and a grain size analysis indicates greater than 35% passing the #200 sieve.

   b. Portland cement is typically used if the PI is less than 20 and there is less than 35% passing the #200 sieve.

   c. The specific proportions of chemical modifying agents and/or recommendations for mechanical modification and/or recommendations for removal and replacement is recommended by the Division of Materials or Geotechnical Consultant. If not specified, quantities of chemical modifying agent is estimated on the basis of 6% by dry weight and a dry unit weight of soil assumed as 105 pounds per cubic foot.

3. Alternate methods of subgrade modification is considered on a site specific basis. These include mechanical methods (blending soil and aggregate), use of fabrics and/or geogrids with aggregate, use of a combination of lime and portland cement for soil modification, and ultimately removal and replacement.

4. The thickness of modified subgrade follows:
   a. Minimum of 8 inches
   b. Maximum as directed by Division of Materials or Geotechnical Consultant

5. Subgrade modification is for the full roadbed width (shoulder edge to shoulder edge).

6. A subbase material may be considered as an alternate for subgrade modification on a project by project basis. Examples of subbase materials are bank gravel or other local deposits of rock or gravel, shot limestone rock, and some high quality shot shales such as the New Albany Shale. Subbase materials are selected on a site specific basis by the Division of Design in cooperation with the Division of Materials.

7. Subgrade modification is not normally considered for pavements with annual ESAL's less than 50,000.

   Subgrade modification is considered but not required for pavements with annual ESAL's greater than or equal to 50,000 and less than 250,000.

   Subgrade modification is normally considered for pavements with annual ESAL's greater than or equal to 250,000.

8. The structural credit assigned to chemically modified roadbed shall be determined by the Division of Design (Pavement Branch).

IV. PAVEMENT SUBSURFACE DRAINAGE

A. A pavement subsurface drainage system is not normally considered for pavements with annual ESAL's less than 50,000.

B. A pavement subsurface drainage system considered but not required for pavements with annual ESAL's between 50,000 and 250,000 inclusive.

C. A pavement subsurface drainage system is normally considered for pavements with annual ESAL's greater than 250,000.

D. Procedures for design of pavement drainage systems will generally follow guidelines presented in FHWA Report TS-80-224 "Highway Subdrainage Design".

E. DRAINABLE BASE LAYERS

   Drainable base layers may be either bound our unbound as specified by the Division of Design. Bound drainable base layers may be either bituminous treated or cement treated. Unbound aggregate drainable base layers typically are crushed limestone #57 aggregate. Alternate gradations for unbound aggregate drainable base layers may be considered on a site specific basis. The structural credit associated with bound drainage base layers will be determined by the Division of Design (Pavement Branch).

V. UNBOUND AGGREGATE BASE MATERIALS

A. The minimum thickness of unbound aggregate base material is 4 inches.

B. For pavements with annual ESAL's less than 50,000 the unbound base material is Crushed Stone Base or Dense Graded Aggregate Base (DGA) as designated in the Kentucky Standard Specifications, Special Provisions and or Special Notes. The use of Crushed Stone Base versus DGA Base will be specified by the Division of Design (Pavement Branch) on the basis of site specific conditions. Where appropriate, Crushed Stone Base may be used in lieu of Dense Graded Aggregate Bases.

C. For pavements with annual ESAL's between 50,000 and 250,000 inclusive, unbound base materials normally considered include:

1. Crushed Stone Base,
2. Dense Graded Aggregate Bases, or
3. "#57 Aggregate" used as a drainable base layer in combination with dense graded aggregate (DGA) used as a filter course. The maximum thickness of unbound drainable base layer typically is 4 inches except when used under shoulders.

D. A closed drainage system (edge drains and pipe collection system) is normally considered for all pavements with annual ESAL's greater than 250,000. The drainable base layer (untreated aggregate, bituminous treated, or cement treated) is specified by the Division of Design.

E. Drainable base layers must be protected from intrusion by soil and other fine contaminating materials by use of a filter layer. The filter layer may be either a fabric or aggregate material.

The filter should meet the following criteria to protect the drainage blanket from intrusion by the soil:

(D_{15}) filter is less than or equal to 5 (D_{85}) soil
(D_{50}) filter is less than or equal to 25 (D_{50}) soil

The filter should meet the following criteria to prevent intrusion of filter fines into the base course:

(D_{15}) base is less than or equal to 5 (D_{85}) filter
(D_{50}) base is less than or equal to 25 (D_{50}) filter

Typically dense graded aggregated base can be used as filter material. The Division of Materials will review soils data and make recommendations when DGA is not be an appropriate filter aggregate material.

F. The use of a graded aggregate filter or alternate geotextile fabric is not generally required for chemically modified soils.

VI. THICKNESS DESIGN FOR PAVEMENTS AND OVERLAYS

A. THICKNESS DESIGN PROCEDURES

1. FLEXIBLE PAVEMENTS
Thickness design procedures currently used for design of flexible pavements are presented in Kentucky Transportation Center Research Reports UKTRP 81-17 and UKTRP 81-20.

2. RIGID PAVEMENTS

Rigid pavements will be plain jointed concrete. The thickness design procedure currently used for rigid pavements is presented in Kentucky Transportation Center Report UKTRP 84-3.

B. MINIMUM THICKNESSES

1. RIGID PAVEMENT - Rigid pavement typically is considered for pavement sections designed to accommodate annual ESAL's of 50,000 or more. The minimum thickness of rigid pavement is 8 inches.

2. FLEXIBLE PAVEMENT

a. For annual ESAL's less than 50,000 the minimum thickness of asphaltic concrete is 3 inches.

b. For annual ESAL's between 50,000 and 250,000 inclusive the minimum thickness of asphaltic concrete is 4 inches.

c. For annual ESAL's greater than 250,000 the minimum thickness of asphaltic concrete is 5 inches.

d. The minimum proportion of asphaltic concrete is 33% of the total pavement structure.

e. The minimum thickness for the first layer of asphaltic concrete varies dependent upon the total thickness of asphaltic concrete.

For 6 inches total asphaltic concrete the minimum thickness of the first layer is 3 inches.

For 10 inches total asphaltic concrete the minimum thickness of the first layer of asphaltic concrete is 4 inches.

f. The minimum thickness of asphaltic concrete surfacing is 1 inch.

g. Full Depth Asphaltic Concrete Pavements

Full Depth asphaltic concrete pavement are considered on a site specific basis when at least one of the following conditions exists:

The design CBR is greater than 6 and/or the subgrade material is granular in nature.

The design CBR is less than or equal to 6 and has been modified to provide a stable working platform.

Full depth asphaltic concrete pavement is not normally considered when annual ESAL's are less than 50,000.

Other applications for full depth asphaltic concrete are considered for site specific considerations.

VII. SHOULDERS

Minimum thicknesses for paved shoulders are determined from procedures presented in Kentucky Transportation Center Research Report UKTRP 87-8. Additional thicknesses for shoulders are considered for pavements wherein the shoulders may be used for detours during construction or for other situations wherein the shoulder is expected to function as a travel lane for an extended period of time.

A. Minimum thicknesses for flexible pavement shoulders are:

1. 3 inches minimum asphaltic concrete, and
2. 4 inches minimum unbound aggregate base
3. Full depth asphaltic concrete shoulders are considered on a site specific basis. For these situations, the thickness of asphaltic concrete for shoulders is the same as for mainline pavement.

B. The minimum thickness for a rigid pavement shoulder is 6 inches portland cement concrete.

C. Extended Cross Sections
In some situations, it may be desirable to extend the mainline pavement cross section into the shoulder. The use of an extended cross section may be considered on a site specific basis.

D. Paved shoulders typically are considered for projects with annual design ESAL's between 50,000 and 250,000. Paved shoulders are not typically used for projects with annual ESAL's less than 50,000. Paved shoulders typically are used for projects with annual ESAL's greater than 250,000. The widths of paved shoulders is as specified in geometric design guidelines. Paved shoulders must be used when a drainable base layer is used.

The various types of shoulder treatments are summarized below:

1. Earth Shoulders - Earth shoulders typically are used for lower class pavement facilities with annual ESAL's less than 50,000. The widths of earth shoulders is as specified in geometric design guidelines.

2. Aggregate Shoulders - Aggregate shoulders typically are used for low to moderate class pavement facilities with annual ESAL's less than 250,000. The thickness for aggregate shoulders varies from a minimum of 5 inches to the full thickness of the mainline pavement cross section.

   A bituminous seal is used to stabilize aggregate shoulders and to control erosion.

The widths of aggregate shoulders is as specified in geometric design guidelines.

3. Paved Shoulders - Paved shoulders typically are used for high type pavement facilities and also are used for a number of moderate type pavement facilities. Paved shoulders typically are used for pavements with annual ESAL's greater than 50,000. The widths of paved shoulders varies from partial width paved shoulders to full width paved shoulders. The total shoulder width is specified in geometric design guidelines.

   a. Extended Cross Section Shoulders

      The mainline pavement cross section may be extended into the shoulder for a specific width on selected projects. The width of the extended cross section may vary from a minimum of 2 feet to a maximum of of 12 feet full width.

      A partial width extension of the mainline pavement cross section may be used for selected circumstances. In these situations, the remainder of the shoulder iseither earth or aggregate. Aggregate shoulders used in this application may be either full depth or partial depth. A bituminous seal is specified for the aggregate shoulders dependent upon site specific constraints. A partial width extension of the mainline pavement cross section typically is used for design ESAL's between 50,000 and 250,000.

      A full width extension of the mainline pavement cross section is used only for those situations where the shoulder will be used as a detour or for those situations wherein the shoulder is be expected to function as a travel lane for an extended period of time. This type of shoulder typically is used for pavements with mainline ESAL's greater than 250,000 annually.

   b. Partial Depth Full Width Paved Shoulders

      Partial depth full width paved shoulders are those shoulders wherein the total shoulder thickness is less than the total mainline pavement thickness. Partial depth full width paved shoulders typically are used for pavements with design ESAL's greater than 50,000 annually. The thickness of partial depth paved shoulders may consist of any proportion of asphaltic concrete (or Portland Cement Concrete) and aggregate so long as minimum thickness requirements are not violated.

   c. Full Depth Full Width Paved Shoulders

Full depth full width paved shoulders are those shoulders where in the total shoulder thickness is equal to the thickness of the mainline pavement. The thickness of full depth paved shoulders may consist of any proportion of asphaltic concrete (or Portland Cement Concrete) and aggregate so long as minimum thickness requirements are not violated. Full depth full width paved shoulders typically are used for pavements with design ESAL's greater than 250,000 annually.

E. Paved shoulders are used for bridge replacement projects within the limits of guardrail for the approaches or a minimum of 200 feet. Shoulders are transitioned to existing shoulders thereafter. Paved shoulders are considered on a site specific basis for other spot improvements.

F. Indented rumble strips are used on paved shoulders as specified by the Division of Design. Typically, rumble strips are specified on pavements with design annual ESAL's greater than 50,000.

VIII. THICKNESS DESIGNS FOR OVERLAYS

A. These guidelines currently address only flexible overlays for existing flexible and rigid pavements. Rigid overlays will be considered on a site specific basis.

B. FLEXIBLE OVERLAYS FOR FLEXIBLE PAVEMENTS

Flexible overlays are typically designed on the basis of the "effective thickness approach" as presented in Kentucky Transportation Center Research Report UKTRP 83-24. In some situations elastic layer procedures and the limiting strain criteria used for new pavement design will be used to determine the required overlay thickness. AASHTO overlay design procedures may be consideredfor verification of overlay thicknesses for some site specific projects.

1. The minimum overlay thickness is 1 inch.

2. The maximum overlay thickness characterized as resurfacing is 2 inches. The Pavement Management Branch in Cooperation with the Division of Maintenance is responsible for identifying projects for resurfacing. The thickness of resurfacing is determined on the basis of visual pavement conditions and/or deflections by the Division of Maintenance and the Pavement Management Branch.

3. The Division of Design processes all resurfacing projects. Resurfacing projects for Interstates and Parkways are reviewed by the Pavement Committee. The Pavement Committee also may review other projects that have been resurfaced at an interval of less than 5 years. At the direction of the

Pavement Committee, the Division of Design (Pavement Branch) may be asked to conduct detailed pavement design analysis of these projects to determine the adequacy of the design. Results of more detailed pavement design analyses are presented to the Pavement Strategy Committee for discussion and selection of a resurfacing/rehabilitation strategy.

4. Overlays for pavement rehabilitation are characterized by thicknesses greater than 2 inches. Overlay thicknesses in excess of 2 inches are determined on the basis of visual condition survey results, deflection tests, and/or destructive testing of pavement cores. Overlay thicknesses are determined for design ESAL's for the specified design period. The Pavement Committee reviews bituminous overlays in excess of 2 inches.

C. FLEXIBLE OVERLAYS FOR RIGID PAVEMENTS

Procedures for determination of flexible overlay thicknesses for existing rigid pavements (broken and seated) are presented in Kentucky Transportation Center Research Report UKTRP 87-29 will be used. Procedures for determination of thicknesses for flexible overlays over unbroken concrete are empirical and based on part experience. General guidelines for determination of flexible overlay thicknesses are unbroken concrete (rigid) pavement are presented in the 1986 AASHTO Guide for Design of Pavement Structures and other pavmetn design texts.

1. The minimum thickness of asphaltic concrete overlay placed over unbroken concrete is 2 inches and is applied only to correct ride quality deficiencies.

2. The minimum thickness of asphaltic concrete overlay over broken and seated concrete is 4 inches. Overlay thickness for broken and seated concrete are designed for the design ESAL's associated with the design period as presented earlier. Overlays for broken and seated concrete pavements are reviewed by the Pavement Committee. A pavement design form is prepared and submitted for review and approval for overlays over broken and seated concrete.

3. Moduli for broken and seated concrete are required for use with procedures presented in Research Report UKTRP 87-29. Moduli for broken and seated concrete pavement are estimated using Figure 5 in Research Report UKTRP 87-26 which relates size of broken fragment to effective elastic moduli.

IX. INTERSECTIONS, TRUCK CLIMBING LANES AND OTHER HIGH PAVEMENT STRESS AREAS

Pavement designs for intersections, truck climbing lanes, and other high pavement stress areas may be developed separate from pavement designs for mainline paving.

A. Signalized Intersections

Pavement designs for signalized intersections may be determined separate and independent of mainline pavement designs. "Intersection pavement designs" may be used (as a minimum) within the limits of turning lanes and storage lanes for the intersection. The intersection pavement design typically extends to the back edge of curve radii for cross roads.

B. Truck Climbing Lanes and Other High Pavement Stress Areas

Pavement Designs for truck climbing lanes and other high pavement stress areas may be determined separate and independent of mainline pavement designs. The limits for use of these designs may be determined on a project specific basis.