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PAVEMENT MANAGEMENT IN KENTUCKY

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ABSTRACT

The principal objective of this paper is to summarize current pavement management activities in Kentucky. Early pavement management activities generally were decentralized (involving a number of transportation functions such as planning, design, construction, maintenance, and research) and involved long-term monitoring for skid resistance and ride quality (roughness).

Current pavement management activities may be categorized by evaluation, project selection, and development of recommendations for pavement rehabilitation strategies. Pavement evaluation activities at the statewide system level typically involve assessments of ride quality (rideability index) and estimated pavement serviceability, skid resistance, visual condition ratings, and the accumulation of traffic volumes and pavement fatigue. Funding allocations to highway districts involves the application of limiting criteria to system level data obtained during the evaluation phase. Factors considered include rideability index (estimated from roughness measurements), skid resistance, visual condition ratings, accumulation of traffic volumes and fatigue, and engineering judgment. Recommendations for rehabilitation strategies also may be based on structural evaluations using deflection measurements.

Typical rehabilitation strategies are discussed. Procedures and criteria for the allocation and distribution of funding to the highway districts are presented.

KEY WORDS: Deflection, Distress, FUNDING ALLOCATION, HIGHWAY PAVEMENT, MANAGEMENT, Overlay, Design, PAVEMENT CONDITION, REHABILITATION STRATEGIES, Rideability Index, Roughness, Rutting, Skid Resistance, STRUCTURAL EVALUATION, Traffic

INTRODUCTION

The transportation system in Kentucky consists of 69,200 miles of highways. Of this, 25,000 miles are under the jurisdiction of the Kentucky Transportation Cabinet. This includes 740 miles of interstates, 630 miles of toll roads, 3,200 miles of state primary, 8,000 miles of state secondary, 9,000 miles of rural secondary, 2,500 miles of unclassified roads, and 100 miles of other roads.

Recent studies (1) have indicated that approximately 27 percent of highway expenditures are related to pavements and surfaces. Highway-related expenditures in Kentucky for fiscal year 1984 were 705 million dollars. Therefore, it may be approximated that over 190 million dollars annually are devoted to pavements. During the past several years, pavement rehabilitation costs for state funded programs have been in the order of 42 million dollars and federally funded programs on the order of 45 million dollars. Thus, the significance of pavement management is demonstrated in terms of funding level and scope of activity.

Transportation agencies have always managed pavements. In early stages, pavement management was by default rather than by design. Management procedures were subjective rather than objective and rarely involved a systematic or structured plan for decision making. Maintenance engineers in Kentucky were among the first to become involved in a somewhat structured pavement management program of administering the statewide resurfacing program. Research and planning groups became involved in the development of procedures for evaluation and assessment of pavement conditions and in the development of data banks. Still, pavement management activities were decentralized and not recognized as high priority. Statewide cost estimates of resurfacing, restoration, and rehabilitation needs for interstate pavements (2, 3) clearly demonstrated the importance and need for a strong pavement management program both for Kentucky and nationally.

This paper summarizes current pavement management practices in Kentucky and goals for future development.

ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES

The Pavement Management Unit was assembled 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 rather than within an engineering division allows for greater and more effective interaction of the Pavement Management Unit with other units of the Transportation Cabinet.

Principal responsibilities of the Pavement Management Unit include evaluation of pavement conditions, development and maintenance of computerized data bases, analyses of data, development and implementation of decision criteria, development of recommendations for rehabilitation strategies, and review and refinement of pavement management practices. The current major tasks of the Unit to fulfill the above responsibilities are:

1. Conduct annual roughness surveys of the interstate, toll road and state primary systems and biennial surveys of the state secondary, unclassified, and

rural secondary systems 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. Evaluate the relevance and significance of specific programs, construction procedures, specifications, and other practices. List pavements approaching terminal conditions and assess rehabilitation needs. Provide data, information, and results of analyses to other Transportation Cabinet units whenever necessary.

2. Perform detailed pavement condition evaluations, including roughness, skid resistance, structure adequacy (from deflection tests), and observable distresses. Annually evaluate the interstate and toll road systems and other selected pavements in relation to rehabilitation programs. Select and rank pavements for rehabilitation, recommend scope of rehabilitation, and estimate costs.

3. Test for skid resistance and evaluate the performance of experimental pavement types. Recommend modifications of Departmental guidelines (4) for selection of bituminous surfaces. Perform tests of pavements subjectively identified as being slippery and make recommendations on the basis of Departmental guidelines for de-slicking (5).

4. Test newly constructed and rehabilitated high-type pavements for conformance with Departmental rideability requirements (6).

PAVEMENT CONDITION EVALUATION: METHODS, PROCEDURES, AND CRITERIA

ROUGHNESS

Pavement roughness measurements are obtained using five sedans equipped with Mays Ride Meters and onboard microprocessors for rapid automated data processing. The measurements are converted to rideability index (RI) using correlation equations relating pavement roughness measurements to highway user opinions of rideability (7, 8). The RI scale ranges from 0 to 5. Analyses of roughness index, average daily traffic volumes, and subjective assessments of the need for resurfacing for approximately 1,100 pavements have indicated that need for resurfacing may be associated with some critical RI. Pavements at or below critical RI's, based on traffic volumes, are considered to be in poor condition and may require rehabilitation. Pavements in fair condition may require rehabilitation within, on the average, three years for interstates and toll roads and within five years for other roads. The controlling RI values are cited below:

AVERAGE DAILY TRAFFIC (VEHICLES PER DAY)	RIDEABILITY INDEX	
	CRITICAL	FAIR
Above 8,000	2.7	3.1
6,201-8,000	2.6	3.0
4,401-6,200	2.5	3.0
2,701-4,400	2.4	2.9
1,501-2,700	2.3	2.8
1,101-1,500	2.2	2.8
901-1,100	2.1	2.7
701- 900	2.0	2.7

601-	700	1.9	2.6
501-	600	1.8	2.6
401-	500	1.7	2.5
301-	400	1.6	2.5
201-	200	1.5	2.4
1-	200	1.4	2.4

SKID RESISTANCE

Skid resistance measurements are made using a pavement friction tester in compliance with ASTM E 274. Pavements are selected for testing if slippery conditions are suspected based on either past test results or visual condition surveys or if accident data indicate a disproportionate number of wet-pavement accidents. Performance and suitability of pavements have been analyzed to establish the Cabinet's selection guidelines for bituminous surface courses (4), which specify surface courses to be used for various traffic volume levels. Guidelines for selecting slippery pavements (5) 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) with ADT's between 1,000 and 10,000 qualify for de-slicking when the Skid Number (SN) is less than 25 or SN is 26 to 32 and the benefits (accident reductions) and costs associated with de-slicking result in a B/C 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 costs associated with de-slicking result in a B/C ratio above 2.

RUTTING

Rutting of asphaltic concrete pavements or wear of portland cement concrete pavements are measured with a ruler and 67-inch straight edge.

OBSERVABLE DISTRESSES AND CONDITIONS

Cracking, base failures, faulting, raveling, spalling, and out-of-section are subjectively evaluated for interstates and toll roads in terms of extent and severity. For other roads, edge failures also are 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 for interstate and toll roads because prevailing practice on other roads is to do full-width, long-segment patching that must be considered a capital improvement.

Distresses and conditions are first noted during roughness testing in both directions of travel. Pavements are then traversed again, if necessary, at a lower 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. Symptoms of distress are subjectively evaluated and are defined in terms of demerit points.

STRUCTURAL EVALUATIONS

Pavement deflection measurements are not obtained routinely. Deflection testing has been conducted for pavements where subjective evaluations were inadequate to ascertain structural condition or indicated structural inadequacy. In the past, deflection testing has been conducted using a Model

400 Road Rater. A Model 2000 Road Rater has been purchased to evaluate the structural conditions of pavements. The number of pavements tested will be significantly increased.

Evaluation of asphaltic concrete pavements utilizes elastic layer theory to determine, for each test location, the theoretical model that best matches the measured deflection basin. Using the existing thickness of crushed stone, an effective thickness of reference-quality asphaltic concrete (modulus of elasticity of 480 ksi) and a subgrade modulus are determined that reasonably matches the theoretical model. These values are used in combination with the design fatigue estimated from traffic projections (currently 8-year traffic projections) to determine the total required thickness of asphaltic concrete. The effective thickness of asphaltic concrete is subtracted from the total thickness to determine the required overlay thickness (9, 10). Overlay thicknesses for the test locations are analyzed statistically to determine the 80th percentile overlay thickness for the project length.

Structural evaluation of rigid pavements (11) are more subjective and involve relative comparisons of deflection measurements for one slab versus another slab. Additionally, the efficiency of load transfer may be 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.

EVALUATION SCHEMES AND PRIORITY RANKING

Evaluation schemes and priority rankings of pavements are dependent upon the type of facility involved.

Interstate and Toll Roads

Pavements are visually inspected to assess conditions according to six elements and assigned points (demerits) (maximum of 33 points) as follows:

	EXTENT		SEVERITY			MAXIMUM
	FEW TO EXTENSIVE		SLIGHT TO SEVERE			
Cracking	1	to 6	1	to 4		10
Base Failures (Faulting)	1	to 3	1	to 3		6
Raveling (Spalling)	0.6	to 2	0.6	to 2		4
Out of Section	0.6	to 2	0.6	to 2		4
Patching	1.3	to 4				9
Appearance	Fair to Very Poor (1 to 5)					

Information on pavement and roadway sections is computer stored and a form is automatically printed for all routes according to construction termini. This information includes 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. Pavements are ranked according to RI level, decrease in RI with time, demerit points from

condition surveys, increase in demerit points with time, severity of rutting (or wear for rigid pavements), and structural condition analyses.

Other Roads

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

1. Condition Survey -- maximum 34 points

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

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 (13 points, adjusted according to traffic volume)
5. Traffic Volume -- ADT = 401 (1 point) to 7,501 or higher (12 points)
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. 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 for their information and to assist them in assigning their priority rankings, recommended treatments, and estimated costs. District recommendations are reviewed by the Pavement Management Unit 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.

REHABILITATION STRATEGIES

The development of specific rehabilitation strategies relate to observed distresses (some of which are still subjective) and measurements. Standard practice for resurfacing asphaltic concrete pavements involves leveling and wedging and application of a 1-inch bituminous surface course. Structurally adequate pavements rutted 1/2 inch or more may be milled to minimize leveling and wedging requirements and to improve rideability. Structurally adequate pavements also may be milled as much as 1 inch prior to overlaying to maintain shoulder or curb heights. Thicker overlays are determined on the basis of subjective assessments and from deflection analyses. Overlays of 2 inches or more are considered thick overlays. Stage construction, while not typical, sometimes may be desirable in situations where funding is not available for total rehabilitation.

Extensive maintenance of rigid pavements has not been judged cost effective. Instead, overlaying has been the preferred practice. Overlaying rigid pavement, except for interstate and toll roads, involves leveling and wedging with asphaltic concrete and overlaying with a 1-inch bituminous surface course. Thicker overlays (2 to 10 inches) have been placed on interstate pavements in an attempt to minimize thermal expansion of the portland cement concrete slabs and thereby minimize reflective cracking. This treatment has been relatively unsuccessful. Current practice for interstate and toll roads involves fracturing the existing rigid pavement into 18- to 24-inch fragments, seating the fragments, and overlaying with 5 to 7 inches of asphaltic concrete. This treatment has been successful in controlling reflective cracking for the relatively short time the pavements have been in service. Long-term experience, however, may result in a modification of these practices. Other rehabilitation procedures for rigid pavements involve installation of edge drains and resealing of joints. Full-depth and localized portland cement concrete patching is being done to extend the life of some pavements. Selection of rehabilitation alternatives are still subjective at this time.

ALLOCATION OF FUNDS

INTERSTATE AND TOLL ROADS

Allocation of funds for high-type pavement rehabilitation projects is based on demonstrated need. Those pavements judged in greatest need are given the highest priority. For interstate roads, 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 condition of pavements.

STATE PRIMARY, STATE SECONDARY, AND UNCLASSIFIED ROADS

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 highway district. The allocation formula is as follows:

$$\text{District Allocation} = B \frac{L_d \times C_d \times (S_{\max} - (S_d \times F))}{\sum_{d=1}^{d=12} (L_d \times C_d \times (S_{\max} - (S_d \times F)))}$$

where B = statewide resurfacing budget (dollars),
 L_d = lane-miles of roads in district,
 C_d = cost per ton of bituminous surface materials in district,
 S_d = RI difference from critical RI value in district,
 S_{\max} = largest positive value of RI differences for any district,
F = pavement conditions multiplication factor, and
d = district number.

Pavement conditions in each highway district are characterized in terms of difference in RI's between measured values and critical values. The RI of each homogeneous pavement section is subtracted from the critical RI assigned for the particular traffic volume. The RI difference at 15 percent of the pavement mileage in the poorest condition in each highway district is determined. The largest negative RI difference so determined identifies the highway district with the poorest pavements. Conversely, the largest positive value identifies the highway district with the best pavements. The multiplication factor, F, permits the extent to which pavement conditions influence allocations to be varied. A multiplication factor of zero would completely remove pavement condition from influencing the allocations. On the other hand, as the multiplication 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. If the budget is large, a percentage higher than 15 percent may be selected. Also, a number of multiplication 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 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 highway districts and that a more equitable allocation of funds was needed compared to formulas or distributions made earlier.

Complete equalization in pavement conditions statewide is not sought because traffic loading, subgrade conditions, climate, terrain, etc. distinguishes one highway 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 in an inequitable manner.

REHABILITATION NEEDS ESTIMATES

INTERSTATES AND TOLL ROADS

Pavements on interstates and toll roads in need of rehabilitation are identified each year from detailed pavement condition evaluations. These evaluations along with historic rideability data and, since 1981, yearly pavement condition evaluations provide a basis for estimating when other pavements may need rehabilitation. Pavements judged as needing rehabilitation are ranked in order of conditions. Pavements ascertained as needing rehabilitation later are tabulated by year through the next several years. Rehabilitation remedies and costs are determined for each pavement, and the costs are added to quantify funding needs.

OTHER ROADS

Detailed pavement condition evaluations are not done for all pavements. Rideability indexes, however, are obtained for all state-maintained pavements. Thus, current needs are estimated by identifying pavements with RI's at or below the critical level and totaling the mileages. 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.

Pavements with RI's above the critical level are analyzed to determine if the RI's may decrease to the critical level by the next year. An appropriate annual RI decrease is subtracted from the current RI's and mileages of pavements reaching critical levels are totaled. This process is repeated for remaining pavements to obtain estimates for successive years. 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 obtained for use in budget requests.

THE FUTURE

There is support at all levels of the Kentucky Transportation Cabinet to continue development of a strong and effective Pavement Management Unit. Much has been accomplished, but much remains to be done. Communication and interaction among various Transportation Cabinet units must continue to assure proper feedback and, thereby, continued development and improvement in the management of pavements.

Research and developmental activities are ongoing in many areas applicable to pavement management. Additional information and data are needed to more adequately define life-cycle costs of pavements. Procedures need to be developed to more effectively optimize alternative rehabilitation strategies.

Models and algorithms relative to projecting costs and effects of deferred pavement maintenance and rehabilitation are needed. Verification and updating of all models and algorithms is essential for credibility of evaluation and management procedures. There is also a need for an expanded data base to assure consideration of all elements relating to pavement conditions, needs, etc.

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