

Research Report
UKTRP-87-13

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TO HIGHWAY DISTRICTS IN KENTUCKY

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ABSTRACT

Allocation of resurfacing and rehabilitation monies began in 1967 with the separate funding of a resurfacing program. Pavement projects for resurfacing and rehabilitation were selected more often than not on the basis of politics and arbitrary (i.e., without the benefit of analysis of good inventory and condition data) judgments of decision makers. With the gradual introduction of more adequate roadway inventory and annual condition data, the formula for the allocation of funds has been gradually revised, updated, and improved so there is now a more logical and equitable distribution of funds.

With the formation of a pavement management staff in 1981, the quality of inventory and pavement distress data was greatly improved. Creation of the staff also introduced an organizational means whereby pavement condition information could be routinely used as one of the inputs upon which to base decisions regarding allocation of funds to resurfacing and rehabilitation projects.

The formula currently used to allocate funds is based upon the lane miles of highways in each district, the unit cost of asphaltic concrete in each of the districts, and the average pavement condition in each district. A modifying factor may be applied each year to assign greater weights to the conditions of the pavements in the various districts and to base allocations of funds more or less upon those conditions, depending upon objectives in any given year.

The pavement management staff of the Transportation Cabinet visits the districts each year to share results of pavement condition evaluations, to discuss resurfacing needs in the district compared to other districts, to discuss various pavement management matters, to explain the allocation formula, and to indicate what monies may be provided for the next year. These reviews with district personnel have been effective in convincing them of the appropriateness of the formula and the fairness in the allocations.

The intent is to bring about a more uniform condition of pavements throughout the Commonwealth of Kentucky as well as to improve the overall statewide condition of pavements. The allocation formula is seen as a means of distributing funds in such a way as to eventually meet these goals.

KEY WORDS: Allocation Formula, Pavement Condition, Pavement Management, Resurfacing, Rehabilitation

INTRODUCTION

The method used to allocate state resurfacing program funds in Kentucky will be described. The allocation scheme is considered a success. That success would not have been achieved without involvement of the Pavement Management Staff and utilization of information on pavement conditions generated by them.

KENTUCKY HIGHWAY SYSTEM AND FUNDING

The transportation system in Kentucky includes 69,200 miles of roads. Of this, 25,000 miles are under the jurisdiction of the Kentucky Transportation Cabinet. This includes 740 miles of interstate highways, 560 miles of toll roads, 3,200 miles of state primary, 8,000 miles of state secondary, 9,800 miles of rural secondary, 2,500 miles of supplemental roads, and 100 miles of other roads. As a result of recent legislation, another 2,000 miles of local roads is to be added to the rural secondary road system on July 1, 1987.

The system of rural secondary roads is financed from 22 percent of the gasoline taxes and is allocated for each of the 120 counties according to a prescribed formula. Even though the Kentucky Department of Highways maintains the system, only monies left over from routine maintenance may be applied to pavement and other improvements. That part of the program is administered by the Department of Rural and Municipal Aid.

Monies have been provided from 4-R funds to finance pavement improvements of interstate roads. Funding for pavement improvements is expected to continue. Separate, but limited, appropriations for toll roads improvements were made by the Kentucky General Assembly, but much greater funding is needed for many years to come. The state resurfacing program, therefore, is designed for the remaining 13,700 miles.

The Kentucky highway budget is about \$1 billion this year and reflects an increased gas tax from 10 cents to 15 cents per gallon and a modified truck tax. A total of \$87 million, or about eight percent, each year will be spent on pavement improvements. Forty million dollars are federal monies. Of that, \$30 million will be used for interstate roads and \$10 million on other roads. The state resurfacing program is presently funded at about \$31 million for 1987. The resurfacing program for the rural secondary system is approximately \$16 million. During the last few years, the largest mileage resurfaced was in 1981 with 1,100 miles and the lowest was in 1985 with only 320 miles (see Table 1).

EVOLUTION OF THE ALLOCATION FORMULA

Allocation of resurfacing monies to the 12 highway districts in Kentucky began with the separate funding of a resurfacing program. In 1967, \$5 million dollars were designated for that purpose. Before then, a maintenance improvement fund, known as "additions and betterments," was used for such purposes as widening pavements, shoulders and bridges; straightening curves; sealing pavements; and resurfacing. Some construction monies also were used. Pavements were selected more often than not on the basis of politics and arbitrary (i.e., without the benefit of analysis of

good inventory and condition data) judgments of decision makers.

By 1966, as larger mileages of roads needed resurfacing and more monies were being spent, a pavement evaluation scheme was devised and used by highway district personnel to select the most distressed and poorer riding pavements. Pavement sections with the highest point scores statewide were selected for resurfacing. The consequence was that one district, which rated their pavements most severely, received more than half of the money. From that experience, the need for uniform statewide evaluations of pavements was recognized. In 1967, candidate pavements were requested from the districts, but two engineers from the Division of Maintenance (Central Office) performed the evaluations. That practice continued in the Division of Maintenance. One half the available funds in 1967 were divided equally among the twelve districts and used for those pavements selected by the districts. The other half was spent on the poorest pavements as determined by the Division of Maintenance on a statewide basis. Two districts received more than half of the statewide allocation that year.

The following year a more complicated formula was devised. Again half of the monies were equally divided among the districts and they selected the pavements to be rehabilitated. The other half was divided into 18 "shares". Each district was allocated one share. Additionally, each of the three districts in the mountain region received an additional share (because of heavy coal hauling) and also an additional share was assigned to the three districts with large urban populations. Half of all the monies were spent on district selections, but the Division of Maintenance vetoed those selections considered out of line with needs. The other half was used according to selections made by the Division of Maintenance.

In 1973, the formula was revised. The first 25 percent of available funds was divided equally. The second 25 percent was divided into 15 shares, and one of the three extra shares was given to each of the three urban districts. The third 25 percent was divided into 18 shares, and two additional shares were provided to each of the three mountain region districts. The last 25 percent was divided among the districts according to miles of roads maintained by the district. Again half of all of the monies were spent according to district priorities and half according to priorities established by the Division of Maintenance.

The formula was changed again in 1976. Additional shares to the mountain region districts were dropped because substantial special funding was provided for coal-haul roads. The first 50 percent of the allocation was divided equally. Twenty-five percent was allocated according to miles of roads under maintenance. The final 25 percent was divided into 15 shares; each of the three urban districts received an extra share.

CURRENT ALLOCATION SCHEME

In 1981, staff for pavement management was assembled. Their responsibilities, in part, were to evaluate and rank pavements for improvements, quantify improvement needs, and advise on allocation of monies. The formula used was again examined, especially from the standpoint of incorporating pavement condition information that became available as a result of roughness testing of the entire state primary and state secondary

road systems during the two previous years. Also considered were lane miles of roads, pavement surface area, cost of asphaltic concrete material, and coal-hauling and traffic volumes.

The allocation formula in use at the time included miles of roads because there were differences between districts. On a lane-mile basis (see Table 2), the lowest mileage was in District 12 (6.7 percent) and the highest was in District 2 (11.4 percent). But pavement width also varied between districts and use of pavement surface area may have been a more appropriate basis for allocations. On that basis, District 2 would have remained the highest (11.8 percent), but the lowest would have been District 10 (6.6 percent). The decision was made, however, to use lane miles because it was more straightforward and resulting discrepancies in allocations would be corrected, in time, by inclusion of pavement condition in the formula.

The additional share given then to three districts considered urban was to provide for a higher level of pavement serviceability in the districts with highest traffic volumes. The assumption was that Louisville, Lexington, and northern Kentucky cities near Cincinnati, Ohio, were the high population areas and, therefore, had greater traffic volumes (Table 2). Actually, the third highest traffic volume was in District 2 rather than northern Kentucky (District 6). It was decided to delete traffic volume as a factor and rely on pavement conditions to guide decisions.

Resurfacing costs varied between districts. The cost differences, therefore, needed to be taken into account. The yearly resurfacing costs on a per mile basis would not suffice because pavements resurfaced in a given year varied in width, quantities needed for patching and leveling, shoulder treatment, and, at times, thicker overlays. Also, the districts differed in what they prescribed in the scope of the work to be performed. For instance, in the mountain region, shoulders are narrower or nonexistent while in flat lands the shoulders are wider and more likely to be paved.

Cost of asphaltic concrete used in the surface course is available each year prior to decisions concerning allocations for the next year's program (Table 3). While considering only that cost may be expedient and not fully equitable, pavement condition information would correct the inequities. In 1981, costs varied between \$24.14 and \$32.63 per ton. Each year the costs were somewhat different, but some districts had perpetually lower costs while others continued to have higher costs.

In 1979 and 1980, a large percentage of the state primary and state secondary roads were roughness tested. For the first time, pavement conditions could be quantified in an objective manner, even though the results were in terms of rideability of the pavement and only indirectly indicated pavement conditions for ascertaining resurfacing needs. The rideability index (RI) scale ranges from 0 to 5; zero means the pavement is impassable at the design speed of the road and 5 means the pavement is perfectly smooth (Figure 1).

Average RI and median RI in each district were considered for appropriateness in the formula. RI's also were weighted according to total square yards of pavement surface area in each district. Using a weighted median RI seemed best. Those ranged from a low of 2.64 (District 6) to a

TABLE 1. RECENT RESURFACING PROGRAMS

YEAR	MILES RESURFACED	EXPENDITURES (MILLIONS)
1976	430	\$ 9.8
1977	469	12.1
1978	877	24.4
1979	633	19.6
1980	584	21.3
1981	1,100	39.0
1982	843	27.3
1983	721	24.0
1984	573	19.7
1985	326	12.8
1986	896	35.0

RIDEABILITY INDEX

RIDEABILITY ASSESSMENT

4.0 to 5.0

Very Good

3.0 to 3.9

Good

2.0 to 2.9

Fair

1.0 to 1.9

Poor

0.0 to 0.9

Very Poor

Figure 1. Rideability Scale.

TABLE 2. ROADWAY MILEAGE AND TRAFFIC

DISTRICT	MILEAGE		PAVEMENT AREA		AVERAGE DAILY TRAFFIC VOLUME*
	LANE MILES	% OF TOTAL	SQUARE YARDS (MILLIONS)	% OF TOTAL	
1	2,839	10.1	17.7	10.4	2,920
2	3,220	11.4	20.0	11.8	3,410
3	2,151	7.6	13.1	7.7	2,030
4	2,903	10.3	16.6	9.8	2,250
5	2,135	7.6	13.3	7.8	6,000
6	2,105	7.5	12.2	7.2	2,850
7	2,425	8.6	15.2	8.9	4,460
8	2,294	8.1	14.3	8.4	1,960
9	2,152	7.6	12.7	7.5	2,460
10	2,004	7.1	11.2	6.6	1,580
11	2,050	7.3	13.1	7.7	2,630
12	1,906	6.7	11.6	6.8	3,160
All	28,184		170.0		2,940

* 1977 Counts (Vehicles per Day) for State Primary and Secondary Roads

high of 3.27 (District 3) (see Table 4).

When allocation of monies was first based on lane miles, costs of material, and pavement conditions, it became evident that some districts with the poorest pavements would be allocated too much money compared to those with better pavements. A multiplication factor, F, was incorporated into the formula to moderate the impact of pavement conditions:

$$A = B(L_D \times C_D(\text{Cond}_L - (\text{Cond}_D \times F))) / \sum L_D \times C_D(\text{Cond}_L - (\text{Cond}_D \times F))$$

in which A = allocation (in dollars),
B = total resurfacing program budget (in dollars),
 L_D = lane miles of highway in district D,
 C_D = unit cost of asphaltic concrete in district D per lane mile,
 $Cond_D$ = a quantity expressing average pavement condition in district D,
 $Cond_L$ = maximum of $Cond_D$ values, and
F = modifying factor.

As the multiplication factor increases, highway districts with the poorer pavements would receive proportionately larger allocations. The intent was to equalize condition of pavements statewide over a period of time. Full equality, however, was not being sought because traffic loading, climate, terrain, etc. distinguishes one highway district from another and significantly affects pavement performance. Politics is always a consideration as is maintaining a competitive paving industry.

The following year, and each year thereafter, lane miles, costs, and rideability indices were updated. The condition factor, however, was modified by using 30-percentile RI's of the poorest riding pavements in each district instead of the median RI. Differences in pavement conditions became clearer and better conformed with field observations. Again a multiplication factor for conditions was used to moderate differences.

After the first two years of evaluations of some 1,000 pavement sections by the Pavement Management Staff, a relationship (Figure 2) was established between rideability indices of pavements in need of resurfacing and traffic volumes. Interstate and toll roads were excluded. The critical RI's ranged between 1.4 for ADT's less than 200 vehicles per day and 2.7 for ADT's above 8,000 (Table 5). The RI's in Table 5 may be used to ascertain pavement conditions without visual inspections. The difference between the critical RI value and the measured RI, designated as pavement condition index (PCI), of the pavement indicates whether the pavement may be a candidate for resurfacing. If the PCI is zero or a negative value, the pavement may need to be improved. The larger the minus value, of course, the greater the probability for need of improvement. Conversely, the larger the positive value, the likelihood for need to improve the pavement is less. Those values may then be used to characterize pavement conditions (Figure 3). Mileages associated with various levels of conditions may be obtained and used for estimating conditions and needs for funding (Table 6).

Using this methodology to characterize conditions, various statistics were examined to determine the most appropriate way to quantify differences between districts. Those included average and mean values and several percentages of worst pavements. The 15-percentile point of worst pavements was selected. That percentage applied to between 150 and 240 miles in the districts. The PCI at the 15-percentile point ranged from +0.5 for the best district to -0.6 for the worst (Figure 4). The percentile point selected may be modified to match available funding levels. If the resurfacing program is large, the percentile point may be set at a higher value to identify more pavements as candidate projects.

The order of district rankings according to condition changes somewhat each year (Table 7). Those changes are attributable primarily to miles and

conditions of pavements resurfaced the previous years, maintenance activities, and pavements reaching critical conditions. The rankings may change in time as resurfacing monies are allocated in a desired way. The level of funding is a large factor in that change and, of course, will dictate whether pavement conditions generally improve or deteriorate.

TABLE 3. PER TON COSTS OF ASPHALTIC CONCRETE MATERIALS

DISTRICT	1981		1985	
	DOLLARS	DIFF FROM AVERAGE	DOLLARS	DIFF FROM AVERAGE
1	26.49	-1.08	28.53	+0.01
2	24.14	-3.43	25.18	-3.34
3	25.94	-1.65	26.46	-2.06
4	28.57	+1.00	29.55	+1.03
5	24.38	-3.19	24.53	-3.99
6	25.75	-1.82	26.03	-2.49
7	28.76	+1.19	30.40	+1.88
8	30.86	+3.29	30.67	+2.15
9	25.62	-1.95	29.10	+0.58
10	30.34	+2.77	29.74	+1.22
11	32.63	+5.06	30.58	+2.06
12	32.30	+4.73	31.47	+2.95
Average	27.57		28.52	

TABLE 4. WEIGHTED RIDEABILITY INDICES

DISTRICT	MEDIAN RIDEABILITY INDEX*
1	3.19
2	3.12
3	3.27
4	2.98
5	2.96
6	2.64
7	2.76
8	3.04
9	2.87
10	2.80
11	2.79
12	2.67
All	2.92

* Weighted by Square Yards of Pavement Surface Area

TABLE 5. CRITICAL RI AS A FUNCTION OF TRAFFIC VOLUME

ADT	CRITICAL CONDITION RI
Above 8000	2.7
6201-8000	2.6
4401-6200	2.5
2701-4400	2.4
1501-2700	2.3
1101-1500	2.2
901-1100	2.1
701-900	2.0
601-700	1.9
501-600	1.8
401-500	1.7
301-400	1.6
201-300	1.5
1-200	1.4

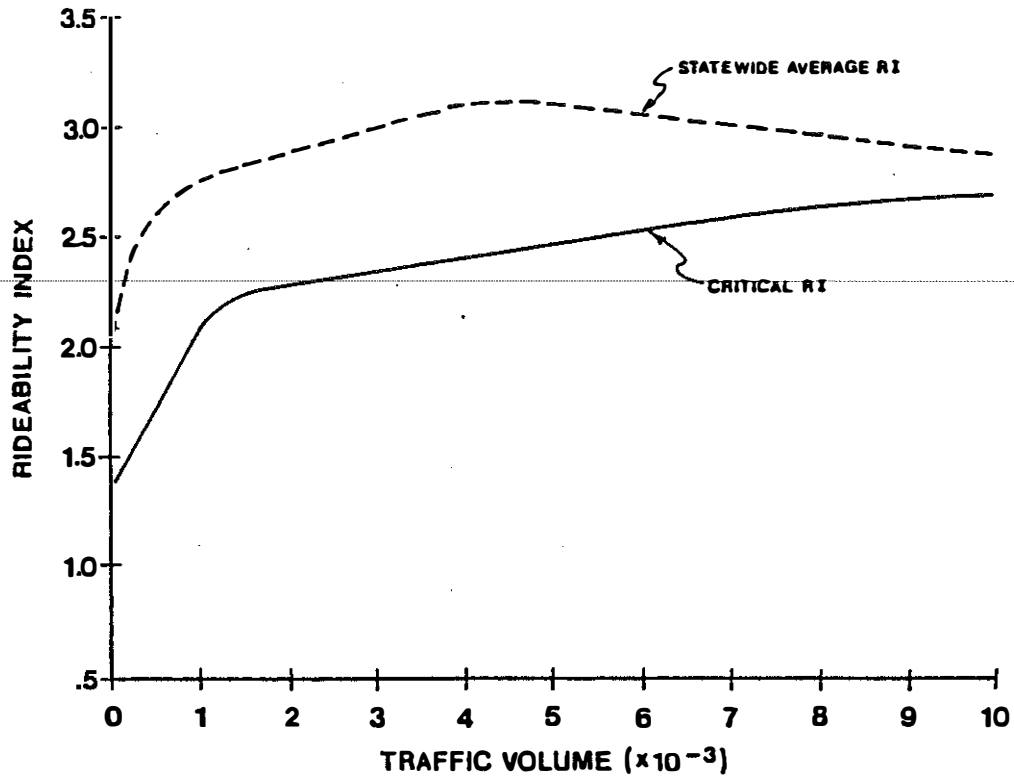


Figure 2. Relationship between Critical Rideability Indices and Traffic Volume.

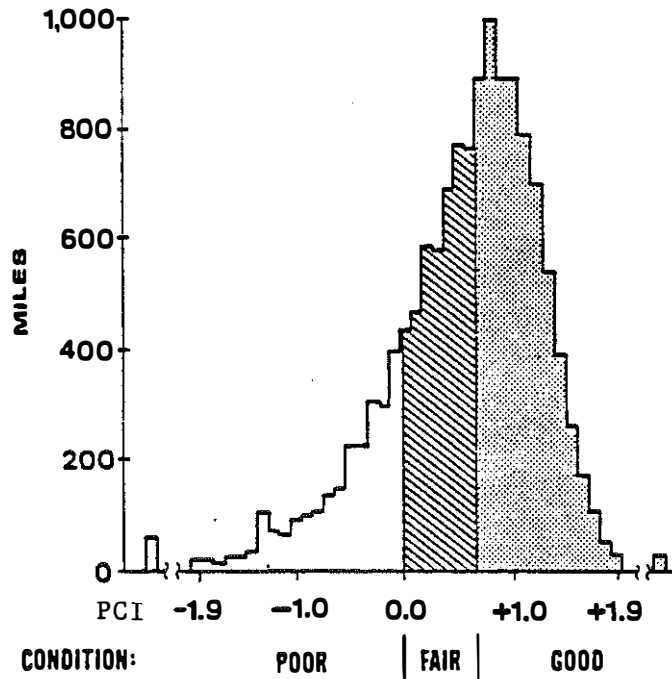


Figure 3. Mileage Distribution According to Pavement Conditions.

TABLE 6. PAVEMENT CONDITIONS FOR
VARIOUS TYPES OF ROADS

ROAD TYPE	"POOR"		"FAIR"		"GOOD"	
	MILES	(%)*	MILES	(%)	MILES	(%)
Interstate	30	(4)	170	(24)	540	(72)
Toll	100	(16)	300	(48)	230	(36)
State Primary	580	(18)	820	(26)	1,780	(56)
State Secondary	1,740	(22)	2,360	(29)	3,940	(49)
Rural Secondary	1,990	(21)	2,940	(30)	4,760	(49)
Supplemental	850	(37)	810	(35)	660	(28)
All	5,290	(21)	7,400	(30)	11,910	(49)

*Percentage of road type in each condition category

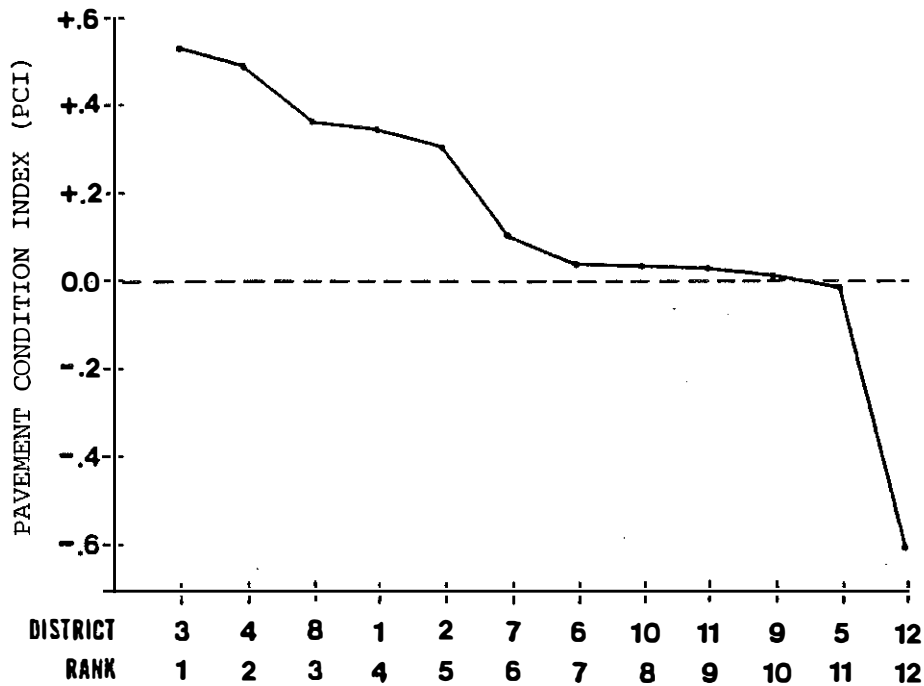


Figure 4. Relative Condition of Pavements in
Highway Districts (at 15% of worst pavements).

Each year a set of computer printouts are generated citing data used in the allocation formula, changes in that data from previous years, allocations to each district for various pavement condition multiplication factors, and comparison of those allocations with those of previous years. These are reviewed by the Pavement Management Staff and the Division of Maintenance, and a multiplication factor is selected that then establishes the allocations to each district. That recommendation is forwarded to the Assistant State Highway Engineer for Operations for approval. Approval by the State Highway Engineer is usually obtained when the program document

TABLE 7. RANK ORDER OF PAVEMENT CONDITIONS
BY VARIOUS METHODS

DISTRICT	MEDIAN	RI AT	MEAS RI - CRIT RI		
	RI	30%	AT 15%		
	1982	1983	1984	1985	1986
1	2	3	3	2	4
2	3	2	5	5	5
3	1	1	1	1	1
4	5	5	4	3	2
5	6	4	6	6	7
6	12	10	11	10	11
7	10	8	8	8	9
8	4	6	2	4	3
9	7	7	7	7	6
10	9	11	9	9	10
11	8	9	10	11	8

listing resurfacing projects is presented to him. The Secretary of the Cabinet, or the Highway Commissioner, of course, finally approves the program.

Inclusion of mileages, costs, pavement conditions, and a condition multiplication factor in the formula has been accepted by both administrative and engineering staff in the central office and the districts. Disagreements have arisen in central office, and to some extent in the districts, concerning the multiplication factor to use and the maximum, and minimum, allocation to any district. If the budget is very small, a smaller factor may be selected to assure a competitive paving industry in those districts with pavements in the best conditions. When the budget is large, the concern is two fold. First, how large an allocation can be given to districts with the better pavements and still be assured the selected pavements are worthy of resurfacing? And, second, how large an allocation can be provided to districts with the poorer pavements and not provoke negative reaction from the other districts. District 12, which is in the mountain region of Kentucky, is subject to heavy coal hauling and is always in the second category. That district has about 20 percent of all resurfacing needs in the state and accounts for less than seven percent of the road system mileage. The use, or misuse, of roads in that region has severe consequences to pavements. The problem of overweight and large volumes of trucks hauling coal has escaped solutions. Monies will not be available to bring pavement conditions in District 12 to what they are in other districts. And therein is a dilemma with which the Department must wrestle every time resurfacing monies are allocated. This year, as once before, District 12 was allocated no more than the district with the next highest allocation because of abuse of pavements. When a cap is placed on allocations for one or more districts, the allocation factor may be redetermined to make sure excessive monies are not again provided to districts with the least needs.

The Pavement Management Staff visits the districts to share results of pavement condition evaluations, to discuss resurfacing needs in the district compared to other districts, to discuss various pavement management matters, to explain the allocation formula, and to indicate what monies may be provided next year. Discussions with the personnel of each district have been effective in convincing them of the appropriateness of the formula and the fairness in the allocations. Oddly enough, formal complaints have come only twice, and from the district given in those years allocations considerably greater than given to the others. While their needs in District 12 were overwhelming, somehow they were not convinced they were indeed given the largest allocation.

GOAL

The continuous and regular use of a pavement management program based upon high-quality data concerning the relative conditions of the existing highway network in the state will eventually and gradually lead to improvement. Statewide roughness testing and condition evaluations of pavements of the state primary and state secondary roads began in 1979. Improvement in rideability occurred from 1980 to 1982 because of the large mileage of highways that were resurfaced in 1981. Annual changes in the rideability index is evident and related to the magnitudes of resurfacing programs. Generally, however, the rideability index has improved since 1979. Another general indication of the improvement of the highway network in Kentucky is the number of miles of highway ranked as being in poor condition. In 1982, approximately 2,000 miles of state primary and state secondary roadways were considered to be poor. In 1986, this mileage had decreased to approximately 1,800 miles, a general decrease over the 4-year period of approximately ten percent. Changes have occurred in the relative proportions of pavements considered the poorest in each district. No improvements and some slight degradation of pavement conditions are evident in districts with the better pavements. Some improvements, however, have been observed in districts with the poorer pavements. In District 12, where pavements have historically been very poor, overall pavement conditions have remained essentially the same as before.

The average pavement condition indices for the 1982-1986 period have remained essentially constant. The lack of a general deterioration is related in part to the fact that the pavement evaluation and management program during that period identified those highway sections most deserving of the resurfacing programs available during that time. The general overall condition of pavements in the state has not improved significantly in that same period. This is related to a relatively small resurfacing program during that same period. Further improvements in conditions are expected in 1987 and in any other year in which a substantial mileage of pavement will be resurfaced.

The intent is to bring about a more uniform condition of pavements among the districts as well as to improve the overall statewide condition. The formula used now will accomplish that in time. That time may be short if funding remains high and long if funding is low. Funding at a level to reduce the existing backlog of pavements in need of resurfacing is the key to success in accomplishing the goal in a reasonable time. In the process, of course, an even more important goal -- to improve conditions of pavements throughout Kentucky -- would have been accomplished.