A METHOD OF MEASURING THE QUALITY OF HIGHWAY MAINTENANCE

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In 1970 the Ohio Department of Transportation developed a method of measuring the quality of highway maintenance. The purpose was threefold: to measure objectively the quality of maintenance achieved by highway maintenance forces, to establish acceptable standards of maintenance quality, and to provide a means of setting annual district and statewide maintenance performance objectives. The resulting method meets these objectives and is recommended for use by other states. The system utilizes a random sample of highway sections on which identifiable maintenance work items are counted by 2-man survey crews working statewide full time. Ohio uses 2 crews to make surveys quarterly. Work items are counted on 2-mile sections of highway using 13 items that reflect the quality of force-account highway maintenance. The field data are reduced to the number of maintenance work items per mile in each maintenance category for each of the 88 counties in Ohio, and these values are plotted by computer in 3 different forms of bar charts. The bar charts show direct expenditures per lane-mile as well as the maintenance work items per mile. This method of measuring the quality of maintenance provides useful information for all levels of management.

•A MAJOR concern to every highway administration is whether or not the highway system is being maintained at the proper level. The levels at which highways are being maintained at a given time depend on a number of factors; among these are maintenance policies, the efficiency of the maintenance force, and the availability of maintenance funds.

A method is being used in Ohio to measure objectively the quality of highway maintenance. The measurement is based on AASHTO-defined objectives of the maintenance program, namely, the physical preservation of the highway and the provision of safe, convenient, and economical highway transportation. Field measurements for each highway element or activity are used as direct measures of quality by conversion to units per mile. The results of the survey method in units per mile are plotted by computer in bar chart form for use by all levels of management. From the graphic presentation of field measurements, Ohio's 88 county superintendents can quickly and easily see what type of maintenance is being neglected and how they compare in quality of maintenance to other counties within their own district and throughout the state.

The same bar charts are used by operations and maintenance engineers at both the district and central office levels to better understand the quality of maintenance being attained in the various counties and as a tool to improve their direction and control of available maintenance resources.

In 1970, because of the interest within the Ohio Department of Transportation to improve the management of maintenance, a consulting firm was engaged to develop a method of measuring the quality of maintenance. The firm of Byrd, Tallamy, MacDonald and Lewis carried out the analysis of field data and developed the method now in use to measure the quality of maintenance. This consulting firm had earlier made a study of highway maintenance needs in Ohio that the department found useful. The

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firm was thus already familiar with the current maintenance management policies and accounting methods. In developing the new method the firm proposed that the collection of raw data be made by the department's maintenance and traffic field engineers. By this means available funds for development were conserved so that the consultant's effort could be concentrated on the analysis of the field data and the development of the final method to be used.

During the early part of calendar year 1970 data were collected from 1,000 miles of highway in each of three transportation districts. Using the data from 3,000 miles of highway, Byrd, Tallamy, MacDonald and Lewis devised the present method of measuring the quality of maintenance on Ohio's highways.

The broad objectives of the maintenance quality survey are (a) to measure objectively the quality of maintenance achieved by county maintenance forces; (b) to establish, after sufficient experience has been attained, acceptable standards of maintenance quality within each district; and (c) to provide a means of setting annual district and statewide maintenance performance objectives.

DEVELOPMENT OF METHOD OF MEASURING MAINTENANCE QUALITY

The Ohio Department of Transportation specified that the measuring system developed by the consultant meet the following requirements:

1. The method should utilize a sample of the highway system in order to keep the field inspection work to a minimum;
2. The method was to be based on objective, quantitative measurements of physical conditions that could be easily and quickly recognized by engineering technicians and understood by maintenance personnel; and
3. The results of the field measurements were to be such that they could be presented in a simple, straightforward, easily understood manner.

The consultant recognized that the quality of highway maintenance affects both the physical integrity and the operational characteristics of the highway. Further, the operational characteristics or influences on the user can be divided into three areas: safety, rideability, and aesthetics. The method used for evaluating highway maintenance must accommodate all 4 areas of influence. Each of the numerous maintenance activities performed by the maintenance forces has a varying impact on the 4 areas of influence. It was both impractical and unwarranted to attempt to evaluate separately each maintenance activity. To determine their relative importance, the various maintenance activities were divided into 9 activity groups, which are given in Table 1 with the percentage of expenditure for each group.

The maintenance quality surveys do not include any measurement of the performance achieved in snow and ice control. Beyond that, the activity groups finally selected for the maintenance quality survey include most of the maintenance elements of an Ohio highway.

The system for measuring highway maintenance quality is not intended to be a system of taking an inventory of all maintenance work items on the highways. Routine inspection, location of work items, and work scheduling activities are a regular part of the duties of county superintendents, their foremen, and district general superintendents and other members of the district maintenance staff. The maintenance quality measurements were designed for making statewide quarterly surveys by special teams using a random sample to obtain representative measurements of the quality of maintenance being achieved.

The consultant found numerous references in the literature for maintenance quality measures and the parameters within which such measuring systems should be developed. The major points emphasized include the following:

1. The evaluation and inspection should be objective.
2. The human element of opinion or judgment should be eliminated and a quantitative value obtained wherever possible.
3. The inspection procedure should be standardized to ensure uniform reports for all areas of the state.
4. The measurement should not include the influence of faulty construction or poor design.

Table 1. Distribution of Ohio maintenance expenditures.

Activity Group	Percent of Expenditure (FY 1969)
Snow and ice control	24
Pavement maintenance	24
Vegetation control	12
Shoulder maintenance	11
Appurtenance maintenance	10
Drainage maintenance	8
Rest area maintenance	4
Bridge maintenance	4
Roadside litter removal	1
All other	2

Table 2. Summary of recordable conditions.

Condition	Description	One Unit Count for Each	Observation Scope
Pavement			
Surface			
Deterioration	2 in. depth and 24 in.^{2} area	2 yd^2	All pavement
Obstructions	Obstruction or 6 in..diameter hole	Location	All pavement
Flushing	Area 1 yd^2 or more	100 lineal ft	All pavement
Striping			
Deterioration	Stripe missing, 6 lineal ft or more	1/10 mile	All pavement
Auxiliary marking			
Deterioration	Markings do not delineate	Location	All pavement
Shoulders			
Surface			
Drop-off	2 in. depth and over 6 lineal ft	100 lineal ft	One shoulder
Obstructions	Obstruction or hole, 2 in. deep, 12 in. diameter	Location	One shoulder
Appurtenances			
Guardrail			
Appearance	Rusty, needs painting	100 lineal ft	All guardrail
Deterioration	Rotten posts, bent rail	100 lineal ft	6 runs of rail
Signing			
Deterioration	Nonfunctional sign	Sign	All signs
Roadway			
Vegetation			
Appearance	Deviation from mowing policy	1/5 mile	All medians and roadsides
Litter			
Appearance	Count of 10 or more items of litter	1/10 mile	All medians and roadsides
Drainage			
Ditches			
Obstruction	Obstruction over 50 percent	100 lineal ft	All ditches
Culverts[a] and pipes			
Deterioration	Repair required	2 yd^2	6 structures
Obstruction	Obstruction over 50 percent	Structure	6 structures

[a]Culverts are defined as pipes or structures with a clear span of less than 10 ft.

5. The evaluation of the condition should be done the same way under any weather conditions.
6. The evaluation of the measurements should provide a basis for comparing the quality of maintenance in various department subdivisions.
7. The various maintenance activities should be weighted to reflect their relative impact on the total highway facility.

The American Association of State Highway and Transportation Officials has defined the objectives of highway maintenance and traffic services in the Manual of Uniform Highway Accounting and Financial Management Procedures. The AASHTO definitions make it clear that AASHTO is concerned with the condition of the elements of a highway. Therefore, the ultimate measure of highway maintenance quality should relate to the condition of the highway elements. Likewise, the AASHTO definition of traffic services indicates that the quality of traffic service should be a measure of the safe, convenient, and economical transportation provided to the public.

The measures and procedures developed were structured to reflect maintenance quality within the AASHTO concepts. Therefore, quality of maintenance may be defined as a measurement of the degree of accomplishment of the maintenance objectives as defined by AASHTO.

The quality of pavement maintenance, for example, is a measurement of how well the pavement is kept in its as-built condition and how well it provides safe, convenient, and economical highway transportation. Perfection in maintenance quality becomes realistic for obvious economic reasons. No highway organization can afford to maintain its system in an essentially new condition. Rather, a gradual deterioration of the elements is accepted and, at intervals, reconstruction is programmed. Because evidence of such deterioration does exist, it can be measured quantitatively and the resulting values can be used to reflect the quality of maintenance accomplished on the highway system.

At intervals, the various elements of the highway facility can be examined and their condition measured. Assuming that the element is maintainable, a good condition will reflect no deterioration or a high level of maintenance quality. A poor condition will reflect a low level of maintenance quality. Therefore, measurements of the condition of the various elements of a highway system become measurements of the quality of the maintenance being realized on the highway system. This measurement of the quality of maintenance provides an additional means of control for maintenance managers.

MEASUREMENTS

Since maintenance quality can be evaluated in terms of the condition of various elements of the highway, these elements, along with their measurable characteristics, need to be identified. The approach taken by the consultant was to identify those characteristics that indicate deterioration of the physical integrity or a reduction in the operational characteristics of the highway.

Because a sampling procedure was to be used, it was important to select identifiable conditions that occurred with reasonable frequency. A series of highway conditions referred to as "recordable conditions" were selected and defined as specific conditions to be observed on the highway system. The Recordable Condition Survey called for unit counts to be made of the elements and conditions given in Table 2.

From the table it is seen that one unit of pavement surface deterioration consists of an area of over 24 in.^{2} and under 2 yd^2 of pavement where the deterioration is 2 in. or more in depth. The entire pavement area in the 2-mile sample section is inspected to determine the number of recordable conditions of this type.

One unit of shoulder drop-off consists of more than 6 lineal ft and less than 100 lineal ft of drop-off that is 2 in. or more in depth. For this type of recordable condition only one shoulder of the road is observed over the length of the sample section.

The survey of maintenance quality does not include bridges. Because an annual detailed inspection is made of every bridge on the state highway system, an evaluation of bridge maintenance is not included in the method described herein. The bridge inspection system now used is considered adequate to provide information relating to the condition of structures of over 10 ft clear span.

SURVEY METHOD USED TO MEASURE MAINTENANCE QUALITY

The recordable conditions given in Table 2 were used on the first survey, which was begun in the spring of 1971 and completed in November of that year. A single 2-man survey crew was used in the beginning, and the first 2 surveys, which were made on randomly selected statewide sections, each required 6 months to complete. In July of 1972 it was decided that maintenance quality surveys should be made quarterly. To increase the survey frequency, a second survey crew was added.

Approximately 1,650 sections of the highway are inspected on each statewide survey. The sections are each 2 miles in length, which means that approximately 19 percent of the total centerline mileage is covered by each survey. The sections are randomly selected by computer from the road inventory. This inventory consists of the straight-line diagram sections and is on file in the Ohio Department of Transportation Computer Center. Because some sections of the inventory are less than 2 centerline miles in length, they are not used in selecting survey sections. Sections that are over 2 miles in length are divided into 2-mile sections, and these 2-mile sections are included in the pool from which sections are chosen. After dividing the longer sections into 2-mile sections, the remaining or last section is over 2 miles and less than 4 miles in length. The total number of sections in the population established in this manner is 4,540.

The Ohio State Highway system is classified into 5 route types: Interstate, major thoroughfare divided, 2-lane major thoroughfare, auxiliary, and local highways. Five sections are chosen at random in each of 88 counties from each of the 5 route types. If 5 sections were available in each of 5 route types in each of the 88 counties, a total of 2,200 sections would result. Because there are many counties without any Interstate route mileage and because of a lack of sufficient sections in the population because of short sections, the sample surveyed consists of 1,650 sections rather than 2,200. However, the number of sections surveyed constitutes a relatively large sample.

The survey crews use the following procedure in carrying out their work:

1. For each of the 12 districts, the county, route number, and mileage log point of each section to be inspected are listed.
2. A map of each district is marked to show the location of each highway section to be inspected. The map is used to make up daily itineraries for the survey work.
3. Inspections are made of each section and a Recordable Condition Report (Figure 1) is completed. These reports are forwarded to the Central Office Bureau of Maintenance for processing.
4. In addition to inspection of the randomly selected sections of highway, the survey crews inspect one-half of the highway rest areas in each county on each survey.

DATA REDUCTION AND BAR CHART PLOTTING

The field data shown in Figure 1 are converted to the number of recordable conditions per centerline mile for each route type. The resulting values for each county and maintenance work category are then weighted by the number of lane-miles in each route type. The resulting values are then listed on computer code sheets and processed as input for the Calcomp Plotter. The weighted values of recordable conditions per mile are plotted in bar chart form (Figure 2) by the Calcomp Plotter. One of the features of the plotter is the automatic selection of the vertical scale so that the resulting plot fills the chart area.

The second item shown on the bar chart plots is the cost per lane-mile for the particular maintenance activity shown. The values of cost shown are the direct expenditures by Division of Highways personnel for labor, equipment, and material reported routinely each day by each county and processed by the Bureau of Auditing and the Computer Center. Some plots are made to show total direct cost per lane-mile (labor, equipment, material) and other plots are made to show labor expenditure per lane-mile only. The reason for using labor expenditure only in some charts has been to make available such charts in a shorter time than that required to produce charts with total cost per lane-mile. The ideal chart would show total cost per lane-mile for the 3 months immediately preceding the completion of the maintenance quality survey.

Figure 1.

STATE OF OHIO — RECORDABLE CONDTION REPORT — DEPARTMENT OF TRANSPORTATION

ROUTE SR 554 COUNTY Gallia DATE 7-31-73
SECTION NO. 68 OBSERVERS Hughes & Stewart

CONDITION	ONE UNIT COUNT FOR EACH	UNITS	TOTAL
PAVEMENT			
Surface			
Deterioration	2 Sq. Yd.	𝍸 1111	9
Obstruction	Location	1	1
Flushing	100 Lin.Ft.	///	3
Striping			
Deterioration	1/10 mile	𝍸 𝍸	10
Auxiliary Marking			
Deterioration	Location		
SHOULDERS (Surface)			
Drop-Off	100 Lin.Ft.	𝍸 𝍸 11	12
Obstruction	Location	1111	4
APPURTENANCES			
Guardrail			
Appearance	100 Lin.Ft.		
Deterioration	100 Lin.Ft.		
Signing			
Deterioration	Sign		
ROADWAY (Appearance)			
Vegetation	1/5 mile	𝍸 11	7
Litter	1/10 mile	1111	4
DRAINAGE (Obstruction)			
Ditches	100 Lin.Ft.		
Structures	Structure		
STRUCTURES			
Deterioration	2 Sq. Yd.		

ODOMETER LOG

Control Point 2.76 (Br 2.25 Pave Narrows)
Section Start 0.00
Guardrail (end of 5th run) 𝍸 1 – 1.05 .58 .66 .79 1.01
Drainage (6th structure) 𝍸 1 – 1.59 .30 .56 .71 .88 1.43
Section end 4.76
Length of Section 2 miles

Figure 2.

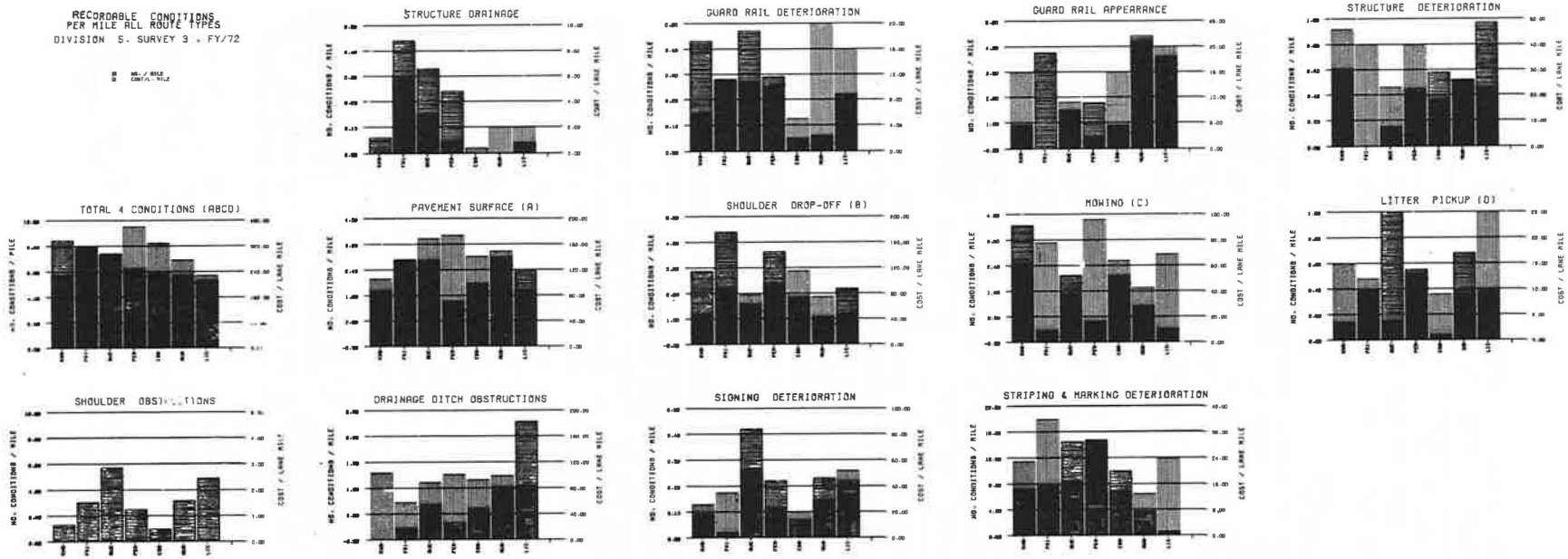
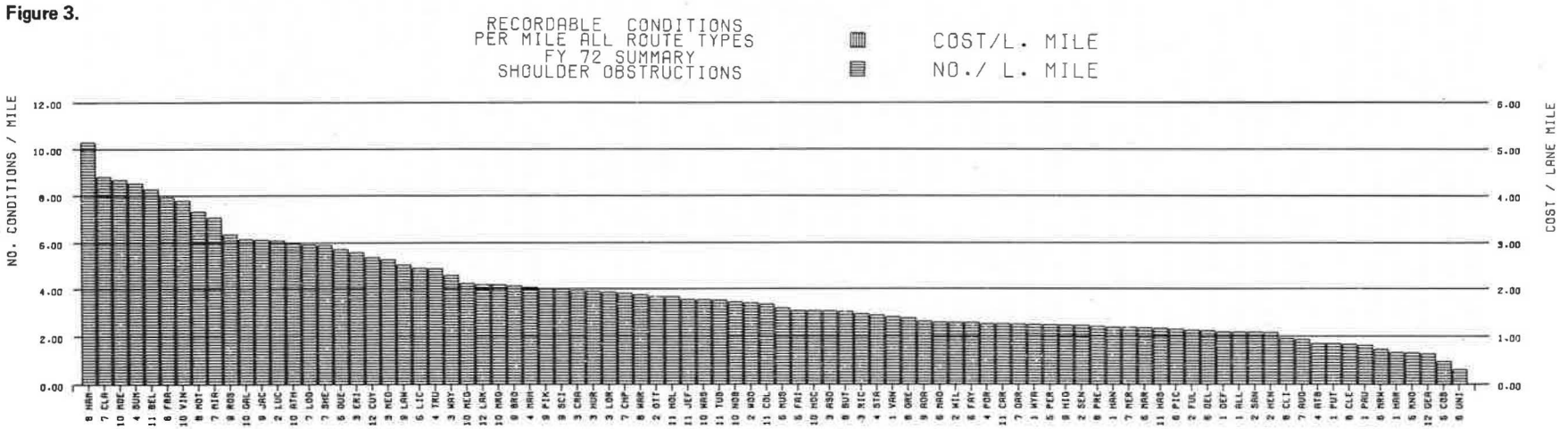


Figure 3.



Beginning with fiscal year 1973, plots were made showing the average values of recordable conditions per mile for all surveys made during the fiscal year. The total direct costs per mile for the fiscal year were shown with the number of recordable conditions per mile. The plots for each successive year will be compared both for recordable conditions and for expenditures per lane-mile to compare annual maintenance performance as represented by the average of 4 quarterly surveys.

Bar Charts of Quality and Cost of Maintenance

The recordable condition data are presented in several forms of bar charts. In actual practice the number of recordable conditions per mile is plotted in black ink and the cost per lane-mile for the same county is plotted in red ink over the black bar. The 2-color bar charts are much more graphic and are more easily understood than the black-and-white bar charts shown here. The 3 letters that appear at the bottom of each bar are the abbreviation for the county for which the data are plotted. The following four types of bar charts are in current use:

1. District bar charts for individual field surveys—These charts show the number of recordable conditions per mile as determined in a particular survey for 13 maintenance categories and a fourteenth chart that is a plot of the sum of the recordable conditions for pavement deterioration, shoulder drop-off, mowing, and litter pickup. The cost per lane-mile values on this chart are the expenditures for direct labor for the calendar quarter preceding the date of the survey. The bar charts are presented on one 11 × 28-in. page similar to that shown in Figure 2. (Figure 2 does not show a bar chart for rest areas, which is included in current versions.)
2. District bar charts for the fiscal year period—These charts are the same type of chart as described above except that the recordable conditions shown are the average values of all surveys made during the fiscal year. The cost per lane-mile values on this chart are the fiscal year total expenditures for labor, equipment, and material.
3. 88-county bar charts for individual maintenance categories—These charts show the same recordable condition and cost values referred to in No. 2 above with values plotted for all of the 88 counties in the state. Each chart is for an individual maintenance category. Figure 3 shows this type of bar chart. The 3-letter abbreviation for the counties and the number of the district that contains the individual county is shown below each bar. In Figure 3 only recordable conditions per mile are shown. In most such charts the cost is also shown as a red bar printed over the black bar.
4. County history charts—These charts (Figure 4) show the recordable conditions per mile and the costs per lane-mile on successive surveys in a particular county. The numbers shown below each bar indicate the particular survey that the bar represents.

The following paragraphs give details concerning the bar charts for the various maintenance activities included in the maintenance quality survey.

Pavement Surface—The pavement surface maintenance quality measurement shown in Figure 5 is the sum of the recordable conditions per mile (Table 2) for pavement deterioration, pavement obstruction, and pavement flushing. The expenditures per lane-mile shown are for (a) surface patching; (b) full-depth pavement replacement, including repair of blowups; (c) filling and sealing cracks and joints; (d) surface treatment, sealing, deslicking, and screening bleeding pavements; and (e) pavement jacking.

Mowing, Litter Pickup, Guardrail Deterioration, Sign Deterioration, Culvert Drainage, Structure Deterioration, Drainage Ditch Obstruction—Each of these 7 activities is plotted singly from the field measurements of recordable conditions as defined in Table 2. The cost per lane-mile that is plotted is the expenditure for each of these individual activities as routinely reported by the county timekeeper.

Shoulder Drop-Off—The definition for a recordable condition in this category is given in Table 2. Expenditures per lane-mile for grading or adding material to shoulders and for widening, reshaping, or stabilizing short sections (less than 500 ft) are also shown in the bar chart.

Total 4 Conditions—This chart (Figure 6) combines the data of 4 other charts to provide a composite rating of individual county maintenance performance. The 4 categories

Figure 4.

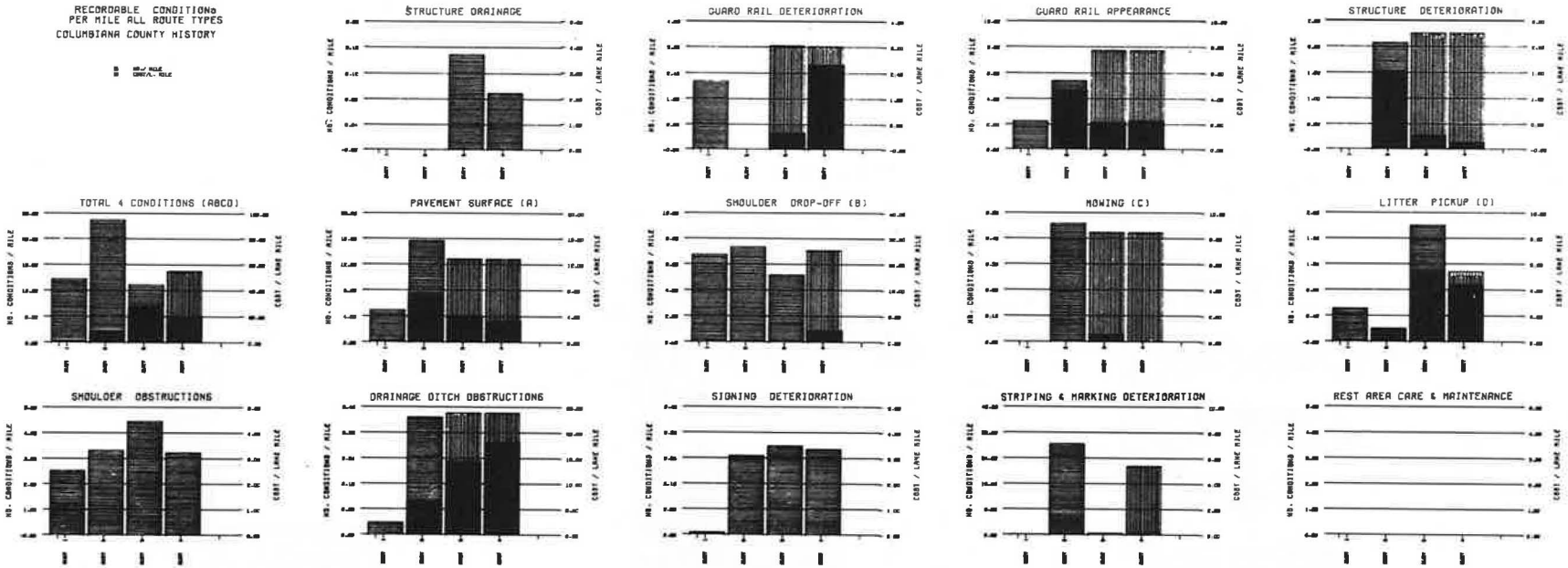

RECORDABLE CONDITIONS
PER MILE ALL ROUTE TYPES
COLUMBIANA COUNTY HISTORY
STRUCTURE DRAINAGE
GUARD RAIL DETERIORATION
GUARD RAIL APPEARANCE
STRUCTURE DETERIORATION
TOTAL 4 CONDITIONS (ABCD)
PAVEMENT SURFACE (A)
SHOULDER DROP-OFF (B)
MOWING (C)
LITTER PICKUP (D)
SHOULDER OBSTRUCTIONS
DRAINAGE DITCH OBSTRUCTIONS
SIGNING DETERIORATION
STRIPING & MARKING DETERIORATION
REST AREA CARE & MAINTENANCE

Figure 5.

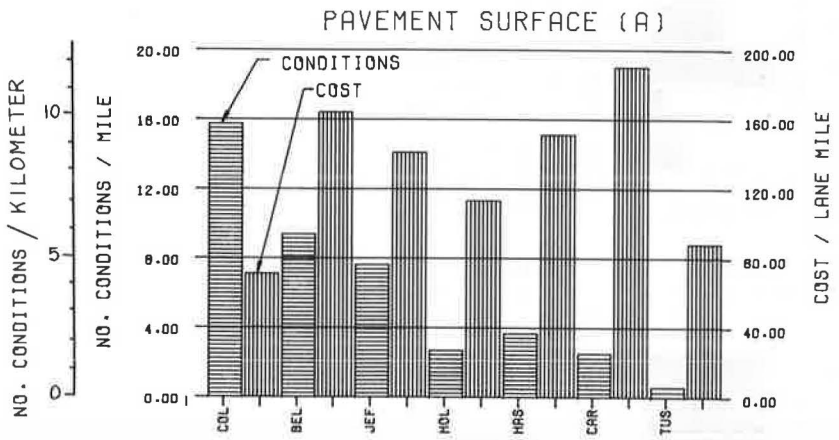


Figure 6.

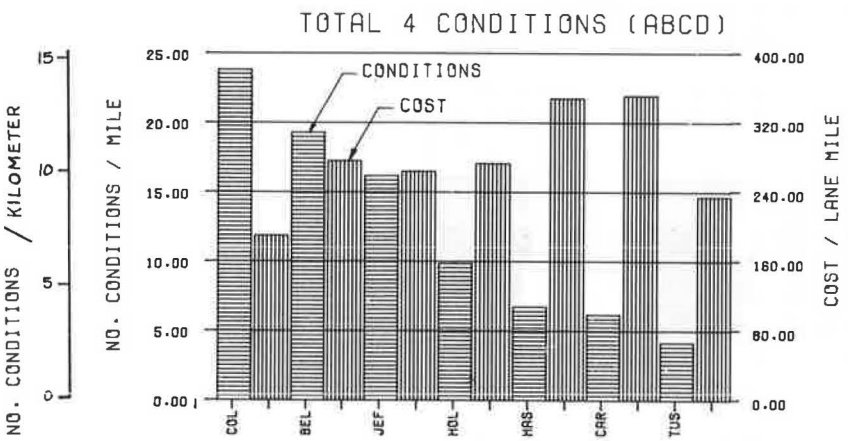
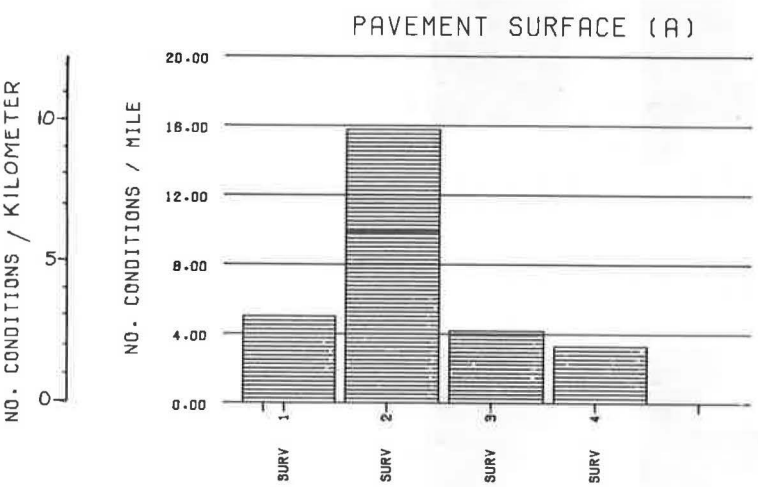


Figure 7.



that are combined were chosen because the recordable conditions in these categories are the result of work by county forces only whereas in other categories district crews contribute to the maintenance work either exclusively or in combination with county maintenance forces.

Category	Item	Weighting Factor
Pavement surface	(A)	1.6
Shoulder drop-off	(B)	1.4
Mowing	(C)	0.6
Litter pickup	(D)	0.4

Because both safety and comfort are involved in items A and B, whereas they are not involved or are involved to only a minor degree in items C and D, the values in the 4 categories are weighted to reflect their relative importance to the highway user. The weighting factors used are given opposite each item. The bar chart for Total 4 Conditions (ABCD) is plotted with the county having the greatest number of recordable conditions first, and the remaining counties are plotted in the order of decreasing values of number of recordable conditions. The same order for the individual counties is used in all other bar charts. This order of plotting is a constraint of the plotter program. Although the bar charts of Figures 5, 6, and 7 are shown here as separate plots, in practice they are all plotted on one large sheet (Figure 2) by the Calcomp Plotter. The plot of cost per lane-mile is an overplot in red ink.

Guardrail Appearance—The recordable conditions per mile used for this item are in accordance with the definition in Table 2. The cost per lane-mile used in this case is the annual contract cost of painting guardrail in each individual county. The recordable conditions shown result from improper programming of contract painting by the district. Such painting is done on a regular 4-year cycle, and this frequency of painting has been found to be adequate.

Shoulder Obstructions—The recordable conditions per mile for this item are as defined in Table 2. At present no cost per lane-mile is shown in the bar chart for this type of work.

Striping and Marking Deterioration—The sum of the recordable conditions per mile (Table 2) for striping deterioration and auxiliary marking deterioration is shown in this bar chart. The expenditures per lane-mile shown are for (a) auxiliary markings, (b) spot and tee markings, (c) other special markings, (d) centerline marking, (e) edgeline marking, and (f) lane line markings.

Rest Area Care and Maintenance—Half of the total rest areas in each county are inspected on each quarterly survey by the maintenance quality survey crew. Figure 8 shows the form used by the survey crew in evaluating rest area maintenance. Definitions are not included in Table 2 for items on this inspection form. Each item has a listed rating value and the total value of all items on the check sheet is 100. The value for a given rest area is the difference between 100 and the total on the inspection sheet. Because Ohio rest areas are of various configurations, depending on the date of construction and the highway facility served, a method of weighting was used to determine the value of recordable conditions per mile plotted for each county. The ratings for each rest area are weighted in accordance with the following weighting factors and the weighted values are plotted on a rest area bar chart:

Class of Rest Area	Weighting Factor
Interstate highway	1.67
Primary highway	1.00
Secondary highway	0.33

Analysis of Bar Charts

Analysis of 2 bar charts is included here to illustrate the use of the maintenance quality survey and bar charts.

Figure 8.

REST AREA INSPECTION FOR MAINTENANCE QUALITY PERFORMANCE SURVEY

#_____ROUTE_____COUNTY_____REPORT BY_____

ITEMS TO RATE	REQUIRED MAINTENANCE	WT.	MAX. VALUE	RATINGS AND DATE				
SANITATION	Odoriferous	10						
	Dirty	10						
	Lacks Supplies	3	27					
	Writing on Walls	3						
	Storage Area Cluttered	1						
FACILITIES	Structural Repair	2 Ea.						
Toilet, Well Shelter,	Staining or Painting							
Picnic Shelter, Motorist	Concrete Repair		24					
Service, Bulletin Boards,	Repair Vandalism							
Grills, Picnic Tables	Utility Repair							
GROUNDS	Littered	5 Ea.						
	Improve Lawn Care							
	Improve Plant Care		20					
	Remove Dead Trees							
PARKING AREA & RAMPS	Surface Deterioration	3 Ea.						
	Littered or Oil Spots							
	Drain Obstruction		15					
	Parking Lines Faded							
	Ruts Along Ramps							
MISCELLANEOUS	Sweep/Remove Snow	1 Ea.						
Walks, Guard Rail, Signs,	Repair							
Telephone, Fence, Light	Replace		14					
Posts, Delineator Posts	Info. on Bull. Board							
Caretaker	Appearance							
	Attention to Duty							
	REST AREA RATING		%					

Indicate which maintenance items are required and the exact location by a circle. 2/9/73

Total 4 Conditions (ABCD)—It can be seen from Figure 6 that the county with the fewest recordable conditions is TUS and the county with the most recordable conditions is COL. This chart has the counties plotted in the order of decreasing values of the number of recordable conditions. The cost per lane-mile as shown by this chart indicates that, in general, the counties having the higher expenditures have fewer recordable conditions.

Pavement Surface—In Figure 5 the county (COL) with the lowest expenditures per lane-mile has the greatest number of recordable conditions per mile. Comparing the counties of COL and TUS, it is seen that expenditures per lane-mile are approximately the same, yet COL has the greatest number of recordable conditions and TUS has the fewest. The bar chart for pavement surface recordable conditions showing all of the 88 counties in Ohio (not included here) indicates that COL county has the second highest number of recordable conditions in the entire state whereas TUS county is within the lowest 11 counties of the state. Figure 7 shows the recordable conditions per mile for COL county on 4 successive surveys. The number of pavement surface recordable conditions was sharply reduced in COL county as shown by the third and fourth surveys. Similar analyses can be made of the other maintenance categories. The use of the charts and the interpretation of the values shown by the several types of bar charts will vary depending on whether the study is made at the county level, the district level, or the central office management level.

USE OF MAINTENANCE QUALITY SURVEY MEASUREMENTS

The central managements in the Division of Highways and the State Department of Administrative Services are concerned primarily with statewide maintenance performance and the overall quality of maintenance. Based on this viewpoint and the data from 9 statewide surveys taken during 3 fiscal years, management will use the surveys to study statewide average values of recordable conditions per mile for each maintenance category. From the average values of all of the surveys made during a given fiscal year, the quality of maintenance can be compared from one year to the next. A statewide objective has been established to equal or better the previous annual statewide average of recordable conditions in each maintenance category. Two surveys were made during fiscal year 1972, 3 surveys were made in fiscal 1973, and 4 surveys will be completed in fiscal 1974 and in each year thereafter. It is believed that the average of 4 surveys made in 1 year will provide a sound basis for evaluating the quality of maintenance for a given year. Because the method was in the development stage in fiscal 1972, a comparison between fiscal 1972 and fiscal 1973 was considered to be of relatively small importance. All levels of management are looking forward to a comparison of fiscal 1973 and fiscal 1974 to determine if the statewide objective of reducing the number of recordable conditions in each category has been met.

At the district level the charts are used in the following ways:

1. In some districts the district deputy director uses the bar charts as a source of information with regard to the quality of maintenance in the several counties within his jurisdiction. When a county is noted to have a higher number of recordable conditions per mile than the district average, the district deputy director may request that corrective measures be taken or ask the district operations engineer for an explanation of the poor quality.
2. The 88-county bar charts (Figure 3) are used by district maintenance managers for comparing the quality of maintenance in their district with the quality in other districts. Although the central office management does not call attention to differences in the quality of maintenance between districts, it is only natural that district managers compare their quality measurement rating with the values of other districts. The 88-county bar chart may show that a county that appears either extremely good or extremely poor in a district comparison has an average quality rating when compared to all other counties in the state. The district operations engineers also like to compare the position of their counties with all of the 88 counties from one year to the next. Dramatic changes in maintenance quality can sometimes be caused by a change in the county maintenance superintendent. Both the 88-county and the district bar charts have been found useful in confirming inadequate county supervision.

3. The district bar charts are used by district operations and maintenance engineers as a source of information in comparing the quality of maintenance between counties under their supervision in specific work categories. One county maintenance superintendent may excel at shoulder maintenance and neglect ditch drainage. A study of the district bar charts can be helpful to the district operations engineer in planning corrective measures where needed. Such measures consist of helping a county superintendent to plan his work better or in acquainting him with a better method of doing a certain maintenance job.

4. In one district the bar charts are used to give recognition to the county superintendent whose county has the fewest recordable conditions. Although the surveys are made quarterly, the survey made at the end of the calendar year is used to determine the county with the highest quality of maintenance. For this purpose the Total 4 Condition values shown in Figure 6 are used. Reports from the district using the measurements of maintenance quality in this way indicate the development of a highly desirable competitive spirit among the counties of the district.

5. A common use of the district bar charts in the district maintenance offices is as a basis for discussion of maintenance quality between the county superintendents and their supervisor, the district maintenance engineer. Because the measurements are made by a central office survey team, the third-party concept makes the discussion between supervisor and subordinate more objective and less personal in nature.

CONCLUSION

Measuring the quality of maintenance that exists on a highway system at a particular time provides useful information to all levels of maintenance management. To our knowledge, such information has not previously been available in quantitative terms. Ohio has used the method reported here over a 3-year trial period, during which implementation of the basic method has been expanded. The survey results are transmitted to all levels of management on a timely basis through the use of 4 different types of bar charts plotted by computer in 2 colors.

Although survey results are plotted in bar chart form for each individual survey, it is believed that the best interpretation of the quality of maintenance is obtained by averaging the results of 4 quarterly surveys to provide a measure of the quality of maintenance for a 12-month period.

The method used to measure the quality of maintenance is objective and has gained the acceptance of the maintenance engineers in the 12 field districts of the Ohio Department of Transportation.

Standards of maintenance quality can be established by the use of the Ohio method after sufficient data have been accumulated. Although tentative standards were set in Ohio after making 5 surveys during a 2-year period, such standards will be confirmed at the end of fiscal year 1974, at which time data from a total of 9 surveys will be available. The method described here is recommended for use by other states. Each state should develop its own standards of the quality of maintenance based on data from surveys in its own state.