

DEPARTMENT OF MAINTENANCE

W. H. ROOR, *Chairman*

REPORT OF COMMITTEE ON MAINTENANCE COSTS¹

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SYNOPSIS

A graphical presentation and review of maintenance cost trends on 18-ft. pavement widths in relation to traffic, for the region comprising Arkansas, Louisiana, Oklahoma and Texas. The following average annual surface maintenance costs per mile are given: Low-type pavements, ranging from \$98 for traffic of 71 vehicles per 24-hour day to \$577 for 484 vehicles. Intermediate type, from \$186 for 91 vehicles to \$249 for 1163 vehicles. High type, from \$64 for 272 vehicles to \$40 for 5312 vehicles.

The following are field inspection ratings of surface maintenance associated with above costs: Low-type surface 83, Intermediate 87, High 89. Numerical deductions from rating of 100 represent extent of repairs needed. When related to construction costs the above maintenance expenditures, within traffic limits shown on graphs, are not only economical but there is margin of additional expenditures that may be made before reconstruction to higher type is to be considered. The data do not consider savings in motor vehicle operating costs which would change latter relations.

During the last two meetings we called to your attention the variations that exist in annual highway maintenance cost and the necessity for accumulating and studying averages over a period of years. Our reports were published in the Highway Research Board *Proceedings*, Vol. 17, pages 384 to 388, Vol. 18, pages 298 to 304.

The study is being conducted through the facilities of the Public Roads Administration and covers 1,233 separate highway sections in 47 States and extends over 18,716 miles of the principal types of surfaces in use. This includes the 622 miles of maintenance sections in Connecticut, New Hampshire and Rhode Island for which another committee of the Highway Research Board is securing a more detailed traffic count.

Our attention was at first devoted to securing a uniform reporting of maintenance costs, each of the 47 States participating in the study at that time

having its own and unrelated system of defining and recording this type of information. The problem has now been solved through the common use of B.P.R. Form M-1 originating with this committee during the organizing stage of the study in 1933, and partly rearranged in 1938 for coordination with the work of the committees on Uniform Accounting of the American Association of State Highway Officials and Highway Research Board. In view of the success of the forms, copies are attached to this report for possible use of other committees engaged in similar studies.

We have maintenance costs accumulated for a 4-year period and segregated for the following six highway elements, surface, shoulders, drainage, structure repairs, roadside and traffic service, which are reported under the following definition of maintenance: "General highway maintenance is the function of preserving

¹ This study is being conducted under the auspices of the Public Roads Administration by the Construction Division, Mr. H. K. Bishop, chief. Acknowledgment is made of the work by Mr. R. F. Severs, in charge of maintenance, and Mr. H. A. Radzikowski on the study and this report. Computations by Messrs. W. T. Hughes and J. T. Dressel.

B.P.R. Maintenance Cost Form M-1

REPORT OF ANNUAL COST OF
ON SECTIONS SELECTED

State

Section number Location Type surfacing

Type shoulders Width shoulders Type shoulders

Traffic count: Trucks Cars Estimated life of surfacing Federal-aid

Additional description of section

DEFINITION OF MAINTENANCE.—General highway maintenance is the function of preserving and keeping each type of highway in satisfactory service. General maintenance does not include reconstruction or addition and betterments.

ANNUAL MAINTENANCE COSTS

SURFACING	PATCHING	JOINT AND CRACK FILLING	DRAGGING	BASE AND SUB-BASE REPAIRS	RETREATMENTS AND ALL CoC ₂
SHOULDERS	PATCHING	DRAGGING	SODDING	RETREATMENTS	
DRAINAGE	DITCHES	DRAINS	CULVERT CLEANING		
STRUCTURE REPAIR (Including bridges not over 20-ft. span)	BRIDGE AND CULVERT	GUARD RAIL			
ROADSIDE	GRASS AND WEED CUTTING	REMOVAL OF DEBRIS	HIGHWAY BEAUTIFICATION	CUTS	FILLS
TRAFFIC SERVICE	HIGHWAY MARKERS	GUIDE-LINE PAINTING	SNOW REMOVAL		

GENERAL INFORMATION

1. ARE ALL RECONSTRUCTION CHARGES EXCLUDED FROM ABOVE COSTS?

2. WHICH OF THE ABOVE COSTS WERE OBTAINED BY PRORATING?

METHOD OF CALCULATING EQUIPMENT DEPRECIATION

LIST MAJOR EQUIPMENT USED ON SECTION, WITH DEPRECIATION RATES

AVERAGE COST OF MAJOR LABOR ITEMS

AVERAGE COST OF MAJOR MATERIAL ITEMS

ORIGINAL CONSTRUCTION COST		RECONSTRUCTION COSTS SINCE CONSTRUCTION	ADDITIONAL COSTS
Total	Surface		

Additional pertinent information:

RURAL HIGHWAY MAINTENANCE
SPECIAL COST STUDY

Report for year ending

Length Width Thickness Year built
 Shoulder width treated
 Maintenance quality rating (S.P.R.)

way, structure, and facilities as near as possible in their original condition as constructed, or as subsequently improved, to

MAINTENANCE COSTS

FEDERAL STATE CLASSIFICATIONS			TOTALS	LABOR	MATERIALS	EQUIPMENT	OVERHEAD
GRAND TOTALS,							

QUESTIONS

3. ARE FIELD AND OFFICE OVERHEAD COSTS INCLUDED IN ABOVE COSTS?

4. ARE ALL EQUIPMENT DEPRECIATION, OPERATING, AND OVERHEAD COSTS INCLUDED?

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SURFACE TREATMENT CHARGES (surface treatment)	REMARKS AS TO UNUSUAL CONDITIONS AFFECTING MAINTENANCE COSTS (TOPOGRAPHY, INADEQUATE DESIGN, SOIL, TRAFFIC WEIGHT, CLIMATE, EXTRAORDINARY EMERGENCY WORK, EXCESSIVE HAUL AFFECTING TRANSPORTATION COSTS, ETC.)

and keeping each type of roadway, structures and facilities as nearly as possible in original condition as constructed or subsequently improved to produce satisfactory service." Our remaining problem is to present the data in form that will not be misused or misconstrued.

Due to the importance of the element of surface, it is being singled out in this report and a tentative analysis submitted in graphical form for our West South Central climatic region. The area is comprised of the States of Arkansas, Louisiana, Oklahoma and Texas. It is hoped that after time has been allowed for review of this presentation it will stimulate suggestions that may be helpful in drafting our final report.

The data in Figures 1 and 2 are confined to surfaces 18 ft. wide, segregated under three general classifications as to surface type—high, intermediate and low¹—and based on Form M-1 records for a 4-year period. The graphs show the best fitted straight-line trend as determined by the theory of least squares, for all values plotted on work sheets. The following number of values determined the trends: High 51, Intermediate 26, and Low 11—covering a total of 1,282 miles. The lines are shown only within the limits of actual traffic count plotted and are not extended for theoretical values. The traffic is a weighted average 24-hour count for all classes of vehicles using the sections.

Figure 1 represents a trend of annual average surface maintenance cost per mile plotted against traffic.

¹ General classification of pavements:

High-type surfaces: concrete, brick, bituminous concrete—rigid and non-rigid base, bituminous macadam.

Intermediate-type surfaces: oil processed, surface treated stone, gravel, sand-clay, etc.

Low-type surfaces: untreated stone, gravel, sand-clay, graded.

Figure 2 represents a trend of average total annual surface cost per mile plotted against traffic.

The total annual surface cost is calculated by adding together the average annual surface maintenance cost and an annual surface construction charge based on life of surface reported from actual field inspections. No charge was made for interest on construction investment as none was reported expended on the sections. The construction item includes only surface and base costs. Grading and other highway costs were considered as fluctuating too widely with local conditions. A comparison of the economy of maintenance on various types of pavements must therefore start from finished grading.

A third graph suggests itself, the surface costs as shown in Figure 2 plus a charge to compensate for savings in motor-vehicle operating costs over the various types of surface, referred to in a report by Mr. R. A. Moyer in Vol. 18, Highway Research Board *Proceedings*, pages 41 to 60. The data therein covered three types of surface while our reports refer to three general classifications of the 57 types of surface included in the study. It being considered outside the scope of the work of the maintenance cost committee to attempt to secure more extensive data on automobile expenditures, no study is being made of the relation of surface maintenance costs to total annual surface charges combined with savings in motor-vehicle operating costs.

Turning to Figure 1, it will be observed that the trend of surface maintenance cost per mile is the highest for the low-type group above traffic of 140 vehicles per 24-hour day, less for intermediate types, and lowest for high types. These trends are not, however, indicative as to the economy of expenditures for reasons to be shown presently in Figure 2.

Figure 1 further shows a steep upward

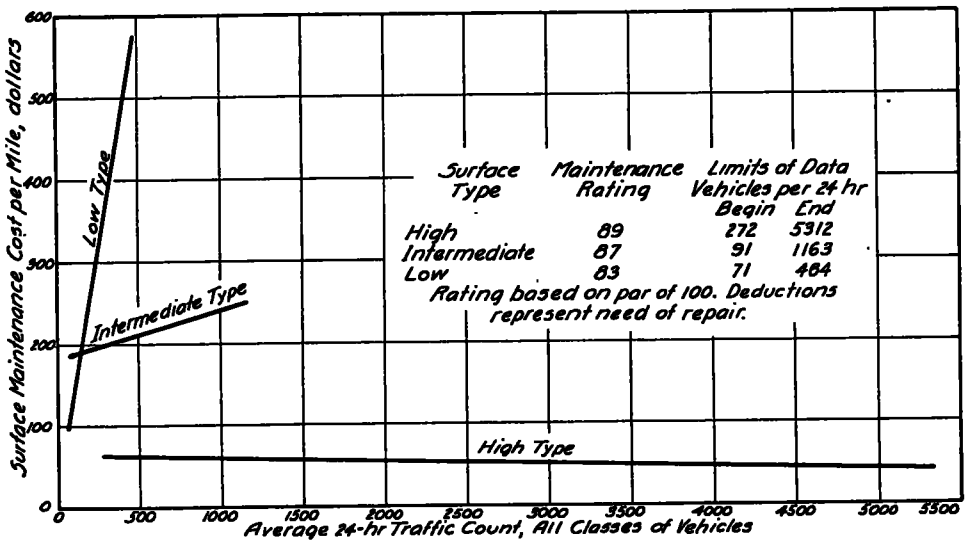


Figure 1. Total Annual Surface Maintenance Cost per Mile Trends by Average 24-hr. Traffic Count. 18 ft. Width Surfaces in West-South-Central Region. Based on Data for Four Years, 88 Sections, 1282 Miles.

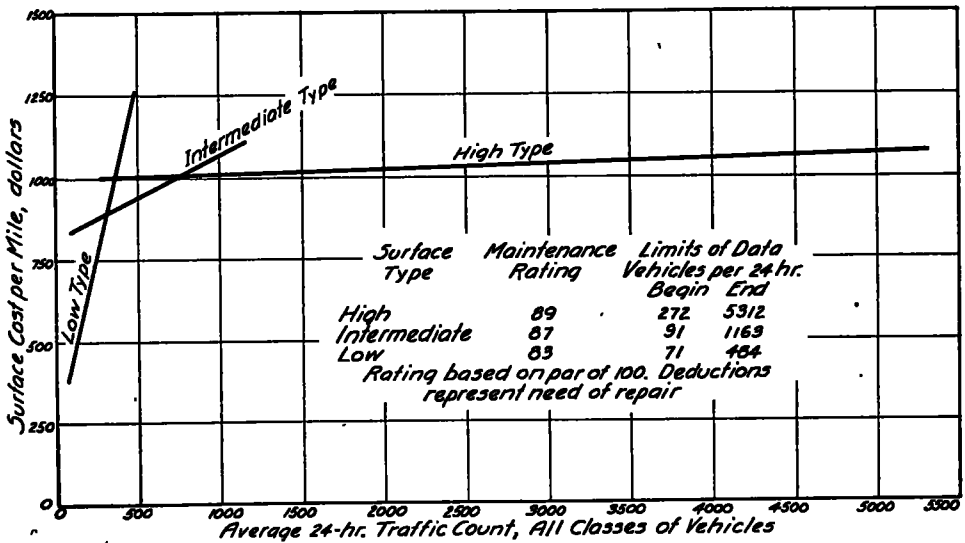


Figure 2. Total Annual Surface Cost per Mile Trends by Average 24-hr. Traffic Count. 18 ft. Width Surfaces in West-South-Central Region. Based on Data for Four Years, 88 Sections, 1282 Miles.

MAINTENANCE

B. P. R. Maintenance Section Cost Form M-1 (Revised)

REPORT OF ANNUAL COST OF
ON SECTIONS SELECTED

State _____

Section number _____ Location _____ Type surfacing in code _____

Type shoulders _____ Width shoulders _____

Traffic count: Trucks _____ Cars _____ Estimated future life of surfacing _____

Additional description of section _____

DEFINITION OF MAINTENANCE.—Highway maintenance is the preserving and keeping of each type of roadway, roadside, structure, and facilities and services to provide satisfactory and safe highway transportation. Maintenance does not include reconstruction or addition.

ANNUAL MAINTENANCE
(Subdivision by operations specified)

MAIN CLASSIFICATIONS	1	2	3	4	5	
	SURFACE-ROUTINE	Patching	Drugging, etc.	Joints and cracks		
SURFACE-SPECIAL	Dust palliatives	Replacements	Reprocessing	Bit. treatment	Mud-jacking	Traffic
SHOULDERS AND APPROACHES	Patching, etc.	Reseeding, reseedling	Ribbon bit. tr.	Retreatments		
ROADSIDE AND DRAINAGE	Cuts, fills, washouts	Drainage channels	Roadside cleaning	Roadside development	Misc. structures	
TRAFFIC SERVICES	Signs, etc.	Surface markings	Guard rail	Lighting, electricity	Comfort stat. etc.	D
SNOW, ICE, AND SAND CONTROL	Snow fence	Snow removal	Sanding	Opening waterways	Sand drifts	
STRUCTURES (Over 20 ft.)						
EXTRAORDINARY REPAIRS						
GENERAL EXPENSE	Office	Field supervision				

GENERAL

1. ARE ALL RECONSTRUCTION CHARGES EXCLUDED FROM ABOVE COSTS? _____

2. WHICH OF THE ABOVE COSTS WERE OBTAINED BY PRORATING? _____

METHOD OF CALCULATING EQUIPMENT DEPRECIATION _____

LIST MAJOR EQUIPMENT USED ON SECTION, WITH DEPRECIATION RATES _____

AVERAGE COST OF MAJOR LABOR ITEMS

AVERAGE COST OF MAJOR MATERIAL ITEMS

ORIGINAL CONSTRUCTION COST		RECONSTRUCTION COSTS SINCE CONSTRUCTION	ADDITIONAL COSTS (Also)
Total	Surface		

Additional pertinent information:

GENERAL HIGHWAY MAINTENANCE
FOR SPECIAL COST STUDY

Report for year ending _____

Length _____ Width _____ Thickness _____ Year built _____
Shoulder treatment _____ Shoulder width treated _____
Federal-aid projects included _____ Maintenance quality rating (B. P. R.) _____

ure, and facility as nearly as possible in its original condition as constructed or as subsequently improved, and the operation of highway
s and betterments.

ENANCE COSTS
(but deductible if kept by the State)

SECTION	OTHER STATE CLASSIFICATIONS			TOTALS	LABOR	MATERIALS	EQUIPMENT
GRAND TOTALS,							

QUESTIONS

- ARE FIELD AND OFFICE OVERHEAD COSTS INCLUDED IN ABOVE COSTS?
- ARE ALL EQUIPMENT DEPRECIATION, OPERATING, AND OVERHEAD COSTS INCLUDED?

ND BETTERMENT CHARGES
(first surface treatment)

REMARKS AS TO UNUSUAL CONDITIONS AFFECTING MAINTENANCE COSTS (TOPOGRAPHY, INADEQUATE DESIGN, SOIL, TRAFFIC WEIGHT, CLIMATE, EXTRAORDINARY EMERGENCY WORK, EXCESSIVE HAUL AFFECTING TRANSPORTATION COSTS, ETC.)

slope on the low-type maintenance cost line for increasing quantities of surface use. Starting with an annual maintenance cost of \$98 per mile for 71 vehicles per 24-hour day and rising to a cost of \$577 for a traffic of 484 vehicles. The intermediate type also shows an upward trend with quantity of traffic use although much less steep, starting with an annual cost of \$186 for 91 vehicles per day and ending with \$249 for 1,163 vehicles.

On the other hand the high-type maintenance cost line shows a slightly downward trend from \$64 per mile for a count of 272 vehicles per day to \$40 per mile at the 5,312 vehicle point. Although this was contrary to expectations, investigation indicated that construction costs were higher at the lower maintenance cost end of the line. From this it may be concluded that with anticipated increase in traffic use durability was built into the pavement and maintenance costs went down. This will be made more apparent from Figure 2 where the high-type line for combined annual maintenance and construction costs slopes slightly upward with increased traffic and from reports of extended life of surface.

Based on a par of 100, the average field inspection ratings of surface maintenance associated with above costs were: Low-type 83, intermediate 87, and high 89. The numerical deductions from the standard represent the extent of repairs the surfaces needed.

Figure 2 discloses a relation, in part the reverse of that shown in Figure 1. The maintenance costs on the graph, when related to construction charges by combination, are shown to be within economic limits for:

- (a) Low-type surfaces, from the traffic value of 71 to 315 vehicles.
- (b) Intermediate types, from the traffic value of 315 to 767 vehicles.

- (c) High types, from the traffic value of 767 to 5,312 vehicles, the end point of our data.

The 315 and 767 traffic values are determined by the intersections of the low-intermediate type and intermediate-high type annual surface cost trend lines. Transferring the traffic data to Figure 1, the maintenance costs within economic limits are shown to range for:

- (a) Low-type surfaces, from \$98 to \$381 per mile.
- (b) Intermediate-type surfaces, from \$199 to \$226 per mile.
- (c) High-type surfaces, from \$62 to \$40 per mile.

These costs are not only economical but the cost trends in Figure 2 show, within a limited range of traffic values, that an additional margin of maintenance expenditures can be made before reconstruction to higher surface type should be considered. The cost trends at the 200 and 400 traffic values are cited as examples. The gap at the 200 traffic point represents that \$221 more per mile per year can be spent for maintenance before the low-type surface becomes uneconomical and reconstruction to an intermediate type should be considered on a cost basis. A similar analysis at the 400 traffic point of the graph shows a margin of \$88 more per mile per year available for maintenance before the intermediate type approaches a reconstruction stage. It seems that the field inspection ratings cited above indicate that at least part of this money could have been used to bring the maintenance up nearer to the par of 100.

The graphical relations shown will vary for each of the nine regions into which the country was divided for the study, depending on climatic, topographical and other conditions. We hope to have at the next meeting similar information to that presented here for each

region, covering a maintenance cost average for five years and a summary for the entire United States.

CONCLUSIONS

1. Annual average surface maintenance cost straight-line trend, based on records for 4-year period, for low-type pavements, 18 ft. wide on highway sections in area mentioned in report, ranged from \$91 per mile for a surface use of 71 vehicles per 24-hour day to \$577 for a traffic of 484 vehicles.

2. For intermediate-type pavements the range is from \$186 per mile for 91 vehicles per day to \$249 for 1,163 vehicles.

3. For high-type pavements the range is from \$64 per mile for 272 vehicles to \$40 for 5,312 vehicles. Additional durability built into the pavements at higher

traffic values lowered the maintenance costs.

4. A measure as to whether above maintenance expenditures are within economic limits is available by comparing the total annual surface cost per mile for each of the three types. This cost is a combined average annual maintenance and surface construction charge.

5. Graphical analysis of the total annual surface cost indicates, within certain traffic values, that these maintenance costs are not only within economic limits, but that additional maintenance expenditures could be made before reconstruction to a higher surface type should be considered on a cost basis. Field maintenance inspection ratings reflected that part of this expenditure would have been desirable to improve condition of surface.