

the filler content and the drop in asphalt penetration after a period of service.

4. The temperature of the mix determines the extent of asphalt penetration drop during mixing. The drop in penetration varied from 7 points at 255 F. to 21 points at 330 F.

5. The mixing time has little or no effect on the amount of drop in penetration during mixing.

6. The asphalt in cutback asphalt wearing surface hardens in approximately 6 years to the degree that incipient raveling occurs.

In order to extend the life of asphaltic

concrete, the test results indicate that it would be advantageous to specify the use of 80-100-penetration asphalt, a minimum asphalt content of 6.5 per cent when sand content is between 25 and 35 per cent, and a maximum temperature of 300 F. for aggregates as they enter the mixer.

#### ACKNOWLEDGMENT

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## DEPARTMENT OF MAINTENANCE

W. H. Root, *Chairman*

### PROGRESS REPORT OF COMMITTEE ON MAINTENANCE COSTS

#### COST TRENDS

1935-1947

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#### SYNOPSIS

The cost of maintaining and operating our national system of state highways is at an all-time high. The trends indicated in the Committee's 1946 report showed the need for a much more detailed study of the year-by-year increase in these costs. Accordingly, this study covering the cost trends during the past 12 years was initiated.

It was determined that the best basis on which to measure these increased costs would be the actual cost of the labor, material, equipment and overhead items necessary to perform each maintenance operation on a representative 10,000 miles of highway, composed of the same proportionate amount of each surface type as contained in the entire national system of state highways. The amount of each of these items necessary for each maintenance operation was first determined. The costs of these items, based on yearly reports submitted by the States and weighted in accordance with the proportionate use by each State, were then used to determine the total labor, material, equipment and overhead costs for each year. The yearly cost of each of these components and the total yearly cost were finally used to establish the cost trends, using the 1935 cost as a base.

The study discloses that the 1947 cost of maintaining and operating this representative 10,000 miles of highway throughout the United States is 71 percent higher than the 1935 cost and 58 percent higher than the 1940 cost. The labor, material, equipment and overhead components of that cost are 98, 46, 53 and 62 percent, respectively above the 1935 level and 77, 45, 43 and 47 percent, respec-

tively, above the 1940 level. Based on these indicated increases in cost, the maintenance operations, which, in 1935, cost \$402.82 per mile, now, in 1947, require an expenditure of \$689.96 per mile.

We know that the costs of maintaining and operating our national system of highways have risen to all-time high. Just how much they have risen has been a debatable point. The Committee, in its 1946 report, indicated the rise that had taken place between 1940 and 1945. The facts brought out by that report showed that a much more detailed analysis was desirable in order to fix the extent of the increase. It was, therefore, decided to undertake a comprehensive study of the unit costs of maintenance (labor, material, equipment and overhead) and from these unit costs determine the year-by-year increase.

The study disclosed that the basis by which these changing costs could best be measured would be the actual cost of maintaining 10,000 miles of highway composed of the same relative mileage of the different surface types that exist on the State highways of the Nation. The surface-type breakdown of the 10,000 miles was, therefore, based on the proportionate mileage of each type under maintenance on these State highway systems.

In order to determine the cost of maintaining and operating the 10,000 miles of highway, it was first necessary to ascertain the amount of labor, material, equipment and overhead involved in the maintenance operations. To do this, the 10,000 miles was first broken down into five types or classes of highways. The classes were designated according to the type of surface existing on each. The five classes were as follows: non-surfaced; soil-, stone- or gravel-surfaced; low type bituminous-surfaced; and cement concrete-surfaced. The high type bituminous-surfaced and cement concrete-surfaced highways were considered as one type (high type surfaced) for all determinations except surface maintenance.

These five classes of highways were then further broken down into six maintenance operations: surface; shoulders and approaches; roadside and drainage, traffic service; snow, ice and sand control; and bridge maintenance. Each operation was finally broken down into such of the 34 labor, material, equipment and overhead items shown in Table 1 as were applicable to that particular operation.

The amount (hours, gallons, miles, etc.) of

each of the 34 items necessary to perform each maintenance operation on each type of highway was determined from data contained in the annual reports of the various State highway departments and the Form M-1 reports submitted annually from 1935 to date by the

TABLE 1  
LABOR, MATERIAL, EQUIPMENT AND OVERHEAD ITEMS

Classification	Unit
<i>Labor</i>	
1. Foreman	Hour
2. Patrolmen	Hour
3. Operators	Hour
4. Skilled	Hour
5. Common	Hour
<i>Material</i>	
6. Crack Seal	Gallon
7. Bituminous Mix	Ton
8. Bituminous Liquid	Gallon
9. Cement	Barrel
10. Chlorides	Ton
11. Stone	Ton
12. Gravel	Ton
13. Sand	Ton
14. Paint	Gallon
15. Lumber	MBF
16. Pipe	Linear Feet
17. Traffic Signs	Each
<i>Equipment</i>	
18. Automobiles and Pickups	Mile
19. Trucks, Light	Hour
20. Trucks, Heavy (Inc. Bituminous Dist.)	Hour
21. Compressors	Hour
22. Bituminous Kettles	Hour
23. Shovels	Hour
24. Graders	Hour
25. Mixers	Hour
26. Mowers	Hour
27. Rollers	Hour
28. Snowplows	Hour
29. Sweepers	Hour
30. Spreaders	Hour
31. Tractors	Hour
32. Loaders	Hour
<i>Overhead</i>	
33. Salaries	Month
34. Transportation	Mile

State highway departments on the maintenance of selected sections of State highways.

After these determinations had been made, it was found that, although the total amounts of the material, labor and equipment items varied considerably between the various classes of highways, the same proportionate

relationship was maintained between these items for all the operations except surface maintenance. Due to this fact, and in order to simplify the yearly calculation, the five classes were consolidated and shown as one for all operations except surface.

The amount (hours, gallons, miles, etc.) of each of the 34 items was further checked by determining the average unit price for each from 1935 to 1942 inclusive. This unit price was then applied to the amount of each item to obtain the cost of the six maintenance operations on the five classes of highways. This cost (for each operation on each class of highway) was finally checked against the expenditures reported by the States for these same operations over the same period of years.

In order to keep the number of items (the 34 items shown on Table 1) reasonably low, certain material and equipment items that make up only a small percentage of the total maintenance cost were combined with other items, the cost of which would follow the same trend. This was accomplished by increasing the quantity of the base item enough to cover the cost of the other item. For instance, two hours of heavy truck time were included to cover each hour of bituminous distributor time, the hourly rental rate of bituminous distributors being twice that of heavy trucks. In a like manner snow fence was included as lumber, several small equipment items were included as similar equipment, etc.

The unit costs of the 34 labor, material and equipment items for the years 1935 through 1946 were obtained from the same M-1 reports previously used to determine the relative use of the various items. These reports, submitted annually by the States, show the unit cost of each item on each of the sections under study (1,123 sections covering 17,400 miles of State highway, approximately equal to the State highway mileage in the six New England States). These data were further checked and augmented by other information contained in the State annual reports. The data for the year 1947 were obtained from special supplementary reports submitted as of November 1947 by the 48 States.

The country-wide average cost of each of the 34 items was obtained by averaging the unit costs from each State, weighting each in accordance with its proportionate use.

Figures 1 to 5 and Table 2 indicate the trend in the cost of maintaining and operating the representative 10,000 miles of State highways and the trends of the four components of the total cost—labor, material, equipment and overhead. These trends were compiled from the yearly costs, using the 1935 cost as a base. The total yearly costs and the yearly costs of the four components of that total were obtained

TABLE 2  
COST TRENDS  
Percentage

Year	Labor	Material	Equip-ment	Over-head	Total
1935	100.00	100.00	100.00	100.00	100.00
1936	102.19	104.31	97.97	100.29	101.24
1937	108.48	104.42	99.31	102.50	104.46
1938	110.17	103.73	103.51	103.97	106.36
1939	111.29	101.64	105.87	105.83	107.23
1940	112.33	100.30	107.12	110.20	108.13
1941	121.16	102.86	110.11	111.33	113.30
1942	134.93	115.68	113.27	113.93	122.83
1943	151.82	117.76	114.46	116.87	130.88
1944	162.42	123.22	116.77	119.81	137.34
1945	171.16	130.10	120.89	125.01	147.52
1946	180.56	132.62	141.28	148.30	156.40
1947	198.40	145.83	153.39	162.38	171.28

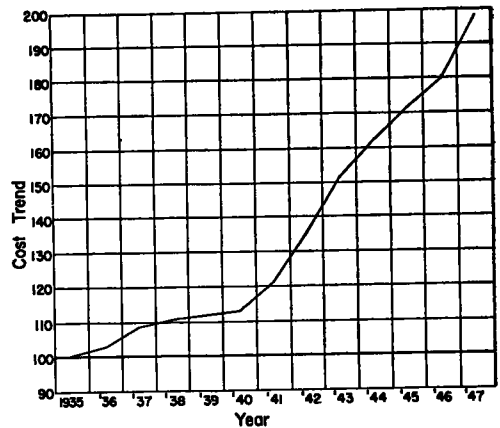


Figure 1. Labor Cost

by applying the country-wide average prices to the 34 items to the constant amounts of each item as previously established for the representative 10,000 miles.

#### LABOR COSTS

The cost of maintenance labor (Fig. 1) increased gradually from 1935 to 1940 and then sharply to its present height. The 1947 cost is 98 percent above the base year of 1935, and 77

percent above 1940. The rise in the wage rate of operators and common laborers is the highest, 104 and 103 percent, respectively, over 1935; the rise in the foremen's rate is the lowest, 70 percent over 1935. Since the cost of labor amounts to approximately half of the total maintenance expenditure, the rise in these costs accounts for the greater part of the increase in the maintenance expenditure.

#### MATERIAL COSTS

The 1947 cost of maintenance materials (Fig. 2) is 46 percent above the 1935 rate, and 45 percent above 1940. These prices increased slightly in 1936-1937 and then decreased until 1940; thereafter they increased in similar proportion to the labor costs. Some material items, such as lumber, have more than doubled in cost over 1935. The large increase in the cost of these items can be attributed in

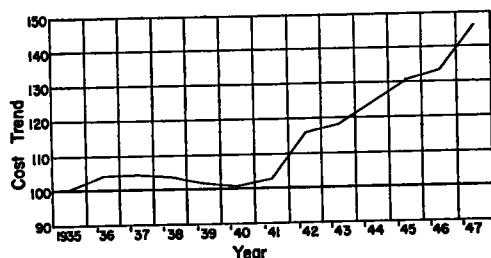


Figure 2. Material Cost

part to the present scarcity. The prices of other items, such as bituminous mix, have risen only slightly. The slow rise in the cost of these items is probably due to increased competition, improved methods, improved equipment, etc.

#### EQUIPMENT COSTS

Equipment rental rates (Fig. 3) decreased slightly in 1937 and then increased slowly until 1944, after which they showed a sharp rise. The 1947 rates are 53 percent above the 1935 rates, and 43 percent above the 1940 rates. This moderate rise is due chiefly to the lag in equipment purchases by the States. Most of the States base their depreciation rates, through the application of some formula, on the purchase price of the equipment. This means that the depreciation realized on each piece of equipment repays the purchase price of the equipment but does not provide a large enough reserve to replace the equipment at

an increased price level. Therefore, this portion of the equipment cost has not as yet been affected to any great extent by the rising prices of new equipment. However, other factors, such as equipment maintenance labor, repair parts and fuel, that enter into the equipment cost have been affected by the rising price levels, and, therefore, the trend has risen to some extent.

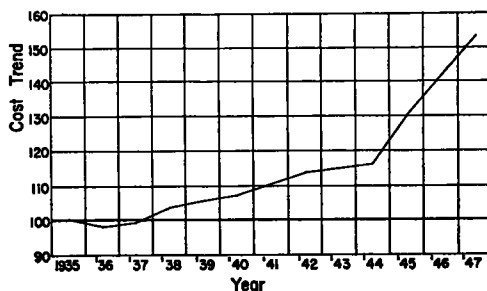


Figure 3. Rental Cost

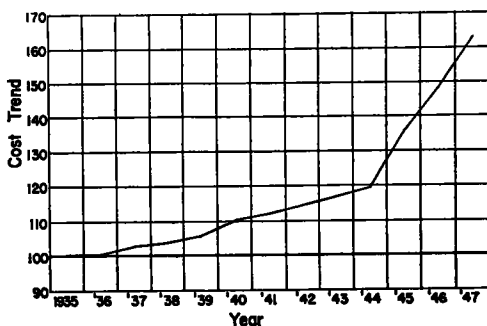


Figure 4. Overhead Cost

It would probably be well for those States that have not already done so to investigate the depreciation returns on their old equipment, and if these returns have not been, or will not be, large enough to replace the particular item of equipment raise the depreciation charges sufficiently to cover these increased replacement costs.

#### OVERHEAD COSTS

Overhead costs (Fig. 4) have risen less than labor costs, 62 percent above the 1935 base and 47 percent above 1940. The overhead costs are made up of four parts; engineering salaries, skilled clerical and supervisory salaries, salaries of clerks and typists of the lower grades and unskilled laborers, and the transportation costs of engineers and super-

visory personnel. Other portions of the overhead costs, such as rent, heat, light, etc., represent such a small percentage of the total costs that they were not included. The three salary items are shown in Table 1 as salaries and transportation as travel miles of automobiles. The rise in overhead costs can be largely attributed to the rise in the lower salaries. These have risen almost as much as the labor items.

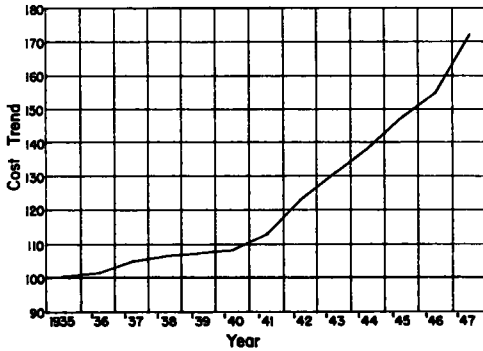


Figure 5. Total Maintenance and Operating Cost

#### TOTAL COST TREND

The trend of total maintenance costs, as shown on Figure 5, follows much the same general pattern as the labor cost trend. It rises slightly from 1935 to 1940 and then sharply to its 1947 height, 71 percent above 1935 and 58 percent above 1940. The 8 percent rise from 1935 to 1940 is due principally to the rise in maintenance labor rates. This rise manifests itself directly in the labor trend curve and indirectly in the overhead and equipment trend curves. Both of these latter costs are made up, to a large extent, of labor which is paid directly from state funds. Material costs held the trend of total maintenance costs down, since they increased slightly in 1937-1938 but decreased to the 1935 level again in 1940. The sharp rise in the total cost curve from 1940 to 1945 is due to the rise in all factors, although equipment and overhead costs did not begin to rise as soon as labor and material.

The average maintenance expenditure on the Nation's State highway system during the years 1934, 1935 and 1936 was \$403.77 per mile. The cost per mile of maintaining the representative 10,000 miles for the year 1935

was \$402.82. The cost per mile of these same fixed unit maintenance items was \$435.56 in 1940 and is \$689.96 in 1947.

It is believed that the cost of maintaining this representative mile, including as it does all the cost factors entering into the maintenance and operation of a typical mile of our State highway system, indicates the expenditure per mile necessary to maintain and operate the State highway system at the present price level. There will be some minor variations, due to differences in wage scales, highway surface types, etc., in any particular State, but these variations should not affect the total 12-year rise in any individual State by more than 10 percent. Large increases in the weight or volume of traffic in specific areas would also increase the required maintenance expenditures in those areas over and above the amount previously indicated in the report. It is believed that each State should, using its own costs and conditions, investigate the unit cost rise in its area and compare that rise with the increase in its maintenance expenditures over the same period of years. This would provide an excellent example for educating the general public regarding the necessity for increased highway revenue.

#### CONCLUSIONS

In conclusion this comprehensive study of maintenance costs shows, as illustrated on Figures 1 through 5 and Table 2 that:

1. The total cost of maintaining and operating the 10,000 miles representative of the entire system of State highways in 1947 is 71 percent higher than the 1935 cost and 58 percent higher than the 1940 cost.
2. The 1947 maintenance labor rates are 98 percent above the 1935 level and 77 percent above the 1940 level.
3. The 1947 cost of maintenance material is 46 percent higher than in 1935 and 45 percent higher than in 1940.
4. The 1947 equipment rental rates are 53 percent above the 1935 rates and 43 percent above the 1940 rates.
5. The 1947 overhead costs are 62 percent higher than in 1935 and 47 percent higher than in 1940.

#### ACKNOWLEDGMENT

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