HIGHWAY RESEARCH BOARD

Bulletin No.21

Maintenance Costs

1949

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1949

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HIGHWAY RESEARCH BOARD

Bulletin No.21

MAINTENANCE COSTS

REPORT OF COMMITTEE AND TWO PAPERS

PRESENTED AT THE TWENTY-EIGHTH ANNUAL MEETING

HIGHWAY RESEARCH BOARD

DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH

NATIONAL RESEARCH COUNCIL

Washington 25, D. C. September 1949

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PROGRESS REPORT OF PROJECT COMMITTEE ON MAINTENANCE COSTS

J. S. BRIGHT, *Chairman*
Deputy Commissioner,
Public Roads Administration

This committee presented at last year's meeting a report on the rise in maintenance costs from 1935 to 1947. The interest in this report was so extensive that it was decided to issue the index on a semi-annual basis. In June of this year we computed the index for the first half of 1948. A report on the subject was distributed throughout the States in the hope that it would be of value to the highway departments in substantiating their budgets for the coming year.

The most substantial rise, seven percent over 1947 and 113 percent over 1935 (Graph 1). Material costs have increased 11 percent over 1947 (Graph 2). This is principally due to the large rise in the cost of bituminous material, approximately two cents per gallon. Equipment costs have also increased materially, 12 percent over 1947 (Graph 3). As usual, the overhead costs have risen least of all, five percent since 1947 (Graph 4). Even this five percent increase is due principally to the rise in the lower salaries and wages; the engineering salaries have gone up even less.

TABLE 1

COST TRENDS

HIGHWAY MAINTENANCE AND OPERATION

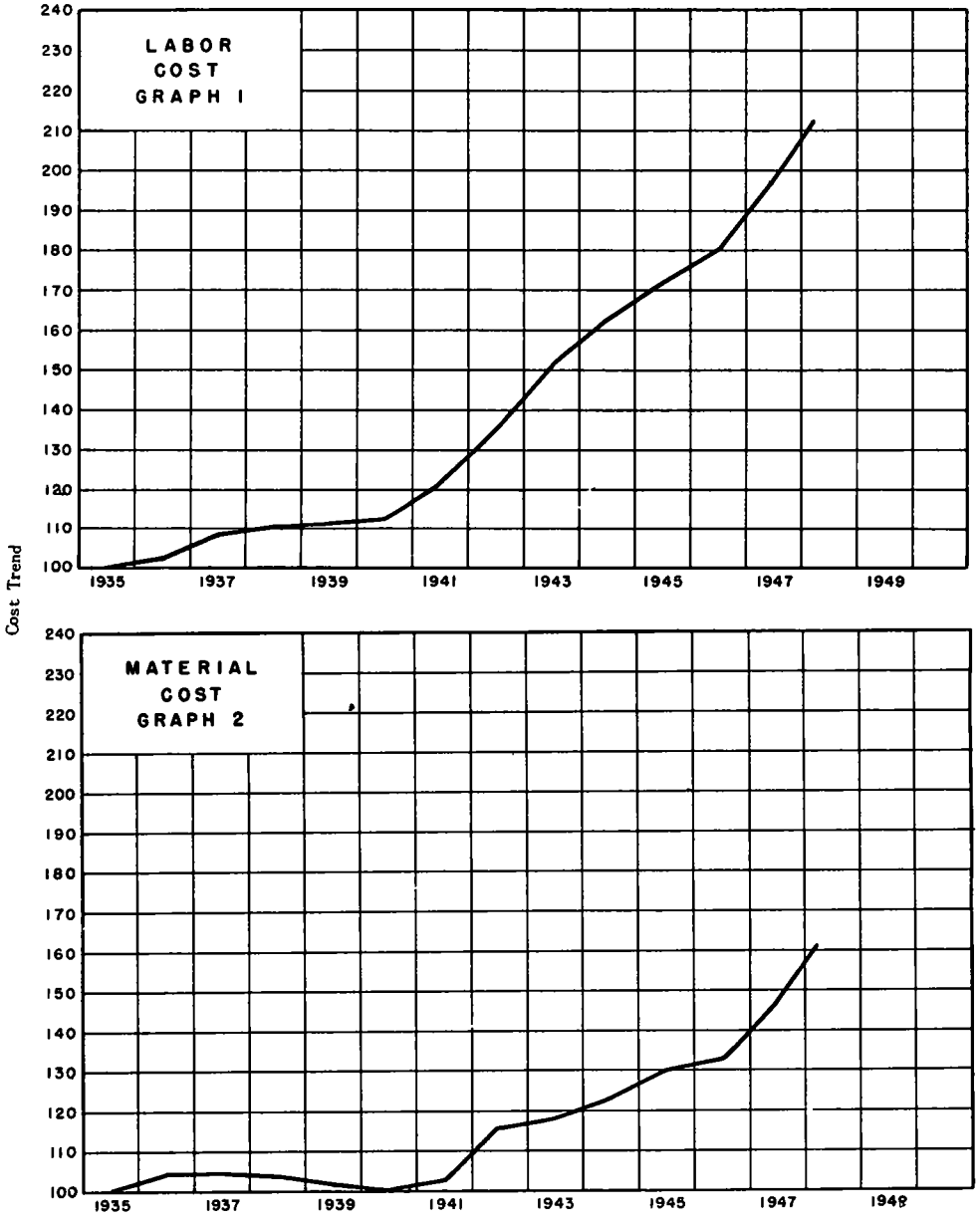
Year	Labor	Material	Equipment	Overhead	Total
1935	100.00	100.00	100.00	100.00	100.00
1936	102.19	104.31	97.97	100.29	101.24
1937	108.48	104.42	99.31	102.50	104.46
1938	110.17	103.73	103.51	103.97	106.36
1939	111.29	101.64	105.87	105.83	107.23
1940	112.33	100.30	107.12	110.20	108.13
1941	121.16	102.86	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	129.89	135.01	147.52
1946	180.56	132.62	141.28	148.30	156.40
1947	198.40	145.83	153.39	162.38	171.28
First 1/2					
1948	212.74	161.20	171.60	170.42	186.42

The maintenance cost index for the first half of 1948 showed an increase of eight percent over 1947, 72 percent over 1940 and 86 percent over 1935 (Graph 5 and Table 1.) Labor has, of course, shown

We are currently engaged in compiling the index for the second half of 1948. To

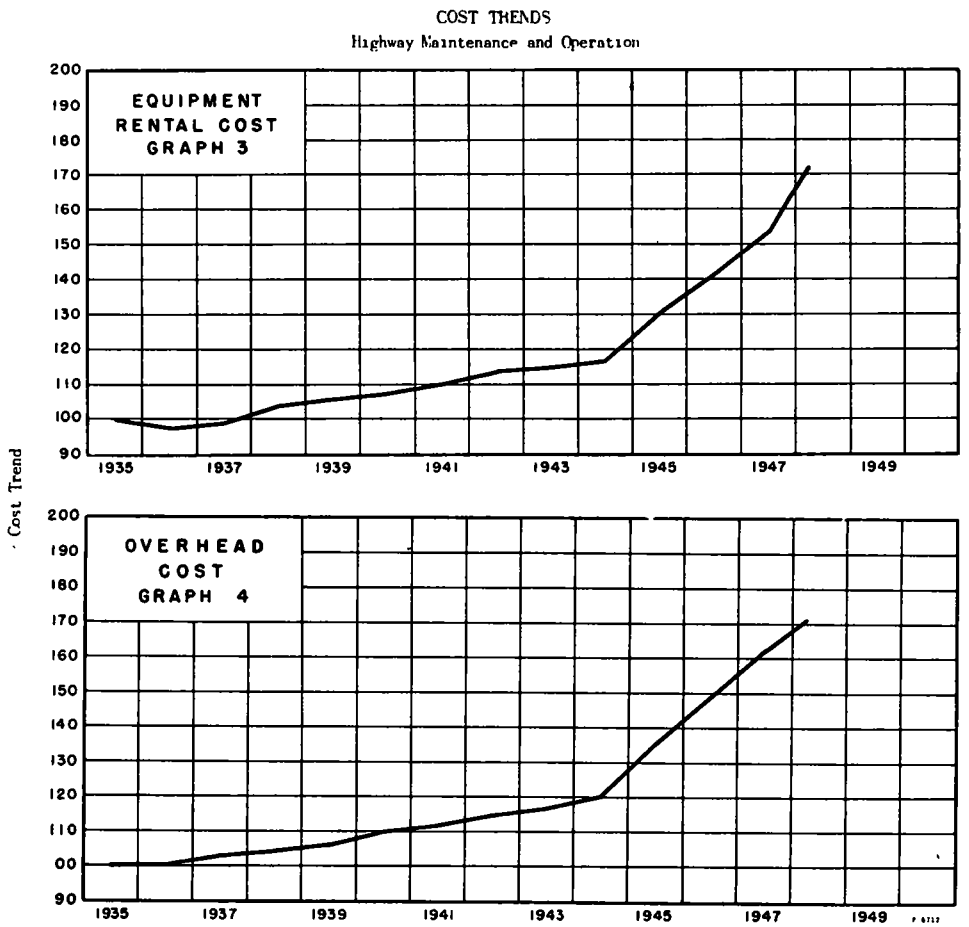
COST TRENDS

Highway Maintenance and Operation



date, sufficient data have not been received to indicate an exact index figure. It is estimated, however, from the data so far received that the index for the last half of 1948 will be approximately 190, two percent over the first half of 1948 and 90 percent higher than 1935. In this case, the average cost of maintenance for the year 1948 would be 88 percent above the 1935 cost. In other words, the 1948 dollar produced, in terms of the 1935 dollar, only fifty-three cents worth of maintenance.

This rapid increase in costs indicates that we, as maintenance administrators, must devise new and improved maintenance equipment and new and improved maintenance methods and procedures in order to



increase the productivity of our maintenance effort and thereby increase the value of the maintenance dollar.

With this increased production we can afford to improve our wage standards without increasing the actual cost of the work. As an illustration of this, we can recall the plight of the coal miners in the pick and shovel days. Today, the Bituminous Coal Institute reports, more than 91 percent of all bituminous coal mined underground is mechanically cut, about 60 percent is mechanically loaded and only four percent is mined by pick and shovel methods. This has not only made better wages possible but has also improved the working conditions of the coal miner.

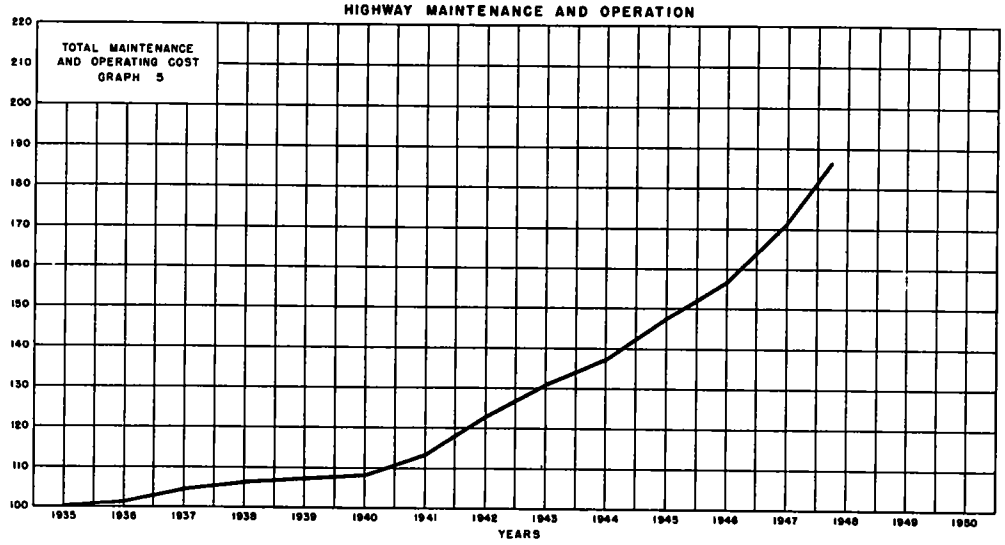
While these data reflect the advancements in other fields, it must be recognized that our maintenance organizations have also made great strides in holding the increase in the costs of certain operations well below the increase in the general level of prices. An indication of the increased productivity of the maintenance man, or at least the increased use of the highways that he was called on to service, may be obtained from the records of revenue-producing traffic. The following increases have occurred per maintenance man employed in 1947 as compared to the number of men employed in 1936:

Item	1947 percent increase over 1936 for each maintenance man employed
Motor vehicle registration .	60
Vehicle miles of travel . . .	79
Ton-miles of traffic . .	120

It is to be noted that the 1947 main-

COST TRENDS

HIGHWAY MAINTENANCE AND OPERATION

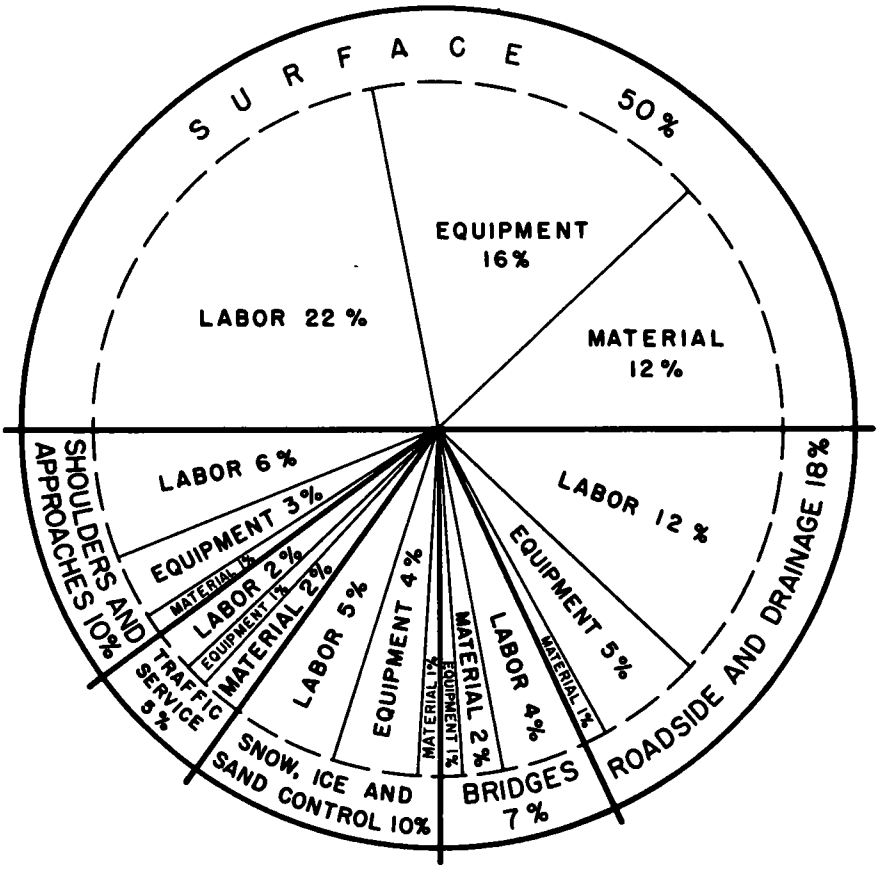


tenance man was assigned to repair the deteriorations caused on highways by the movement of over twice as many ton-miles of traffic as was the case 11 years earlier.

An analysis of the distribution of the expenditures for labor, material and equipment between the various highway maintenance operations is shown graphically on Chart 6. On this chart, the overhead charges have been distributed between the labor, material and equipment items. This chart indicates that half of the total maintenance expenditure is used in maintaining the highway surface. This, based on the 1947 expenditure for State highway maintenance, maintenance overhead and maintenance equipment, amounts to 220 million dollars. Based on the total maintenance expenditure of the Nation (States, counties, townships and municipalities) in 1947, it amounts to about 570 million dollars. The size of this expenditure indicates the large savings that could be accomplished by increasing the productivity of the direct labor engaged in these surface maintenance operations. It has been estimated by the Automobile Manufacturers Association that 30 percent of the 1946 pay roll costs of United States industry was attributable to material handling. It is further estimated that 80 percent of this handling was performed by manual methods. The use of almost half of the surface maintenance funds for direct labor shows that we, the highway maintenance industry, are not doing much better.

Material handling is an important part of all our maintenance operations. Due to the large expenditure for surface maintenance, it is particularly important in this operation. Here the material for surface treatment or patching, bitumen and stone, must be picked up, either from a plant, stock pile or from the surface itself; in some cases graded and screened; transferred to some type of mixing operation; and, finally, placed evenly on the surface and compacted. As you can see, this involves possibly four separate handling operations, loading, two transfers and placing. During the past 20 years, we have made many important advances in the handling of these materials and still almost half of our surface maintenance expenditure is used for labor.

Several new types of equipment are being developed that should measurably increase the productivity of this operation. Two equipment units that will perform parts of the surface reconditioning operation are being field tested. One tears up the old surface and pulverizes it for further manipulation. The other picks up previously scarified material from windrows and pulverizes it, discarding the fines on the surface and windrowing the



Graph 6. The Maintenance Dollar. Maintenance and Operation of State Highway Systems, 1948.

clean material for remixing. Both of these machines should reduce the handling costs on this type of work. A small continuous mix plant has recently been developed that prepares and loads or stock piles patching material without intermediate manual handling. Many new types of tractor- and truck- loaders have been placed on the market recently. These all reduce or eliminate the necessity for hand-loading.

Chart 6 also discloses that the next most costly operation is roadside and drainage maintenance. Two-thirds of the cost of this operation which amounts to slightly less than one-quarter of the total maintenance expenditure is due to direct labor charges. The two most important individual operations involved are the mowing and disposing of roadside vegetation and the cleaning of and the disposing of the spoil from the roadside ditches. Here again, the handling of the cuttings and spoil is the most costly part of the operation.

We have developed in the past few years, mowers that are much more adaptable to highway work than the original farm types. We can now cut at almost any angle, either above or below the horizontal. We have small mowers that can be used on very rough terrain. We have mowers that can cut brush up to three inches in diameter. The difficulty is that we must dispose of this material after it is cut. This is the part of the operation that now requires the greatest labor effort. Some of our States have developed raking de-

vices which collect the cuttings. They must still be loaded and hauled to a suitable dumping area. A machine is being developed which will pulverize the cuttings. This material can then be deposited on most roadsides without creating a fire hazard or spoiling the view. The development of a mobile incinerator such as is used in another industry has also been suggested. The cuttings could be burned and the ash deposited on the shoulder or roadside.

Several of the States are experimenting with or have adopted the use of some type of herbicide. These selective chemicals kill off the most troublesome vegetation and allow the better grasses to grow. In this way the necessity for removing the cuttings is reduced or eliminated.

The cleaning of the roadside ditches also entails much hand labor. Many types of tow and power graders have been developed which will do an excellent job of cleaning and reshaping the ditches. Here again, the difficulty is that we must dispose of the excess material. This is a handling operation, loading and hauling. Recently, power loaders have become available that will load this material at a fraction of the cost of hand labor. It is reported that the actual loading cost can be reduced to three cents per cubic yard. It is necessary in most cases, however, to blade this spoil onto the shoulder or surface of the highway in order to make it available to the loader. This is not adviseable on many of our surface types since the spoil usually contains an excess of fines. These should not be allowed to lower the quality of the stable shoulder or surface material. A machine which would shape the ditch and at the same time carry the spoil over the shoulder into a truck appears to be a desirable development.

Over half the cost of the remaining maintenance operations which together account for over one-quarter of our maintenance expenditure can be attributed to labor. The introduction of new equipment types together with the consequent improvement in our maintenance methods and procedures should materially increase the productivity and decrease the cost of these operations.

We have with us today two men who will discuss from the standpoint of economy two very common maintenance operations. These two men will give you the benefit of their experience in combating the high cost of maintenance through the development of new maintenance equipment and new maintenance methods. That they are well informed on the subject of costs will be readily apparent when I tell you that between them they are responsible for the expenditure of over $80,000,000 on the maintenance, operation and improvement of their State highways.

Mr. Forrer of Virginia will discuss the savings that can be accomplished by the use of mechanical loading methods. Mr. Beckley of Pennsylvania will discuss the cost of resurfacing disintegrated pavements. I feel sure that their experience will be of value to all of us.

COST OF MECHANICAL LOADERS IN DITCH CLEANING AS COMPARED WITH COSTS OF HAND OPERATIONS IN VIRGINIA

J. J. FORRER, *Maintenance Engineer*
Virginia Department of Highways

The information contained in this paper is compiled from data collected from the field engineer in charge of maintenance operations throughout Virginia only.

The Virginia Department of Highways maintains 9,000 miles of primary roads and 38,000 miles of secondary roads. As in most States, during and since the war, a very definite shortage of hand labor has existed. At the same time, naturally, many miles of ditches were becoming clogged with grass and washed in debris. Inadequate drainage was causing excessive base and surface failures. Grader equipment, both one-man and tractor pulled, was available for pulling material from the ditches onto the shoulders of the road. The complete disposal of this material was a real necessity and presented a big problem. Labor not being available, it became evident that the loading of this material onto trucks would have to be done by machinery. It was necessary that such a machine be capable of picking up wet or dry sandy or clayey materials containing grass, roots or small stones and load them onto trucks working in line so that there would be a minimum of interference to traffic. Also the machine would have to be capable of moving rapidly from one location to another under its own power.

In attempting to arrive at comparison

TABLE 1

ENGINEERS' REPORTS - COMPARING COSTS AND SAVINGS OF THE MECHANICAL LOADING OF DITCH CLEANING OVER HAND LABOR METHODS

Mechanical Loading Costs Per Mile (Both Ditches)		Hand Labor Loading Costs Per Mile (Both Ditches)		Difference in Cost Per Mile	Estimates of Number of Laborers Replaced by Loading Equipment	
Test Sections	Cost Per Mile	Test Sections	Cost Per Mile		No Engineers Reporting	No Laborers Replaced
1	$ 40 00	1	$ 274 00	$ 234 00	1	25
2	111 00	2	274 00	163 00	1	30
3	51 16	3	482 60	431 44	2	40
4	23 65	4	76 39	52 74	4	50
5	75 00	5	130 00	55 00	1	80
6	128 58	6	500 00	371 42		
7	135 00	7	225 00	90 00		
8	100 00	8	165 00	65 00		
9	80 00	9	100 00	20 00		
10	95 00	10	165 00	70 00		
11	35 00	11	102 00	67 00		
12	62 13	12	275 92	213 99		
NOTE-The engineers reported a rate of progress of from 1 to 5 miles per day		NOTE-The engineers reported a rate of progress of from 1/4 to ½ mile per day				
The outfits consisted of 1 Foreman 1 One-man or tractor pulled grader and operator 1 Mechanical Loader and Operator 4 to 5 1½ Ton dump body trucks and drivers 1 Rotary power broom 2 to 3 Laborers		The outfits consisted of 1 Foreman 1 One-man or tractor pulled grader and operator 4 to 6 1½ Ton dump body trucks and drivers 12 to 16 Laborers				

TABLE 2

TIME STUDIES OF LOADING ONE TRUCK
(3 Cubic Yard Load)

Test Number	Mechanical Loading Average Time Recorded Minutes	Hand Loading Average Time Recorded Minutes
1	1/4	3
2	1/2	5
3	2/3	10
4	2/3	12
5	1	12
6	1	15
7	1	25
8	1-1/4	17½
9	1-1/2	25
10	2	10
11	2	12
12	2	20
13	2-1/2	7½
14	2-1/2	10
15	2-1/2	15
16	3	10
17	3	15
18	3	12
19	4	20
20	5	12

TABLE 3

COST STUDIES OF LOADING ONE TRUCK
(3 Cubic Yard Load)

Test Number	Mechanical Loading Average Cost Recorded	Hand Loading Average Cost Recorded
1	$ 0.12	$ 0.70
2	0.24	1.33
3	0.25	2.88
4	0.33	1.63
5	0.39	1.55
6	0.43	1.23
7	0.72	2.13
8	0.78	4.07
9	0.81	1.65
10	0.91	3.17
11	0.92	2.19
12	0.95	1.50
13	1.01	2.06
14	1.05	2 01
15	1.32	4 89
16	1 67	5.87

costs it soon became obvious that practically every road had its peculiarities which reflected in the cost of the operation, i.e., the amount of material from the ditch, the kind of material handled, and the distance that the excess material had to be hauled for disposal, etc.

The disposal of the materials from the ditches, within a reasonable haul, does not present any problem. The materials that contain good soil and grass are used extensively for top dressing slopes and fills. The materials that contain stones or clay are dumped uniformly over the fills. Often the material is given to citizens along the road for filling low spots in fields and house lots. In many cases the citizens are so anxious to get the materials that they will furnish trucks at their expense.

The wide variation in operations and locations accounts for the wide variations in replies received from the field engineers (Table 1 - 3). Also the terrain in Virginia varies from the tidewater area in the east, rolling country in the central section and mountainous conditions in the west. The soils in each area are widely different, varying from sandy loams to heavy clays.

The machines capable of loading ditch materials are also used for many other purposes such as loading aggregates from stockpiles, light excavation work in widening narrow grades, and for loading snow. We are now operating in Virginia 85 mechanical loaders for these purposes.

It would be very desirable to have a machine that would clean ditches, and in the same operation load the material onto trucks. Such a machine, so far as known, has not been developed. It is believed there is a definite field for such a machine.

ECONOMICS OF RESURFACING DISINTEGRATED PAVEMENTS

C. OWEN BECKLEY
Assistant Chief Maintenance Engineer
Pennsylvania Department of Highways

In making a detailed study of the economics of the resurfacing of disintegrated pavements, many factors are involved, each demanding careful consideration in order that a complete understanding may be had, not only of the economics of the operation itself, but also of the economic justification of the operation or program.

In justifying resurfacing work, one of the first factors to be considered is the need for the work itself. Let us first investigate the justification of need for resurfacing of concrete pavements, plain or reinforced. The first item to support the need is probably the age of the pavement. In considering the age of the pavement such items as slab design, present condition of the concrete itself, and width of the existing pavement will demand study and answer as to whether or not the slab design is heavy enough to withstand the traffic loads that the pavement is asked to carry; whether or not the slab is showing disintegration or failure to the extent that it is no longer possible to maintain it satisfactorily with the funds available for maintenance and, whether or not the width of the existing pavement is ample to safely accomodate the traffic load it is now asked to carry. With respect to traffic density and unit weights that many pavements are now carrying, it is probably universally true that these density and weight demands far exceed any anticipation of these items that may have been estimated at the time the pavement was designed and constructed.

Further items of study demanding consideration is the alignment and grade of the existing pavement. These items will no doubt vary as extensively as the terrain over which any highway department has constructed or will be asked to construct highways. Line and grade are highly important however to the ultimate success of resurfacing work, because after the work is done a better riding highway will result which will promote an increase in the speed of traffic, thereby requiring a line and grade of such nature as to insure a satisfactory degree of safety to an accelerated traffic flow.

The study items reviewed also apply to pavement types other than concrete that may be considered for resurfacing. Other common types considered may be macadam or brick pavements. In addition to making the same studies for these pavements as for concrete, such items as existing cross section in the case of early macadam pavements, and supporting base in the case of brick pavements, will call for consideration and determination in order to ascertain if the resurfacing is economically feasible.

Another factor having a direct bearing on whether or not resurfacing is economically sound is the magnitude of needed reconstruction and whether or not available funds for reconstruction are ample to meet that need. In many cases it is highly probable that the need for reconstruction in cost will far exceed the possibilities in so far as available funds for reconstruction are concerned. The problem is then usually partially solved by deciding to extend the life of existing pavements and in some cases no doubt to the point where maintenance costs become prohibitive. In many cases the problem of spreading reconstruction opera-

tions over an extended period can be solved by supplementing with and substituting resurfacing on projects that by their location, use and physical status will warrant a resurfacing operation.

So far this discussion has considered only the generalities dealing with establishing the need for resurfacing. Assuming that the need for resurfacing has been justified, we will next consider some items of preparation and operation that require study in order to expedite a more economical resurfacing program.

Let us assume that the resurfacing program has been made of individual projects that are being considered for resurfacing because they either cannot be reconstructed because of financial or physical impossibility, or are structurally sound to the point that reconstruction cannot be warranted but the specific highway in question is unsatisfactory by virtue of its width, lack of curve elevation or other conditions that do require some modernization to adequately meet traffic demands. The questions to be answered than are, in the first case, how long must reconstruction be deferred? How much base correction will be required to carry the pavement for that length of time? Will the job require plans? How thick must the resurfacing course be to successfully carry the pavement for the required length of time? In the latter type of pavement being considered for resurfacing, where the existing highway can be salvaged and modernized by widening, curve elevation, etc., the question of how much refinement can be justified must be answered in addition to consideration being given to the foregoing items, all having a direct bearing on the economic justification for resurfacing.

After the resurfacing program has been established, there are many items of detail operation that must be investigated and worked out. These include such items as specifications for the resurfacing material, the types of resurfacing material needed, whether it may be a mixed in place material or a plant mix material, shall the material be a cold mix type material or a hot mix type material; the type of aggregates available that can be utilized in the production of bituminous concrete; the plants available that can produce bituminous concrete; the proximity of the plants to the site of the work, keeping the length of haul to a minimum, thereby effecting the economy; the types of material the available plants are able to produce; the possibility and feasibility of the use of portable plants. All of these items bear an important relationship to the resultant overall cost of resurfacing projects and programs.

The above factors were given consideration in the State of Pennsylvania and a study was made of our highway system in an effort to determine its needs in order to keep it currently modern. The following are some of the facts and figures with which we were and are confronted.

The Pennsylvania State Highway System consists of 40,893 miles of road, which mileage includes 6,667 miles of concrete pavement, 24,742 miles of bituminous pavement and 2,058 miles of miscellaneous improved types (brick, block, bituminous concrete).

1,818 miles of the concrete pavement and 3,282 miles of the bituminous pavement are more than 25 years old. In 1941 the Department of Highways estimated that modernization of its highway system would require an expenditure of 550 million dollars within a period of 5 years, or an average of 110 million dollars per year. During the period of 1942 to 1945 inclusive, very little new construction was undertaken, with the result that this program was set back. Another modernization estimate was made in 1946, and, due to disintegration from heavy war traffic, it was then estimated the process of modernization would cost 850 million dollars if this were to be completed in a five year period, or an average of 170 million dollars per year.

We have compiled some costs comparing the costs of reconstructing two-lane highways on approximately the existing road bed with a minimum of grading quantities and using the existing structures, where possible. In comparison to these figures we have also compiled cost for resurfacing

that was done during the same period. In 1946 we reconstructed 110 miles of road at a total cost of $6,074,710, or an average of $55,225 per mile. During the same period 256 miles of road were widened and resurfaced, or resurfaced without widening, at a total cost of $7,776,470, or an average of $30,377 per mile.

In 1947 it was decided that this program of resurfacing or rehabilitation should be expanded and in that year 162 miles of reconstruction work was completed at a total cost of $8,974,400, or an average of $55,400 per mile, and 286 miles of resurfacing, or widening and resurfacing were completed at a total cost of $11,088,400, or an average of $38,771 per mile.

The funds available to the Department of Highways to date will permit a construction program of approximately 100 million dollars per year, but beginning with 1949 approximately 65 million dollars per year will be available. It is necessary, therefore, that the funds available for construction be used to provide modern express highways in those locations where large volumes of traffic must be handled, and the Department must resort to the rehabilitation of other roads on the State Highway System in order to provide for the increased traffic on them.

Resurfacing or widening, where necessary, permits us to salvage the existing pavement and use it as a base course, and with the addition of a new wearing surface, the life of the pavement can be extended for at least ten years. This life may be extended further. The first resurfacing job of any size in Pennsylvania was completed in 1933. Amiesite was used on this project. This surface has been surface treated three times, to date, and is still giving good service. Some of our outstanding salvage and resurfacing jobs are as follows:

In 1943 we had a section of road in Schuylkill County (Route 140) where the concrete pavement which was placed in 1925 had failed to the extent that we were unable to maintain it. In desperation we arranged for resurfacing the existing pavement with 2 in. of bituminous concrete. This work was done by contract. The project was 5.79 miles in length and the total cost was $151,498, or an average of $26,165 per mile. The average daily traffic on this road is 2,380 automobiles and 420 trucks, or a total of 2800 vehicles. This pavement is subject to heavy coal hauling and today is in good condition. The pavement maintenance on this particular section of road has been a minimum. Up to the present, the failures have not exceeded 300 square yards of the 61,000 square yards of resurfacing done.

The William Penn Highway (Routes 285 and 285 Sp) between Harrisburg and Allentown took a terrific beating during the war. Certain sections of this road east of Hamburg were recommended for resurfacing in 1947. An inspection of this road in May 1947 indicated that resurfacing could be delayed for at least one year, in hopes that the reconstruction of this particular section of road could be undertaken. However, we found that reconstruction would be delayed for several years, and an inspection in July revealed that the concrete slabs had been so badly broken in the 3 months' interval that it would be impossible to maintain this pavement for the heavy truck traffic involved during the coming winter. It was therefore decided immediately to subseal this pavement, replace the dinintegrated concrete and resurface with 3 in. of hot bituminous concrete. This work was started in August and completed in November. This pavement has been in service more than a year and no failures are visible. The total cost of this work is $26,670 per mile. It is estimated that this pavement will now carry traffic satisfactorily for 8 to 10 years, during which time reconstruction or relocation will be undertaken. When the road is reconstructed on relocation the old road will still be in satisfactory condition to return the local authorities for maintenance. In 1948 on the same general section of the William Penn Highway carrying heavy traffic between Harrisburg and New York City, more resurfacing was constructed on sections that were deferred in 1947. This work consisted of 9.28 miles and was constructed at a total

cost of $287,865, or an average of $31,020 per mile. It is interesting to note that these costs are approximately $5,000 per mile higher than the work done in the same vicinity the preceding year. This increase in cost was due primarily to the additional amount of concrete patching that was made necessary due to the work being deferred and a possible slight increase in cost of materials over the preceding year. As brought out above, it is estimated that this pavement will now carry traffic satisfactorily from 8 to 10 years.

On Traffic Route 6 between Coudersport and Galeton, we had a section of concrete pavement that was constructed in 1921, 1922 and 1923. This pavement started to show signs of failure in 1936 and 9.4 miles were resurfaced with 2 in. of amiesite type bituminous concrete. This pavement was maintained by concrete patching for several years and in 1948 it had reached the point where it was practically impossible to maintain it for traffic. It was decided at that time that we would resurface the entire section, 18.11 miles in length, with hot bituminous concrete. On the sections previously resurfaced a new 1 in. surface was placed; on the remaining sections a 3 in. bituminous surface was placed. This work was done by contract. The total cost was $257,827, or an average of $14,240 per mile. This entire project was completed in three months' time and this pavement is now in such condition that it will successfully carry traffic for at least 10 years. The present traffic on this road averages 1,123 vehicles per day. With this volume of traffic it is doubtful if reconstruction will be required within the next 10 or 15 years.

On Traffic Route 22 in Washington County, which is the William Penn Highway, in a section west of Pittsburgh from 1944 to 1947, 12.71 miles were resurfaced at a total cost of $169,849, or an average of $13,363 per mile. The unit cost will indicate that negligible grading quantities were required, with practically no work necessary on structures. This route carried extremely heavy traffic during the war, such traffic being made up of heavy loads of steel being transported from the steel mills around Pittsburgh to Steubenville, Ohio, and other points for further processing. The sections that were completed in 1944 have now been subject to traffic over 4 years and show no signs of distress or deterioration. The material that was used was a hot mix type bituminous concrete.

On L.R. 93, T.R. 62, in Forest and Warren Counties, from a period 1944 to 1947, 24.04 miles were resurfaced at a total cost of $889,285, or an average cost of $36,992 per mile. This pavement had originally been constructed in 1928 and was made up of 16 ft. and 18 ft. widths with a comparatively light design. The resurfacing consisted of widening to 20 ft., elevating the curves, extending the drainage structures where necessary and providing adequate width berms. The resultant pavement is one that, barring an unforseen up-surge in traffic demands, should give indefinite service. Although some slight failure, due to pumping joints, motivated the resurfacing, this project serves as a splendid example to illustrate the value of salvaging the existing pavement wherever possible.

On L.R. 142 in Montgomery and Chester Counties, which is better identified as being the Lincoln Highway, leading west from Philadelphia, 20.85 miles of pavement were resurfaced at a total cost of $874,862, or an average cost of $41,960 per mile. For the most part, this section of pavement is 3-lane, which is reflected in the unit cost. Needless to say, this highway carries very heavy traffic and observation discloses that the sections resurfaced early are giving very satisfactory results.

On L.R. 212, T.R. 6 in Tioga County we experienced extensive break-ups over the past winter, which necessitated something being done during the present working season. With Department Forces we have completed this year on this section of highway 8.94 miles of resurfacing at a total cost of $299,979, or an average cost of $33,555 per mile. In this resurfacing operation it was necessary to provide a 6 in. aggregate base course over approximately 3½ miles of the existing

pavement in order to provide needed additional strength, the cost of which operation is reflected in the somewhat higher than usual unit cost for ordinary resurfacing operations. This section of highway carries approximately 1,200 vehicles per day and with the treatment given to it is expected to render satisfactory service for many years to come.

The demands for highway improvements in Pennsylvania have reached the point where our finances will not permit reconstruction as rapidly as traffic demands. Consequently, it is necessary for us to consider rehabilitation rather than reconstruction, particularly in view of the fact that rehabilitation can be undertaken at approximately one-half to one-third the cost of reconstruction. The rehabilitation work that we have completed indicates that this is a sound policy and we intend to expand this program.

Our program consists of four types of work: (1) Resurfacing the existing pavement, which consists of repairing the existing base course (concrete or macadam) and placing a new wearing surface; (2) placing additional depth of base on the existing pavement and placing a new surface; (3) widening and repairing the existing pavement and placing a new surface and (4) subsealing and repairing the existing pavement and placing a new surface thereon.

This program has been accepted with favor by the traveling public and the comments received indicate that motorists are more interested in a smoother riding surface than in expensive corrections of profile and alignment. Our rehabilitation program has also enabled us to keep our maintenance costs within reasonable limits, because in most instances those pavements that were in such condition that they had to be resurfaced had deteriorated to the point where maintenance costs were almost prohibitive. It is our opinion that with the rapid increase in traffic volume and the demand for super-highways in urban areas, and on main state highways, the only way that the integrity of the State Highway System can be preserved is by the reclamation or salvaging of highways carrying comparatively smaller volumes of traffic. It is doubted if our highway system will ever reach the point where we can say that it is adequate for traffic at all times; however, we are limited in funds and also the facilities--labor, equipment and materials--required to carry out reconstruction programs that will keep our highway systems 100 percent modern. Consequently the maximum salvaging of our present pavements by resurfacing appears to be the only method whereby we can continue the satisfactory use of our highway transportation system.

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