Rejuvenating Highway Pavement

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The paper describes the resurfacing with a flexible pavement of the Roy Junction - Muck Creek section of Primary State Highway 5, located 6 miles south of Tacoma, Washington, on the route to Mount Rainier National Park that was originally paved in August 1914 with a 16-foot-wide portland-cement-concrete pavement. This section, 5.46 miles in length, was widened to 22 feet in 1940, using a 3-inch-depth asphaltic-concrete-base mixture as a widening medium and the widened roadway was resurfaced with an average thickness of 2½ inches of asphaltic concrete material.

A description of the type of soil underlying the pavement is given and the condition of the old pavement before resurfacing. Figures show typical sections before and after resurfacing and after 14 years of service.

The typical grading of the base, leveling and wearing surface mixtures is outlined along with the type and character of the mineral aggregates used and the grade and source of asphalt cement. A brief description of the methods and types of equipment used in construction of the resurfacing is given, also the length of time and the cost to construct the project.

A table indicating the cost to maintain this section of highway per year per mile is presented, also the average daily traffic for each year. Slides showing the crack patterns that have developed during the 14 years of this pavement's life are shown with an analysis of the cause of each type.

The paper is concluded with an attempted evaluation of this resurfacing work, pointing out the weaknesses that have developed and how possible correction can and has been made in this type of construction.

● THE problem of providing adequate highway surfaces in the face of ever increasing traffic volumes and inadequate funds is one the Washington State Highway Department has shared with the other 47 states of the union since the advent of the motorized vehicle.

A part of Primary State Highway 5, located 6 miles south of Tacoma, Washington, and known as the Roy junction to Muck Creek section, was judged to be in critical need of widening and improvement of the riding surface when the biennial construction budget of 1939-40 was made. This was due to the increased traffic by reason of the expansion of population of the second largest city in Washington and spread of home building in all directions, increased use of trucks to haul logs and rough lumber to Tacoma mills from forests and small mills south of Tacoma, and growing popularity of Mount Rainier National Park as a recreational center for motorists from Seattle-Tacoma vicinities.

The glacial deposit of sand and gravel which underlies this section of highway, up to 50 feet deep, provides an excellent free-draining foundation, and conditions would be ideal if it were not for a highly plastic, silty, black-colored soil that covers the gravel from 4 to 8 inches in depth. It is this soil that, due partly to ignorance and partly to carelessness on the part of the inspectors, was allowed to become mixed in some areas with the base aggregate for the widened areas and that later caused trouble, as will be shown in this paper.

A flexible type of widening and resurfacing material over the rigid portland-cement-concrete pavement was determined early in 1940 to be an adequate method of rejuvenating this section of 16-foot wide pavement, which is 5.46 miles long and was constructed in August 1914 on an existing gravel road. The old pavement had a slab thickness of 5-7-5 inches and was not subsealed, due to the fact this technique was untried and unknown in Washington in 1940.

A typical cross-section of this project, as shown in Figure 1, consisted of 3 feet of widening on each side of the old pavement with a 2½-inch asphalt-concrete base, after which a leveling course with a minimum thickness of ½ inch over high points, or an average thickness of 1 inch was placed over the old 16-foot roadway. The depth of leveling mix on the new base course varied from ½ to ¾ inch. A wearing surfacing of 1½-

inch uniform thickness was constructed to complete the resurfaced roadway. In areas where depths of more than 2 inches of leveling course were required to produce a uniform grade line, leveling mix was spread by motor-patrol blade to prelevel the depressions in the old cement concrete pavement. The shoulders on each side of the pavement were excavated to a width of 5 feet and depth of 6 inches below grade line of the finished subgrade. This area was then filled and compacted with selected gravel roadway borrow upon which to lay the asphalt concrete base mixture. One exception to the above cross-

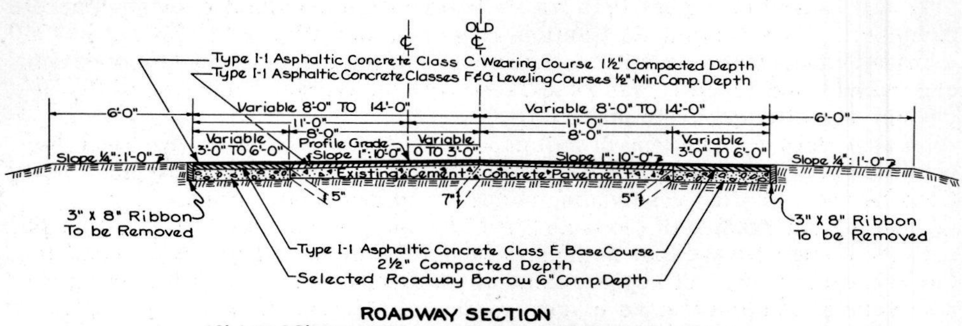

Figure 1.

section was a ¾-mile area where, due to limited right of way, the widening was all constructed on the east side of the roadway.

Figure 2 shows the old pavement as it appeared in March 1940, or nearly 26 years after it was constructed. Note the transverse cracks and the indications of pumping movement of the slabs at the expansion joints by the light patches near the center line. Figure 3, taken in September 1940, illustrates the resurfaced pavement at the same location as Figure 2, while Figure 4 was taken in October 1954, showing the conditions of this pavement 14 years later. These three views were taken at the north end of the project at the same location.

Figure 5 reveals the condition of the old pavement at approximately the center of the project and although some of the corners of the slabs are broken and the expansion joints

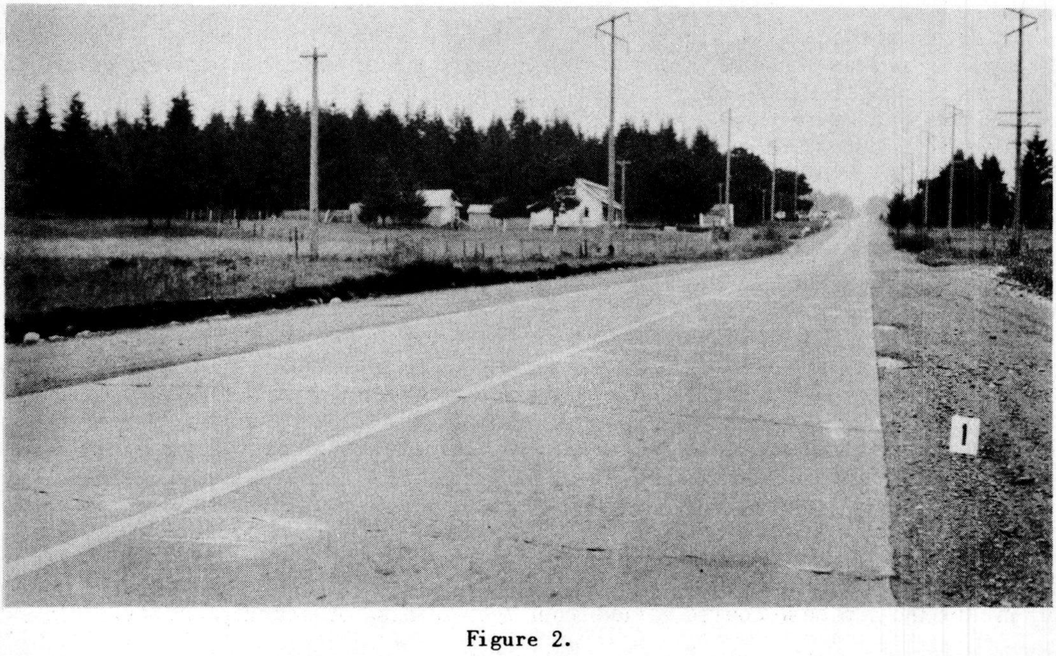

Figure 2.

Figure 3.

are chipped, the 26-year old pavement is in fair condition at this point.

Figure 6 exhibits the completed resurfacing work in September 1940, showing the rather granular texture of the wearing surface. Figure 7 discloses this same area in October 1954, or 14 years later.

The contract for the widening and resurfacing work on this section was awarded in April 1940 to two Tacoma contracting firms, Paine & Gallucci and Woodworth & Cornell, working as partners. Woodworth & Cornell constructed the asphalt-concrete portion of the work. The mixtures were produced by a standard four-bin batching type plant with a 2,000-lb. capacity mixer, located along the waterfront in Tacoma. The mixtures were hauled by truck an average distance of 15 miles to the job. A Jaeger self-propelled, mechanical spreading machine was used to spread all mixtures, except the base and spot

Figure 4.

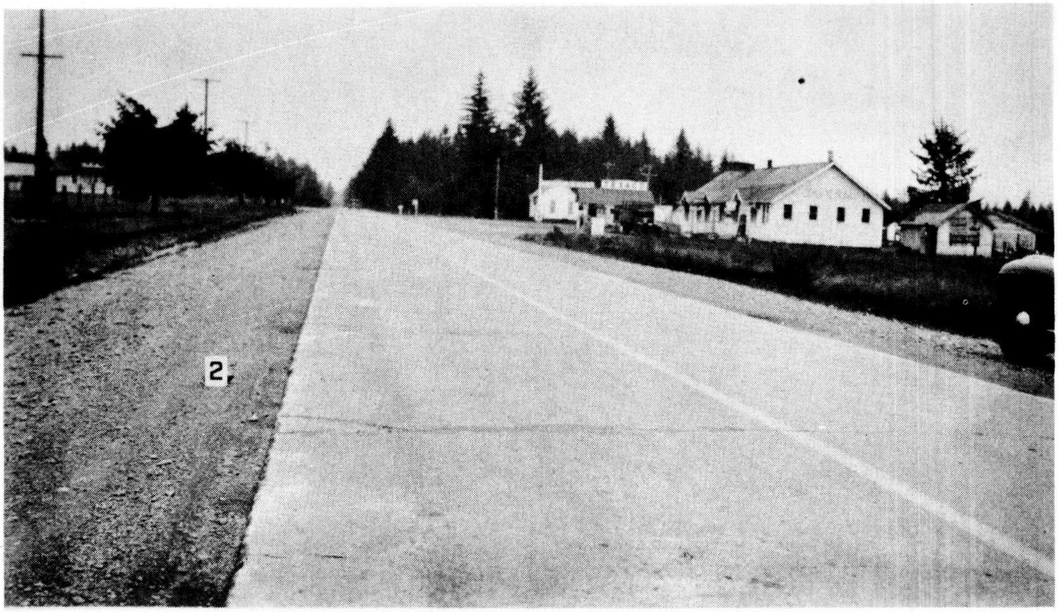

Figure 5.

Figure 6.

leveling materials. These were placed with a heavy motor-patrol blade. The pavement was rolled with one 10-ton, three-wheel and one 8-ton tandem roller. Figure 8 shows the spreading machine working on leveling mix and the three-wheel roller can be seen in the background.

Figure 9 demonstrates a straightedge equipped with an adjustable carpenter's level for obtaining the thickness of mat on the old pavement for correct crown. Marks indicating the thickness of the mat were placed on the pavement each 25 feet of length for the information of the machine operator and inspector.

Figure 10 discloses the base mix compacted in place on each edge of the old pavement. Note the 3-by-8-inch wood form laid on edge at each side of the roadway. These forms were removed after the asphalt concrete was completed and before the shoulder material was placed. Present-day construction does not require forms of any type, since it has been found the mechanical self-propelled machines do not require side forms for grade or alignment.

Representative composite screen gradings of the three classes of mixtures used on this project are shown in Table 1. Note the grading of material is expressed on a passing-and-retained basis rather than a total passing. The mixtures were within the limits of the 1935 standard specifications of the department. There was no difficulty experienced in adjusting the feed of the aggregates at the plant to meet the specification in grading.

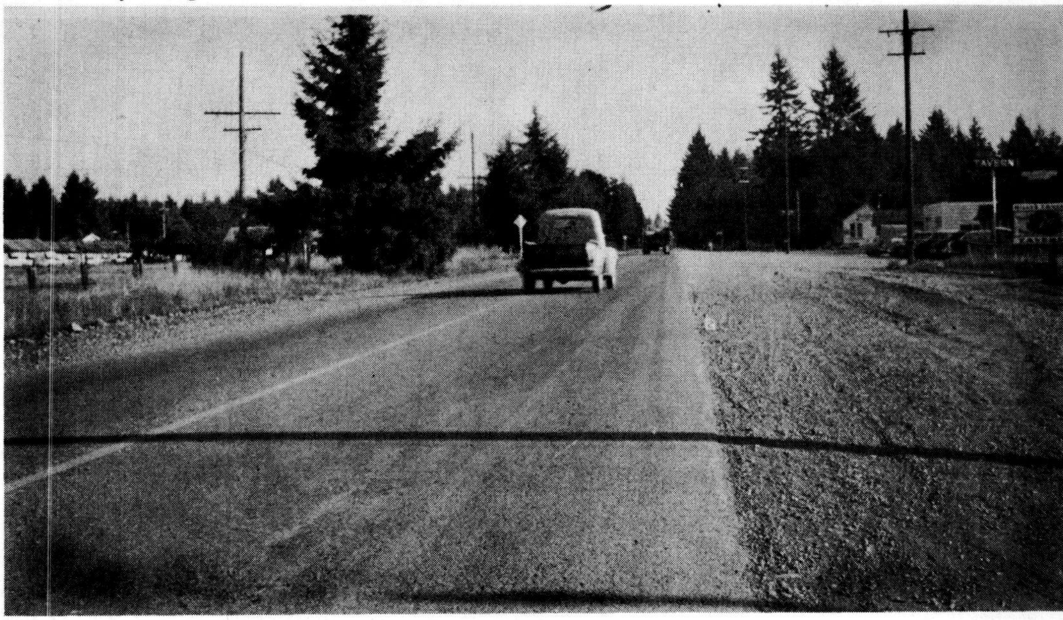

Figure 7.

Figure 8.

Figure 9.

The aggregate was an excellent 100-percent crushed gravel shipped to the asphalt plant in barges from a gravel plant located at Steilacoom, Washington, that primarily produced aggregates for cement concrete use. The large, oversize gravel pieces were crushed to produce the asphalt concrete. This gravel is considered as a high-quality aggregate and is used as a standard material in the department's material testing laboratory. The blending or muck sand used to mix with the pass No. 10 mesh sieve of the crushed, ⅝-inch-to-0 gravel was obtained from the Hylebos Hill pit owned by the contractor and located 3 miles from the asphalt plant. This material is composed of sharp,

Figure 10.

clean particles and has a good grading for a blending sand. The limestone dust used only in the wearing-surface mix at the rate of 2 percent was obtained from commercial sources in Seattle. The asphalt cement was supplied by the Standard Oil Company and was 61-70 penetration grade, meeting the department's specification in all respects.

TABLE 1

Size of Round Opening Screens	Weaving Surface Mix Class C	Leveling Mix Class F	Base Mix Class E
Pass 2" ret. 1¼"			8.0
Pass 1¼" ret. 1"			8.0
Pass 1" ret. ¾"			10.0
Pass ¾" ret. ½"			14.0
Pass ⅝" ret. ½"	6.0	5.5	-
Pass ½" ret. ¼"	46.0	41.0	19.0
Pass ¼" ret. No. 10 sieve	27.0	20.0	14.0
Pass No. 10 sieve ret. No. 40 sieve	4.0	6.5	7.0
Pass No. 40 sieve ret. No. 80 sieve	7.5	13.0	10.0
Pass No. 80 sieve ret. No. 200 sieve	6.0	10.0	8.0
Pass No. 200 sieve	3.5	4.0	2.0
Total	100.0	100.0	100.0
Percent asphalt cement	4.9-5.0	4.5-5.0	4.6-5.0

A total of 13,845 tons of asphaltic concrete was used in the project, of which 6,650 tons was wearing surface, 3,895 tons was leveling mix, and 3,300 tons base mixture. The unit cost of the asphalt concrete was $6 per ton for all classes of mixture, or a total cost of $83,070. There was a total of 69,595 sq. yd., including intersections, in the contract. The unit cost per square yard was $1.19 for the asphalt concrete resurfacing. The total cost of the contract paid the contractor on the final estimate for all items of work was $106,989.45.

The resurfacing portion of the project was started on April 22, 1940, and completed on June 24, or an elapsed time of 64 calendar days. The contractor required 37 working days to complete the work. Much of the delay was due to unfavorable weather conditions during April and May.

The cost per mile per year to maintain the traveled or paved area of the section and the average daily traffic since 1940 are shown in Table 2. During the last two years of World War II and the two years following, the cost to maintain the pavement surface only was not segregated from the costs to maintain shoulders, ditches, and other items of maintenance work. The maintenance costs are shown for the fiscal year ending March 31, while the ADT shown is computed on a calendar year basis. It is to be noted that traffic counts on this section were not recorded during the war years and not until 1947. It is estimated that 10 to 15 percent of the traffic using the northbound lane was logging trucks with maximum loads of 40.5 tons or more.

The cracks that have developed in the wearing surface of the pavement fall into two

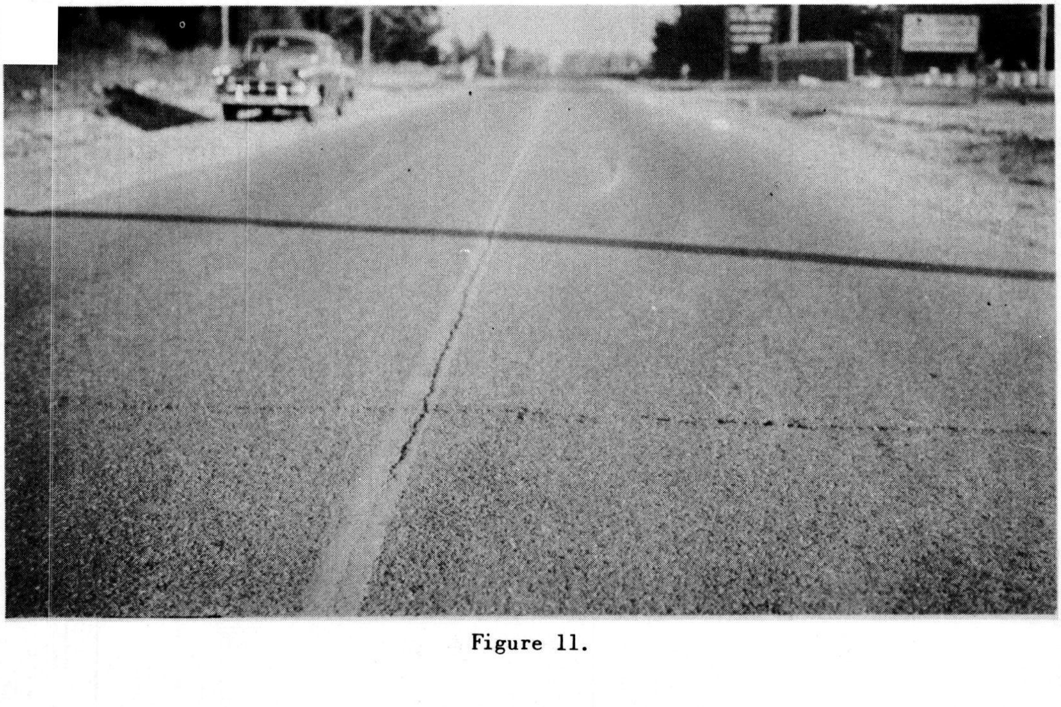

Figure 11.

TABLE 2

Year	Cost to maintain pavement surface only per mile computed to closest dollar	Average daily traffic
1941	1	2940
1942	19	-
1943	6	-
1947	-	3206
1948	96	3391
1949	36	2671
1950	63	2890
1951	43	3414
1952	68	3109
1953	122	3209
1954	90	-

general classes that are common in this type of construction. The first class is where a relatively thin flexible pavement is placed over a rigid pavement or base and the expansion joint pattern in the rigid base reflects through to the new surface after a few years. The second class of crack pattern is where the nonrigid base under the widened area is lacking in thickness or contains plastic material which causes the pavement to yield under traffic during wet weather or during the early spring thawing period.

Figures 11 and 12 illustrate the first type of crack pattern that developed in this pavement to a minor extent the second year after it was laid. The second type of crack pattern in Figures 13 and 14 indicates the foundation under the asphalt concrete pavement has yielded and caused the surface to form an irregular crack pattern, sometimes called alligator cracks. There are cases where this type crack will form due to lack of compaction of the widened area, and the area, under traffic, will compact and subside causing the cracks to form. However, cracks caused from lack of compaction will usually heal up in following years and will not recur when the base material is unyielding. The cracks over the old concrete pavement are less noticeable during the summer and early fall months before cool weather causes the old pavement to contract. To date little patching has been done on this asphalt-concrete resurfacing, and the cracks have never been poured with a crack-filling material. However, such areas as shown in Figures 13 and 14 will need attention in the next year, since they are becoming progressively wider and allowing more water to reach the base or foundation.

From experience gained by study and observation of the wearing ability and value to the tax-paying highway user of the Roy junction to Muck Creek project and many other sections resurfaced before and after this work, certain criteria have been established and must be satisfied before such work is budgeted. The tests are as follows:

1. Does the old rigid-type pavement to be resurfaced have fair to good alignment,

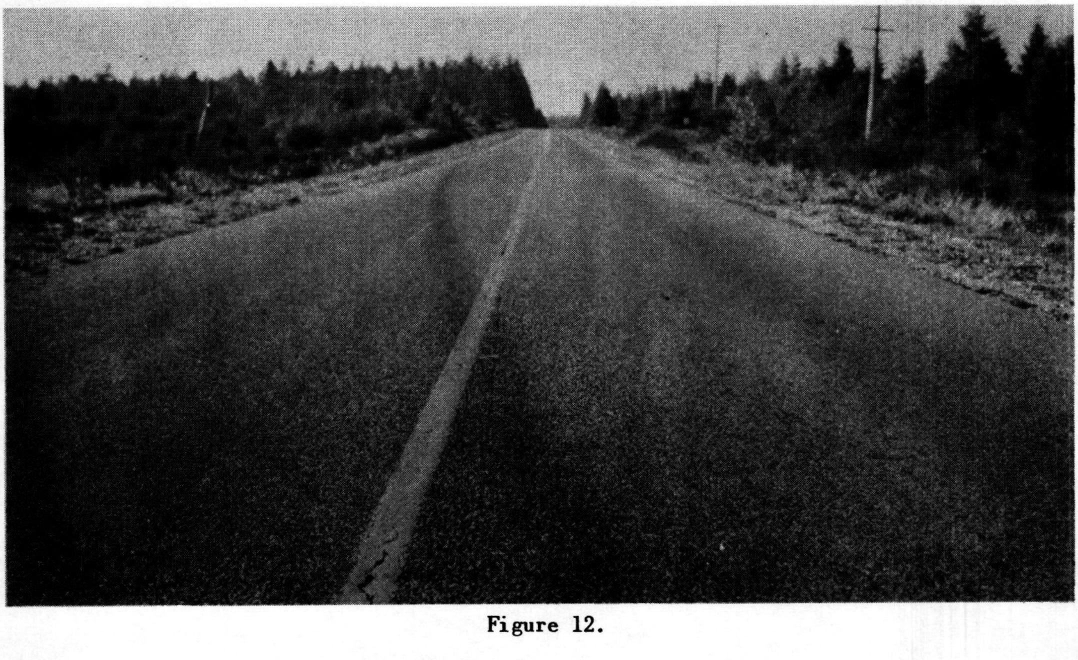

Figure 12.

Figure 13.

so that if it were resurfaced with or without widening of the traveled surface and shoulders, the resurfaced pavement will have capacity to carry the anticipated traffic during the next 10 to 15 years? It is apparent that if the horizontal and vertical curves existing in the old roadway are so sharp that the section will have to be reconstructed to present day standard within a few years in order to carry traffic, the mere act of smoothing and widening the highway would be a wasteful expenditure of funds.

2. Does the old pavement have sufficient foundation as observed by an inspection? If the old pavement has many areas that are unstable, causing excessive patching, it is obvious that a flexible resurfacing would have a short useful life and should be reballasted

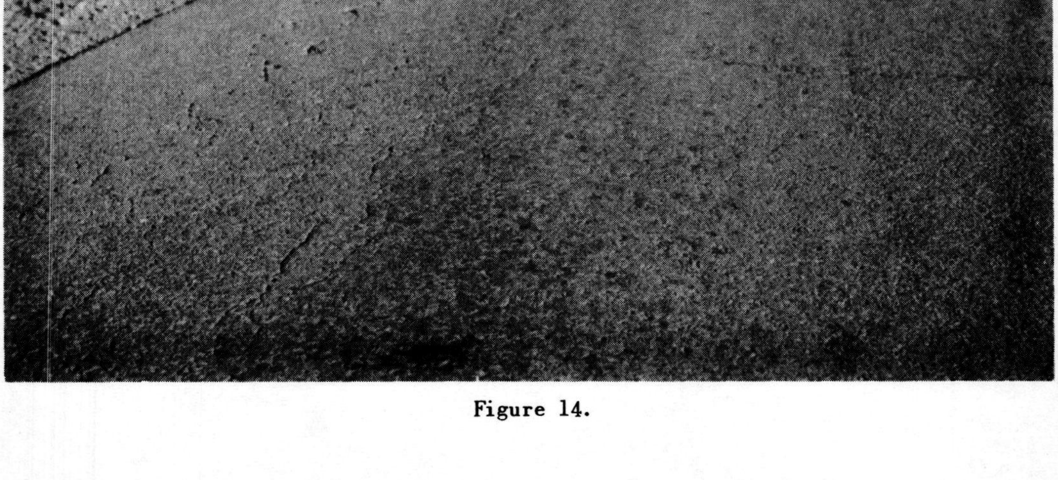

Figure 14.

or an unyielding foundation constructed before any type resurfacing is attempted. However, if the old pavement is rough from settlement and has only minor foundation deficiencies, the logical procedure is to correct these areas by removal and replacing with suitable base material and the whole section resurfaced with a two-course asphalt-concrete mat.

3. The present or anticipated traffic on any section must be such that the expenditure of funds is warranted.

It has been observed from the inspection of many sections resurfaced with a flexible pavement that pavements with overlay thickness of a minimum of $2\frac{1}{2}$ to 3 inches suffer less from expansion-joint cracks eventually showing through than do pavements having thinner overlays. Also, where an old pavement is to be widened and resurfaced with asphalt concrete, it is mandatory to get the most-thorough compaction possible of the base material under the widened asphaltic concrete. Other observations are that when an old pavement is resurfaced, it is profitable to remove the old shoulder material to an elevation slightly below the bottom of the old pavement, so that all impounded water under the pavement will be drained.

The engineers of this department have been surprised to find large quantities of water under old pavements, even when the underlying soil has been sandy in character. The excavated shoulder area should then be replaced with a granular, free-draining aggregate. It has been found that when old rigid pavements are found to have slabs rocking or moving under traffic, it is good insurance from future maintenance to subseal these pavements with a low-penetration, air-blown asphalt to seal the joints from beneath and fill in depressions under the slabs. The rule observed by the Washington highway department on whether or not a rigid pavement needs undersealing before resurfacing depends on the observed pumping action of the slabs. Where no action is noted, subsealing is usually omitted.

In conclusion, it is the opinion of the author that the scope and evaluations of Highway Research Board Project Committee on Salvaging Old Pavements by Resurfacing will develop methods and techniques that will be invaluable to all highway organizations. The evaluation of the work completed to date in Washington descloses that this type of work on old pavements, when and if the section satisfies the criteria noted above: (1) receives favorable comment from the tax-paying public, especially the truckers; (2) reduces maintenance costs from 50 to 75 percent; and (3) speeds up traffic on sections of highway that formerly were bottlenecks. To evaluate this saving in dollars would be difficult and subject to controversy, but the conserving in tire wear, mechanical repair to springs, etc., and the reduction in vibration resulting from the resurfacing of a rough pavement with a nonskid, smooth-riding surface must play an important part in making this type of work popular with the traveling public.