

bituminous material was tar and we found it excellent in building a bituminous mulch surface.

After the prime coat was applied, we then proceeded to mix material in place, using a 10-foot grader and mixing back and forth on the surface until the metal was thoroughly coated. After the metal had attained a good, black color, we graded it out to a flat surface and used a maintainer for leveling. In the process of leveling, we were careful to get as smooth a surface as possible. We found the use of a 20-foot straight edge very effective in locating high and low spots in the surface. If high spots were found, we eliminated them with a maintainer.

After the first and second applications and the mixing and leveling of material were completed, we then opened the road for traffic. After traffic had used the surface for possibly 20 days, we then applied the third application, using $\frac{1}{4}$ gallon of the material and about 40 pounds of stone chips per square yard. This third application is known as the seal coat.

A smooth riding-surface is very important in road construction or maintenance, and this can be easily obtained if proper methods are used with this particular type of surface. I think this type of surface is bound to be attractive, especially on secondary roads. Methods of construction are very simple if care is taken in preparing the surface. If a road has been properly maintained, you will find it necessary to add but very little material to the surface although it should have at least 1 inch of loose material. This particular type of surface eliminates the dust nuisance and provides a smooth riding-surface at low cost. Our average cost per mile was \$1,119, including all labor and material.

EXPERIENCE WITH THREE-INCH BITUMINOUS GRAVEL MIXTURE

By S. T. Hollingsworth, Howard County Highway
Superintendent

The extraordinarily easy-riding quality of a well constructed and properly maintained gravel road has been widely noted and commented upon by engineers as well as the traveling public. Most of these gravel roads are at their best when the gravel is moist but not saturated with water. If they could be kept permanently in this condition, their traffic-carrying capacity would be much higher and the cost of maintenance would be greatly reduced. The same result has been noted of what have been termed "traffic-bound broken-stone roads," composed of small-sized broken-stone fragments, together with fines produced at the crushing plant, and constructed in the same manner as gravel roads, being compacted

by traffic and frequent blading with a road machine. For best results the proportion of coarse to fine fragments should be such as to produce a dense aggregate when compacted.

Although perhaps not generally recognized, the basic principle of the use of bitumen in what has been termed the "surface-mixed" or "mixed-in-place" gravel and broken-stone roads appears to be the substitution of bituminous material for that amount of water which would produce the most satisfactory condition for the particular untreated aggregate. This class of construction has been most extensively adopted by California; but other states, including Oregon, Idaho, Arizona, New Mexico, and Nevada, have closely followed the California method in less extensive work; and modifications of this method have been used to some extent in Wisconsin and Minnesota.

METHOD USED IN HOWARD COUNTY

In treating an existing traffic-bound gravel or broken-stone road sufficiently thick to eliminate the necessity of using additional mineral aggregate our county observes the following specifications:

The old road shall first be scarified to a uniform depth of 3 inches and then harrowed or pulverized. If the road does not have sufficient material to warrant scarifying, new aggregate shall be added. It shall be uniformly graded from fine to coarse. One hundred per cent should pass an 1 $\frac{1}{4}$ -inch screen. Fifty to seventy per cent should pass a number 4 screen, thirty to sixty per cent should pass a 10-mesh sieve, and five to ten per cent should pass a 200-mesh, although this is not imperative. Sand may be added to the pit or crusher-run product to supply any deficiency in the 10-mesh size, and dirt or dust filler may be added to supply any deficiency in the 200-mesh material.

The road is now ready for the bituminous binder, which shall be an asphaltic content oil of 50 to 70 per cent applied at a temperature of 150° F. by means of a pressure distributor, the rate of application being 1 $\frac{1}{2}$ gallons per square yard, in not less than 3 applications of $\frac{1}{2}$ gallon each. Immediately following each application of oil, the material shall be disked not less than 5 times, with a double farm disc, at fairly high speed to prevent the oil from being picked up by the mixing equipment and to eliminate a sloppy condition. Multiple-blade maintainers and power or tractor drawn graders are used for mixing by working the treated portion from one side of the road to the other in a windrow. This operation is continued until the mixture is of uniform color and texture.

At this point the windrow shall be examined to determine whether the oil content is correct. In case of doubt the stain test, which consists of the screening of a small portion through a 10-mesh sieve, shall be applied. This mixture should produce a light yellowish-brown stain, in which the impression of

the individual sand particles may be distinguished and which is not blurred or blotched when compressed between two pieces of smooth white writing paper. A block of wood 2 inches thick placed on top of the paper shall be tapped moderately with a light hammer to obtain the imprint. Should this test show too lean a mixture, additional oil shall be added to produce the proper results. Should the original mixture show too much oil, additional aggregates shall be added by further scarifying the old road-bed or by adding new material. When the proper mixture is obtained, it shall be spread to a uniform thickness and opened to traffic for compaction.

At this point, we have found it very practical to drive a truck with a wide rear tire down the edges to compact them first. A blade grader or maintainer must be kept in use in order to maintain a smooth, even surface until compaction. The road, when finished, has the general appearance of a well-bonded asphaltic concrete pavement, although the mixture is not as hard and firmly bonded as in the case of a hot-mixed asphaltic concrete. If at any time the road fails because of lack of oil or an excess amount of oil, it may be scarified and additional oil or more aggregates added as the case may warrant. This is a very good feature, as it gives the same surface as that of a new road.

COST

The cost of this type of work in our county ranges from \$900 to \$1,000 per mile, where new aggregate is not needed, and varies with the price of the oil applied. Last year the oil cost 5.1 cents per gallon applied; and 15,600 gallons were used, the total cost being \$795.60. Four days' labor at \$35 per day including gas, oil, and wages, equals \$140 which, added to the cost of oil, gives a total cost of \$935.60 per mile.

It is my opinion that no other type of road giving equal riding qualities and an equal depth of treated material can be had at anywhere near this figure. One thing, however, that should be determined first is the depth of aggregate in the old road. This work should not be attempted on a road having less than 6 inches of material, and 8 inches or more is much better. Great care should be taken in all the details of this work, especially in the proper distribution of oil. No gaps or long laps should be made at the joints. And let me add that apparently the close attention paid to little details determines the difference between a good job and a poor one.