

per-day average can be maintained by a capable operator; but other roads and other operators might average only ten or twelve miles daily. As highways are mowed year after year, the average speed should improve materially, both because of improved roadside terrain and because operators will become more thoroughly acquainted with equipment and specific conditions.

Operating costs quoted here are based upon the entire 1941 season, consisting of 1,155 hours of mowing time. During this time, the mowers travelled 4,230 miles, using 634 gallons of fuel, or an average of $5\frac{1}{2}$ gallons per day per machine. Mower repairs for the season were \$99.51 for materials only, labor being by the county garage staff. Oil consumption was only \$1.08. The entire cost of mowing the county highways during the 1941 season of $115\frac{1}{2}$ days, including salaries and all expenses, but not including depreciation of machinery, was \$649.33, or an average of 15.3 cents per mile of roadside mowed.

The mileage in these figures represents the distance travelled by one mower in mowing one five-foot cut only, and not the entire mileage involving one to three cuts on each side of the road. Necessarily, the cost figures include mowing under all sorts of conditions during the season beginning about June 15 and extending to late October.

OPERATING A COUNTY-OWNED GRAVEL SCREENING AND CRUSHING PLANT

E. F. Lamb,

Howard County Road Supervisor

Howard County has owned and operated a gravel screening and crushing plant for thirteen years. Our main roads have been graveled with crushed material from this machine with very good results. In preparing the material for a base on which a bituminous surface is to be placed, this crusher is supplied with a revolving screen with a one-inch opening, so that the material has to be smaller than one-inch in size to pass through the screen. The crusher has a capacity of from 175 to 200 cubic yards daily, depending, of course, on the size of the rocks to be crushed.

This is a jaw-type crusher that can be adjusted for either fine or coarse crush. We have found that if we crush our gravel much finer than $\frac{3}{4}$ -inch in size, sharp pebbles will result, which cause damage to truck and automobile tires. We have noted damage to our equipment from this source; and rather than make the gravel any finer, we run the sand and gravel through the one-inch screen. This produces a very good road maintenance material and also makes maintenance much easier and more economical with our equipment, consisting of four maintainers drawn by tractors.

COSTS

The cost of producing this crusher gravel is not excessive. The County Commissioners buy piles of dipped gravel ranging from 8,000 to 10,000 cubic yards. The cost averages 45 cents per cubic yard. Crushing and screening adds about 40 cents, which makes the gravel cost us a total of 85 cents per cubic yard. Then there is the cost of hauling and spreading on the road to be added, which makes a total cost on the road of from \$1.25 to \$1.45 per cubic yard, according to the distance hauled. We are allowed \$1.45 per cubic yard for contribution by WPA.

It requires four men to operate the crusher, one on the hoist, two on the trap, and one to operate the crusher and load the trucks. The trucks are loaded quickly and easily from an elevated bin or hopper with a capacity of 25 cubic yards. The large bin capacity helps to keep the trucks moving because it provides a reserve quantity of material in case of some stoppage of the crusher. A conveyor belt leads from the trap to the crusher, and another leads from the crusher to the bin. Each belt is approximately 50 feet in length.

A four-cylinder Caterpillar gasoline engine operates the crusher and the crusher belt. A four-cylinder I.H.C. gasoline engine furnishes power for the hoist. A 600-foot, steel plow cable, $\frac{5}{8}$ of an inch in diameter, attached to a dipper, is provided for pulling gravel to the trap. This equipment is expensive and requires mechanical ability to install, adjust, and operate; therefore, it is very important to secure the right kind of men for these jobs. Breakdowns are costly in time and expense, especially in the loss of time. A serious breakdown could very well hold up big road-building projects, and throw many men out of work. We find that a piece of steel going through the crusher is the greatest threat to continuous operation. Fortunately, we have the kind of men needed for the job, men who take a sincere, personal interest in their work, and are anxious to deliver the goods. Our breakdowns and delays have been reduced to a minimum.

All the units of this crusher outfit are portable. We have a heavy, low-down, four-wheel trailer on which we move the crusher from one gravel pit to another. The crusher and motors are very heavy, but we experience little difficulty in loading and unloading. On arriving at a new gravel pile, we try to set the various units at convenient points for efficient operation. An important item to keep in mind is the matter of ingress and egress of the trucks. They should be able to get to and from the crusher at all times to avoid possible delays in road building.

The cost of a crusher outfit might cause one to hesitate in making an investment of this kind; however, from the results we have obtained from its use, we feel the investment is justified. It can be made to furnish any grade of material needed. A road supervisor, in possession of a crusher, is in a

position to know when and where he may get material that meets his needs. He can produce his own and not have to depend on any outside source.

QUALITY OF GRAVEL

Occasionally we find gravel unfit for bituminous surfacing but that will serve as a base course. Unfortunately, a large amount of this inferior gravel has been used for blacktop construction, with many damaged road surfaces as the result, because of "shoving" under the terrific pounding of today's traffic. We are exercising a great deal of care in selecting surface materials. We now add a quantity of No. 8 crushed stone to the mix to insure stability. It seems to work very satisfactorily.

As far as our gravel roads are concerned, we experience some difficulty in keeping the surface in proper condition, in either wet or dry seasons. The reason for this is that the extreme weight of trucks and the excessive speed of almost all motor vehicles cause wear and displacement of road material to a serious degree, thus making proper maintenance a big problem. This loss of material makes it necessary continually to add new fine gravel for wearing surface.

The maintenance gravel, we make sure, is of a very good grade. We make tests of it before dipping, rejecting that with too much fine sand and dirt content. However, there should be at least 2 per cent of clay in the gravel to make it pack quickly under traffic. We use from 400 to 600 cubic yards of this crushed gravel to the mile where widening is being done under WPA.

We use a standard right-of-way width of 50 feet in our projects. The first season we widen and gravel and then let it settle and pack during the winter, maintaining it to an 18-foot width. In this way we do not have oversized rocks in the mix when blacktopping takes place the following season. For a blacktop mix, we add 400 tons of No. 8 stone and 300 tons of gravel to the mile. This makes a very good road if properly maintained after construction.

Most of our county roads were built several years ago and have been subjected to severe usage and wear. Most of them have a thickness of from 10 to 15 inches of gravel and are well packed. As a result, a good foundation has been established. In some cases we have to install subsurface drainage to prevent frost boils during the spring thaws. Naturally, at this time when the ground is so softened by the water released by the receding frost the roads are in no condition to sustain heavy traffic. They need constant attention by maintainers and other equipment to prevent damage caused by careless or indifferent motorists.

In this motor age, people demand good roads and seem to be less interested in their cost than in a firm, smooth-riding

surface. The American people are speedminded, and they will not take no for an answer. Speed is the greatest contributing factor to road damage and deterioration. Quick starting and stopping, violent turns and use of brakes with their grinding and pulverizing effect, make imperative the need for a well-drained, solid subgrade and a smooth firm surface.

The building of roads capable of sustaining present-day traffic is a comparatively new field of endeavor for engineers, road builders, and commissioners. The demands of the motoring public present difficulties and problems the like of which have never before been known. Much has been accomplished, but we still have quite a long way to go. However, we may rest assured that the ingenuity and initiative of our roadmen will solve these problems.

SOIL-CEMENT BASE STABILIZATION

Ralph Witt,

St. Joseph County Surveyor

There is a growing interest in soil-cement stabilization for several reasons. Materials are more expensive, transportation has in many cases become a major factor, some types of road material are practically unobtainable, and that important word "priority" is becoming more effective daily. There is another problem that may seriously affect road maintenance as well as new construction. The restrictions on tires and automobiles will reduce gasoline consumption with a resulting drop in the gasoline-tax revenue far below normal anticipation. We must, therefore, carefully study and plan all types of road work in the light of these new developments.

Defense roads are taking the spotlight and very little new construction will be done that is not of this type. The cost of the project may not be the final governing factor. In some localities aggregates are scarce or non-existent. In many counties where local deposits of aggregate are not available, soil-cement roads will undoubtedly be a cheaper type to build. It is reasonable to assume that any type of road utilizing materials at hand will be less expensive than a type requiring the purchase and shipment of aggregate.

In our county we have plenty of local aggregate reasonably accessible to all parts of the county. As later figures will show, we can build a cheaper type of road. But, since all counties in Indiana do not have an abundance of aggregate, I believe our experience with soil-cement will be of interest to this group.

CONSTRUCTION METHODS

Detailed specifications are available from several sources. The City of South Bend has a complete set of specifications to