Mr. Koronski has the courage to see new horizons; he has given you something to think about. All his Michigan problems do not apply to Indiana, but the same amount of serious thought by each county and state road engineer in Indiana would make this state the envy of the world. The public support is here, the soil is here, the trees are here, the grasses are here. Try putting them to work for you. Then you won't have to worry quite so much about changes of administration.

GRAVEL ROAD STABILIZATION WITH CALCIUM CHLORIDE

L. B. Griffin,
Johnson County Road Supervisor

The use of calcium chloride for base stabilization was first undertaken in Johnson County in 1940 as a result of efforts to improve bad road conditions caused principally by extremely dry weather. The gravel roads had become rough and able conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Most of the roads were those for which bituminous paving being thrown out by traffic immediately after grading. Considerable gravel was thrown into the ditches by traffic or ground into dust and blown away. This dust created intolerable conditions to residents along the roads, and the replacement cost of the lost material was increasing each year. All roads were rather heavily traveled and we had a constant flow of complaints both from drivers and from those living along the roads who were compelled to keep doors and windows closed on account of the dust.

Setting back fence and clearing roadside preparatory to re-shaping side ditch and shoulder. (Courtesy Better Roads Magazine.)
roads which were on the program for such improvement but which required immediate attention, especially the construction of a good base. The problem seemed to be one of keeping sufficient moisture in the surface to hold down the dust and to pack the roadway under traffic. After some investigation during the early summer it was decided to proceed with some calcium chloride stabilization experiments, which if satisfactory could be included in the next year's improvement program. As this could be done more rapidly than black-topping, it could be expanded to include roads where this was planned at a later date.

The road selected for the first experiment was one and one-quarter miles in length, three miles from Franklin, carrying fairly heavy traffic, and leading into State Road Number 144. This road was not on the yearly program; consequently, we did not obtain easements for widening nor do any work except cut out the ditches with the grader. We prepared the roadbed and applied the calcium chloride to the surface. This was in September during a prolonged spell of dry weather; but in spite of the apparent lack of moisture, the road packed down and became very hard. Nothing more was done on this road at all during the fall and winter, and late in the following spring we ran a maintainer over it and made a surface application of calcium chloride at the rate of one-half pound per square yard. This road had another grading in the middle of December and is now very smooth and hard.

As the result of this work we were convinced of the merits of this type of improvement and set up our schedule for this year to include 16½ miles of base-stabilized road. This paper
is intended to be a report of our experience, with a description of the methods, materials, and equipment used and the results obtained. As it is almost impossible to get comparative costs by reason of the varying conditions in the counties of the state, Professor Petty's suggestion will be followed, that of giving quantities per square yard with the prices of the materials used, from which the cost can be computed by the counties that may do work of similar nature.

**CONSTRUCTION METHODS**

Since construction of the first road, we have done all this work under the same regulations as the black-topping, with fences set back, side ditches and berms, and drainage openings conforming to the county standards for WPA projects. Except for the work done by the WPA on fences and berms, all materials were furnished and labor was done by the county forces and equipment.

All roads worked on had a good gravel base. To this we added about 350 cubic yards of gravel per mile from local pits to insure surface smoothness. The first thing we learned was that the material already on the road was too large. Our new gravel was loaded from stockpiles with a loader fitted with a bar screen. The size of this screen has been reduced from time to time as we observed the undesirable effects of large stones, until we are now using a screen with $\frac{3}{4}$-inch spacing. This results in some waste but has greatly improved the road surface.

Upon this gravel we spread the clay binder, using 50 to 55 cubic yards per mile, which was approximately 10 per cent
of the loose gravel. We obtained this clay as near to the work as possible, and we were very fortunate in being able to find it without having long hauls. Our first clay came from a location used by the state highway men several years ago while they were doing some work nearby and was of good quality. We later found a soil-survey map at Purdue from which it was possible to locate this material near all our work, and thus we saved a lot of testing and, later, hauling. The top soil was removed from the clay source and the clay cut into windrows, with a motor grader, or a pull-type grader and tractor, and loaded with the gravel loader. Several times it was necessary to cut the clay with a disc harrow before loading, as some of it was very tough, the quality most necessary for the best results. After the clay was reduced to a size suitable for loading and spreading, it was hauled to the road and spread uniformly over the loose gravel. The materials were then mixed, spread, and rolled, operations which will be discussed in detail later. Following this, calcium chloride was applied to the finished surface.

This material was flake calcium chloride, in 100-pound, moisture-proof paper bags, loaded into trucks in the sacks and spread with an ordinary lime spreader. On the first work we used 6 tons per mile on a 16-foot roadway, but later all subsequent spreads were made over an 18-foot roadway, and 8.8 tons per mile were used. This represents a uniform quantity of 1 1/2 pounds per square yard. Soon after the application, the flakes had gone into solution and the road was damp. In a very few hours traffic had compacted the road into a surface which was very hard and smooth.

The methods of procedure varied from time to time under different weather conditions and as we saw defects, but for the most part were as follows:

After the gravel and binder materials were on the road, the mixing was started with the motor graders. It was soon noted that proper, or improper, mixing had a very definite effect on the finished road and for this reason the number of times of mixing was increased until we were sure that it was thoroughly done. When the binder was in clods, it was soon ground into dust by the traffic in dry weather; but in wet weather it simply pancaked and was very hard to work.

After the mixing was complete, the materials were bladed into windrows on each side of the road to await rain. This was done to eliminate the costly operation of hauling water, which is essential to thorough compaction. It was a very bad summer for this, as we had little rain. As a result, we were considerably delayed in finishing the work and received many complaints from residents along the road who were bothered by the dust. In fact, the dust was so bad and we had waited for the rain so long that finally we gave up hope and hauled water to wet the mixture for spreading. Because of the extreme dryness of both the base and the mixed materials plus
the rapid evaporation at that time of year, we had difficulty in hauling enough water to furnish adequate moisture. Unless the water supply is near and several distributors are available, we strongly advise against this method of securing moisture.

While wet, the materials were bladed back onto the road and spread with the graders and maintainers. Of course, the condition of the material depends upon the amount of rain; but we have never found it too wet. The dry roadbed absorbs the water very rapidly, and several times the top became so dry that it did not pack readily. In a moist condition the spreading was easily and rapidly done. The graders left the road in approximate proper cross-section but it was found that the maintainers were necessary for finishing. The work done by the graders was the approximate equivalent of screeding concrete work, while the maintainers can be compared to the use of a float, spreading the materials in the proper place but working none of it to the edge. The crown of the road was kept at about \( \frac{1}{2} \) inch per foot; and instead of a curved crown, which is too flat at the center for proper drainage, we used a modified A-type with straight slopes from the center. It has been noted this fall that a flat center has tended to develop potholes but that the roads kept to the proper cross-section did not.

After the maintainer, loaded trucks were run over the road, working from the edges in toward the center and packing the entire road width. This rolling smooths down the surface and is the final preparation. Where it was omitted, the materials tended to pull off the road by sticking to tires of passing vehicles, which left ruts and holes.

On the first road the spread of calcium chloride was only 16 feet wide since we expected this to spread, through leaching, to the edge of the road. This did not occur, however, and a strip of loose material was left on each side of the road, about 2 feet in width. Later, this method was changed and the spread increased to 18 feet, which had the effect of preventing loose material from developing at the edges when traffic used the full width of the road. On most roads, however, this was not the case, since traffic tended to stay in the center and a considerable amount of loose gravel developed. At first this was considered objectionable, as the road looked as though it were ravelling, but it was later found that this loose material could be graded into the traffic lane by the maintainers and packed down to its original smoothness. This maintenance work must be done during or immediately after rains which soften the surface enough to permit reconsolidation of the loose material. The common tendency of travel is to stay in the center of the road and, as a result, the two tire tracks become smooth and compacted very hard and there is a light float left at the edges which will be very useful for grading.

As our spreader is 8 feet long, the 16-foot spread made by driving down one side of the center and back on the other was
unsatisfactory since it left a dry strip in the center. Later, when spreading a width of 18 feet, a 4-foot lap was made on the center line. Although it is sometimes recommended to spread the calcium chloride not closer than 6 to 8 inches from the edge of the road, we have found that there is practically no migration of this material laterally and we spread right out to the edge to reduce dust. The results of tests of migration of sodium and calcium chloride as reported in the Proceedings of the Road School last year showed considerable such migration; but it seems to be entirely due to wet weather, or at least to more rain than we have had. It would probably be good practice to follow the recommendations and not spread to the edges in a climate with more rainfall, but I think that for the small amount of material required it is well worth while to cover the entire width.

The equipment used was all owned by the county, except the lime spreader. This was purchased for $49.90, less tires, and after some working over, was found to be exactly suited for the work. The pole with which it was equipped was taken out, and a 4"x6" hitch with side braces substituted. This was made so that the spreader was directly under the tail gate of the dump trucks. We also raised the sides by bolting a 1"x12" board at the top, forming a hopper that was just below the truck bed, and raised the shut-off lever to a position where it could be controlled from the truck.

The calcium chloride was taken to the job in dump trucks, and two men were able to empty the sacks into the hopper as the truck was driven over the road. When the truck became empty, the spreader was hitched to a loaded truck and the empty returned to the garage for another load. It was found best to use one driver for spreading as he soon learned to maintain an even speed while the spread was being made. The truck was driven about 4 or 5 miles per hour, the feed of the spreader being adjusted to apply the proper amount. Our greatest error in getting the required amount was never greater than 2 or 3 sacks per mile, after all adjustments were made and the truck was driven at a steady speed. A few trials will be necessary to adjust any particular spreader according to length, size, and number of holes feeding the material. If the spreader should be stopped while full, the material will soon absorb enough moisture to solidify around the openings and stop the feed, even with the agitator running. If possible, the spreader should be kept moving until empty and should be thoroughly cleaned at the end of the work. The calcium chloride was also spread into all farm drives to the fence line and at road intersections to prevent ravelling at the edges. The other equipment used included a gravel loader, graders, maintainers, and trucks.
Costs

Our cost records for road improvement of this type include all the materials and labor, although the gravel and a portion of the blading could be omitted as being such as could properly be charged to the road if left as a loose gravel surface. On the basis of an 18-foot roadway, the cost was:

- Calcium Chloride—8.8 tons per mile at $20.50 per ton—$0.017 per square yard.
- Gravel—350 cubic yards at $0.85 per cubic yard, including loading and hauling—$0.028 per square yard.
- Clay—55 cubic yards per mile at $0.30 per yard, including loading and hauling—$0.0016 per square yard.
- Grading and mixing—$0.034 per square yard.
- Total cost—$0.0806 per square yard.

The cost of the calcium chloride and the binder, the only materials used in addition to those necessary for a loose gravel road, was about $200 per mile.

Maintenance

Our experience in the maintenance of these roads has been very good. In the beginning we were doubtful as to the methods used, but these have since proved to be practical and efficient. As holes developed in the surface because of lack of crown and improper mixing, we tried patching; but this proved too slow. Through experience we found that cutting the road from the center to the side and back to the center, with graders and maintainers to restore it to the original cross-section, eliminated these holes and that the materials immediately packed down as hard and dustless as ever. This work, of course, is done only when the road is damp enough to permit repacking of the loosened material. This fall there was enough dampness on the roads in the morning to keep the graders going until about noon. Also, during or immediately after rains has proved to be a very good time to get the road in condition. In fact, blading at any other time will only destroy the compacted surface and cause further ravelling. On only one road has it been necessary to do this grading more than once, and in some miles there has been no maintenance at all since the roads were finished in June.

It is our opinion that practically all the potholes or other defects were caused by too large gravel or too much binder material insufficiently mixed, and it is the intention to be more careful of these things in future work. Generally, the appearance of the aggregate after mixing looks as if there is not enough binder, and the tendency is to add more. In one case, we used as much as 70 yards per mile, with the result that during the rain that followed we had a very "tacky" mix. This has since required grading twice during rains, since it becomes soft. The control of the binder ratio should be such as to
TWENTY-EIGHTH ANNUAL ROAD SCHOOL

insure the proper amount of clay being added to the gravel. This will vary according to the size and character of the aggregate and the plasticity of the clay. The Michigan State Highway Department has a design chart for stabilization of loose material that can be used to great advantage. The clay needed can roughly be estimated to be approximately 10 per cent of the loose material on the road. New gravel placed on the road should not be larger than \( \frac{3}{4} \) to 1 inch in size; and if the old road has larger loose stones, they should be removed.

It will be noted that holes develop at farm drives and at road intersections. This seems to be due to traffic slowing up at these locations and making quick starts, causing the wheels to tear into the road. If the stabilization is extended to cover these places, this can be avoided.

We intend to start our work earlier for the coming year and do as much work as possible during the season of most rain in order to avoid the dry summer when the dust becomes intolerable. Last year there were very few days that the work could not have been carried on, and several miles were finished before the summer was advanced.

By selection of proper materials and their correct application we are getting a stabilized road surface that is standing up under ordinary traffic conditions and is answering the needs of the landowners by providing a hard, dustless road. It is our intention to blacktop several miles of road that has been so treated, and we plan to extend this stabilization to the secondary roads leading into the main traffic lanes. The highway officials of our county are convinced that there should be some sort of improvement to serve those who do not live on our main highways and that our limited income can be spread over more miles in this way than in any other. In other words, we are working out a planned program to give us the types of roads best suited to our traffic demands, placing them where they are most needed when they can be afforded.

It is relatively simple to build high-type roads expensively, but to build them at a cost which is within our budget is another matter. We feel that we have solved the problem by keeping our low-cost roads really low in cost and our high-type roads as high in type and low in cost as possible and yet building them according to good engineering principles.

ROADSIDE MOWING—METHODS AND COSTS

Ray Linn,
Montgomery County Road Supervisor

Roadside mowing is a rather new maintenance operation in most Indiana counties. For many years the law provided that farmers must mow the roadsides along their farms and were entitled to a road tax credit of $3.00 for each day spent in mowing. This law remained on the statute books long after all