

the city dweller, it is essential that we have improvements made on the local and county roads as well as on the state highways.

If we assume that each of the 800,000 motor vehicles owned and operated by the citizens of the state of Indiana travel 5,000 miles per year and that through efficient maintenance on the highways each owner is saved one cent a mile in vehicle operating costs there would be a total saving of $800,000 \times 5,000 \times 1c = \$40,000,000$. This looks like a large sum but I believe it is conservative.

I do not know what amount of money is being spent for the maintenance of all rural highways in your state but I venture to say that it is under ten million dollars. Even at this figure you would be saving 3 times the actual expenditure to say nothing of the added safety, comfort and convenience. I like to think of maintenance not as an expenditure but as a saving to the motoring public. We must not lose sight of the facts because upon the highway official will rest the responsibility of rendering efficient traffic service. Each has his part to play from the patrolman up to the state highway engineer and when thorough co-operation exists between all, then can it truly be said that traffic is served.

PRACTICAL HIGHWAY ENGINEERING

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In this paper I will give you a description of the plan and methods as applied to the particular types of roads which are being constructed and maintained in Kent County, Michigan. Do not understand that I am advising everyone to follow our methods. I will only attempt to describe to you the practices which we are following in our highway work leaving it to you to pick out such features of the work as may possibly apply to your own work.

We have three general classifications of roads in Kent County.

The state trunk line and federal aid roads comprise 150 miles of the total system and are quite largely paved with concrete. The county road system makes up about 350 miles, some of which is paved with concrete and the balance being gravel. The township roads total about 1,400 miles, some of

which are improved with gravel of various widths and thicknesses and the balance, which amount to a large percentage of the total mileage, are dirt roads, some graded and others only trails.

Under the present Michigan laws the state trunk line and federal aid roads are being constructed and maintained entirely at state expense. These roads are of interest to the county road commission, however, inasmuch as the county has been handling the maintenance work for the state as well as a large share of the state's engineering work in the county. The township highways are under the supervision of the various township highway commissioners and do not concern the county road commission except in cases where the township boards and the county road commission cooperate so as to have roads built and maintained by the county road commission in the township and at the township's expense. The 350 miles of improved highways, which are under the direct supervision of the county road commission are of chief interest to us at this time, and are the only roads which will be extensively considered in this paper.

These county roads have been financed by a direct tax upon the county at large and also by an assessment district plan, whereby the cost of a road is met by an assessment upon a district adjacent to the road. The first plan, that of direct taxation on the county at large, is the one which is being followed almost exclusively at the present time. This plan calls for an appropriation from the board of supervisors each year and may be called the "Pay as you go" plan. The funds so raised by the county are also supplemented by moneys returned to the county from the state, from a weight and license tax on automobiles. We also have a gasoline tax in Michigan but the counties do not participate in this revenue. In Kent County the total revenue received each year from both the county tax and the automobile money ordinarily amounts to approximately \$700,000. All the activities of the road commissioners are paid for out of this sum, except occasional jobs under the assessment district plan previously mentioned.

Owing to the abundance of good gravel which we have in Kent County, a large mileage of gravel roads has been constructed. For the same reason, we have found that cement concrete is an economical type for us to build on roads which receive traffic too heavy for gravel surfaces. The result is that almost all our mileage is made up of concrete and gravel with the concrete from 16 to 20 feet in width on the heavily travelled roads. The 20 foot concrete roads are now costing us about \$35,000, and the 16 foot gravel roads are costing from \$8,000 to \$9,000 per mile. These costs include surveys, plans, engineering and inspection.

Engineering Involved

Our engineering work consists of the making of surveys and plans, and the supervision of construction contracts. This work is all in charge of a road and bridge engineer, who is in turn responsible to the engineer-manager. Under the direction of the engineer in charge of this department we have quite a number of draftsmen and field engineers. When construction work opens up in the spring the total number of contracts are divided among three or four field or project engineers. Each project engineer then has charge of the engineering work on a certain group of roads, usually four or five contracts during the whole construction season. The project engineer does not have time to do a great deal of staking work, but has one or more field parties working under his direction doing the various kinds of staking work, which will be described later. All of the inspectors used on these contracts work under the direction of the project engineer.

About the first of September our program for the next year is finally decided upon and the project engineers through their various field parties are given the task of completing all of the surveys for the ensuing year's work, before they are blocked from further field work by extremely cold weather and heavy snows. By September, a large number of the contracts have usually been completed or nearly completed so that the field men are able to handle this survey work in addition to their supervision of construction. By Christmas this survey work is usually completed. All of the project engineers and chiefs of parties are then brought into the office and set to work preparing plans for the roads on which they have just completed the surveys. During the winter we do not attempt to hold over our rodmen, chainmen, and inspectors, but we do try to hold all of our project engineers and chiefs of parties. As the plans are completed during the winter the various jobs are placed under contract and when spring work opens up we again find ourselves with a lot of contracts ready to start and the same field men to go out and take charge of the work. This system of handling our engineering organization has worked out very satisfactorily with the result that many of our engineers stay with us continuously for five to six years. The plan of having the same men handle a road job from the beginning of the survey to the completion of the work also makes for greater efficiency and better quality results in the final construction of the road.

The road must be designed so as to have alignment and grades in keeping with the volume of traffic which it is expected the road will be called upon to carry. This may be explained by saying that on light traveled roads one may

be less rigid with respect to grades and alignment than on heavily traveled roads. As an economic proposition, the amount spent to get certain specified grades and alignment should be somewhat in proportion to the volume of expected traffic.

After a road is placed under contract there is considerable field engineering work to be accomplished to assure getting proper road construction in accordance with the plans. The same men who made the plans have charge of this work. We start out by slope-staking the road for the rough grading operations. We usually stake out all culverts and bridges as the contractor progresses with his work. After the rough grade has been constructed we set shoulder stakes every 100 feet to enable the contractor to do the final trimming up of the grade. As fast as the grade is trimmed up and completed our survey parties check up the grade and cross section it at the same locations at which cross sections were obtained on the survey. By following this work along as the contractor progresses we are able to have the office men compute the final earthwork quantities, so that when the road is finished we are in a position to make final payment to the contractor.

After the grade has been trimmed up and completed it is then trenched with a grader by grading out from the center, leaving a sub-grade which is ready to receive the surface. The shoulder dirt for the final trimming, however, is then on the shoulders where it belongs, and there is practically no longitudinal haul of dirt after the surface has been placed. Up to this point the construction features are essentially the same no matter what type of surface is placed. In the case of a gravel surface, the inspection of the gravel with reference to quality, depth, etc., is taken care of by the project engineer in charge of the job. In the case of a concrete pavement, however, it is necessary to place inspectors at the mixing plant and the proportioning plant, and, on some jobs, at other points on the construction. These inspectors work under the direction and supervision of the project engineers.

Costs

A little information with reference to the cost of the engineering work just described may be of interest. Our completed surveys cost approximately \$200 and the plans \$100, making a total of approximately \$300 per mile. This cost is much less, however, than the cost of engineering, and supervision of the work during the progress of construction. On our gravel roads the cost of surveys, plans, supervision and inspection amounts to approximately 8 per cent of the amount of the contract. On the paving jobs this figure is approximately 3 per cent.

Maintenance

Maintenance in Kent County may be divided into road maintenance, bridge maintenance, and the maintenance of buildings and equipment. The maintenance of our roads and bridges is handled under the direction of a maintenance superintendent, who is aided by four district superintendents. Each district superintendent looks after the roads and bridges in approximately one-quarter of the total area of the county, which by the way is larger than the average county, having twenty-four townships instead of sixteen. Each district maintenance foreman has a garage or headquarters in his district and all operations of equipment for his district are handled from his headquarters rather than from the main plant at Grand Rapids. This feature of our maintenance work not only facilitates and speeds up the work, but over the period of a year saves considerable money.

Under the head of general maintenance may be included the repair and painting of guard rails, the repair and re-building of culverts, shoulder maintenance, cleaning out ditches, cutting weeds and brush and the maintenance of markers and signs. All of this work is handled under the direct supervision of our district maintenance superintendents. No doubt, all of this work is familiar and it will not be necessary to go into details. I might state, however, that the painting of guard rails is not done by hand, but is handled by two men with a spray machine. The spray machine, which includes engine, compressor, paint tank and two lines of hose with spray guns, is mounted on a light truck so that the whole outfit can be easily moved along as the work progresses. One man operates the truck and paints the insides of the guard rail, while the other man sprays the outside. It is interesting to note that the standard wooden guard rail can be painted in this manner for about \$.01½ per foot as against \$.04 and \$.05 by hand. Of course, the painting of cable guard rails, which we are using almost exclusively at this time, costs much less.

Concrete:

The maintenance of concrete surfaces consists mainly in pouring tar or asphalt into the cracks and joints once or twice each year in addition to such concrete patching work as becomes necessary from time to time. The maintenance of cracks and joints is handled by a crew of four or five men equipped with a truck and a tar or asphalt heater mounted on a rubber tire trailer behind the truck. The sand for covering the hot material is carried on the truck as well as the supply of additional tar or asphalt and the small tools used in the work. Two outfits handle all of this work for us.

Concrete patching work has not yet become a serious operation in Kent County, but we have been forced to handle a small

amount of such work. For this purpose we have rigged up a pavement breaker which is simply a large cast iron weight which is raised up and down over a small crane projecting from the rear end of a truck. A hoist mounted on the truck raises the weight and lets it drop onto the concrete to be broken. This works quite satisfactorily and saves considerable time and money in the removal of the old concrete. The replacement of the patch is handled in the same manner as the placing of new concrete on a regular paving job except that we usually use some method to obtain early strength in the concrete so that the patch may be opened to traffic within a short time. In extreme cases where we are forced to open the patch in one day we have used Lumnite Cement and a rather rich mix. Due to the high cost of this method, however, most of our patching has been done with the use of a rich mix and the addition of calcium chloride in solution in the mix to obtain the early strength desired. This method enables us to open the road in about three days.

Gravel:

The maintenance of gravel roads makes up a larger part of our work than all of the other maintenance features put together. Briefly our system on this work consists in keeping a thin layer of fine, screened gravel on the surface of the road at all times, and properly distributing this over the surface of the road by the use of motor trucks equipped with spring scrapers. We operate four gravel screening plants of our own which are moved from one gravel pit to another as the work requires. We own a great many gravel pits and by using fairly light portable gravel screens we are able to get out screened gravel reasonably close to the places where the gravel is to be used. *We have used nothing but screened gravel all under one inch in size for the past five years.*

For the scraping work each district is supplied with three or four three-ton trucks with ten-foot spring scraper attachments. These scrapers operate at a speed of eight to ten miles per hour and handle all of our scraping work excepting the use of a very heavy grader once or twice a year.

Eliminating Dust:

One feature of our gravel road maintenance work which is followed up more closely in Kent County than in most parts of Michigan is that of laying the dust. During 1926 we used approximately 2,000 tons of calcium chloride on both the county and state trunk line gravel roads. We buy the chloride in 100 lb. sacks during the winter and have it shipped to our several district plants. Here it is stored until we are ready to use it. As soon as the roads begin to get dusty in the spring, which is usually sometime in May, we start spreading the chloride at the rate of approximately $\frac{1}{2}$ pound per square

yard of gravel surface. The chloride is spread on the road by the use of a chloride drill or lime sower hooked behind a truck. The chloride is carried on the truck and a couple of men empty the sacks into the drill as they proceed along the road. It is not necessary to stop until the entire load of chloride has been used up, and by that time another truck load will have arrived and the men simply transfer the drill to the other truck sending the empty one back for another load.

The quantity of chloride necessary to properly lay the dust for a whole season depends largely on the volume of traffic on the road. We have been following a rule about as follows for the total season's requirements:

1st—No dust layer used on roads carrying less than 100 vehicles per day.

2nd—One pound of chloride per square yard, or two $\frac{1}{2}$ pound treatments, for roads carrying from 100 to 200 vehicles per day.

3rd—One and one-half pounds, or three treatments, on roads carrying from 200 to 500 vehicles per day.

4th—Two pounds, or four $\frac{1}{2}$ lb. treatments, for all roads which carry more than 500 vehicles per day.

In extreme cases where gravel roads receive three thousand to four thousand vehicles per day it is necessary to use another half pound treatment, or a total of $2\frac{1}{2}$ pounds per square yard for the season. We have a few roads in the last classification, but none in the first. This plan of distributing dust layer in proportion to the volume of traffic has worked out very satisfactorily for several years. For the benefit of anyone just beginning to use chloride, I would caution against the use of too heavy treatments. Too much chloride has a tendency to harden the surface which makes it difficult to scrape and eventually results in a road which becomes rough and pitted. For the first application on roads which have never been treated before, I would advise using not to exceed one pound per square yard and for all future treatments I would recommend the schedule described above. The best results can be obtained by the use of many light treatments rather than a few heavy ones.

The cost of this work amounts to approximately \$30 per ton applied on the road. This makes a dust layer cost of from \$100 to \$300 per mile depending upon the quantity used. This may seem like a considerable amount of money to pay for simply laying the dust but as a matter of fact the chloride does much more than lay the dust. We know from past experience that it costs almost as much to maintain a gravel road without a dust layer of calcium chloride as it does with such a treatment. We can only draw one conclusion from this and that is that the chloride saves a large quantity of gravel by

holding the binder on the road. We know that this is true and a study of our cost records show that the chloride saves almost enough gravel to pay the entire cost of the dust layer.

Bridges:

The maintenance of bridges for the past five or six years has consisted chiefly of re-flooring and re-conditioning old steel, truss bridges. In most cases the bridges are inherited from the townships and we find them only sixteen feet wide with loosened and vibrating steel work and worn out transverse plank floors. Of course, we can not widen the roadways on these bridges under any system of maintenance, but we have been able to place a number of them in a much more satisfactory condition. This is ordinarily done by taking off the old plank floor, replacing the worn out stringers, tightening up and painting all of the steel work and placing a new floor. On this type of work we have found two-by-fours placed on edge, transverse to the roadway and spiked together so as to cover the entire floor surface, to be a very economical and satisfactory floor. By fastening this floor to the stringers and floor beams with "U" bolts we have been able to eliminate the vibration which a bridge receives from a transverse plank floor. If No. 1 long leaf yellow pine is used for this work the floor will remain in good condition for at least five or six years, and quite often by that time arrangements for financing the construction of a new bridge have been worked out. Otherwise, the floor can be again replaced for less money than almost any other type of smooth riding floor.

Buildings and Equipment:

The maintenance of buildings and equipment fall under the supervision of our plant superintendent, who looks after everything in connection with our main plant and offices in Grand Rapids, and has complete charge of the repair of all equipment. Only about one-quarter of all our equipment is kept constantly at this plant, but a check up system has been established whereby every motor vehicle goes to the Grand Rapids plant once each month for a complete check up and then goes back to its district in first class condition. Sometimes this check-up can be done in a couple of hours and in other cases a complete overhaul is required. At least once each year a new painting job is included. Any minor repairs on the trucks in the three districts outside of Grand Rapids are taken care of by a repair man at the district garage. For major repairs, however, the trucks or other motor vehicles are taken to the Grand Rapids plant.

In addition to this check up system we employ mechanics to do certain night work on equipment. This work consists chiefly of greasing and oiling, tightening nuts and bolts and

other minor repair work. By the employment of a few night men in this way we save the time of a large number of men during the day, and also greatly facilitate the work. This is particularly true of work on cars which are being used during the day by survey parties.

Forestry

The roadside development work consists of trimming the existing trees and shrubs, planting new ones and miscellaneous other work, such as sodding, stabilizing sand banks by certain planting, etc. The entire county road system has been taken care of in this manner for about five years. It costs approximately \$75 per mile to properly trim the roadside trees and shrubs the first time over but subsequent trimming is handled for approximately \$5 per mile per year. Some planting has been done in the open spaces along our roadsides, but because of the abundance of natural roadside trees and shrubs now in existence the most of our planting work has been confined to our County Parks.

Another phase of our work which is placed under the supervision of our forester is that of controlling the location of new pole lines along the highways and any tree trimming work which is done by any of the pole line companies. These companies are required by law to obtain a permit from the highway authorities before doing any trimming work and consequently the details of this matter are left with our forester to work out. This system has forced the pole line companies to employ trained foresters of their own which results in a quality and kind of trimming work done by these companies which was never before realized. By the re-location of pole lines it is also possible to do away with all trimming on many long stretches of road.

RECENT DEVELOPMENTS IN ROAD MAINTENANCE METHODS

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Each year we find new developments in the methods of repairing and maintaining the highways. Some of these methods prove to be valuable and remain as standard practice, while others prove to be useless and are displaced by still newer processes. It is only by experiment which may extend over a period of years that the worth of any new process can be fully proven. The length of time required for a field test to