MAINTENANCE OF SECONDARY TYPE ROADS

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If we could be assured that the volume and nature of traffic on our roads would not change, the problem of maintaining them would be very much simplified. It would be comparatively easy to work out efficient methods with satisfactory equipment, and when once organized one could sit back and watch the work go on without further worries. Instead of having such a condition we are confronted with an ever increasing volume and weight of traffic, and in addition the users of the highways are becoming more insistent on greater comfort and better service. The result is that the maintenance of roads is an ever changing problem, requiring new methods and new operations as the traffic demand increases. This constant change and its effect, is much more evident on the secondary or cheaper type of roads which are surfaced with stone, gravel, sand-clay, etc., than on the higher type, paved roads. Usually the capacity of the secondary type road is constantly being taxed to the limit, which necessitates relief measures which will serve until a higher type of road can be constructed. This condition is in many instances successfully met with a systematized, progressive improvement or development, with occasional results which ultimately approach the serviceability of the higher types.

After all, the real purpose of all our operations is to provide the public with a serviceable road, and with the constantly changing traffic, it is self-evident that the nature of the road must be changed either by gradual betterment as the traffic increases or abruptly by construction when the road will no longer carry the traffic. Apparently the most certain feature in our work is that the traffic will continue to increase.

Road Mileage and Traffic Data

The maintenance problem in Minnesota involves the upkeep of a 7,000 mile state maintained road system, of which 5,500 miles are gravel surfaced, and a 12,000 mile county maintained, state aid system, of which 9,000 miles are gravel surfaced.

We have systematically taken a large number of traffic counts on the state maintained system during the past seven years, and these indicate that our average rate of increase in volume of traffic is somewhere between 20 and 25 per cent per year. The counts are ordinarily taken at points between the various cities and villages, so as to avoid the purely urban

traffic. The average daily traffic on the state maintained system is 940 vehicles per day, ranging from 144 as the low, to 6,895 as the average daily traffic on our heaviest traveled road, with single days above 15,000. The average traffic on our pavements is about 2,103 vehicles per day and on our bituminous treated roads the average is 1,274 per day. From a rather careful analysis we have arrived at a figure of 580 vehicles per day as the economic limit of traffic on our untreated gravel roads. We are actually carrying an average of 630.

Patrol Organization

We have passed through the stages of wheelbarrow patrol, team patrol, gang patrol, and tractor and truck patrol. The wheelbarrow patrol passed out of the picture along with the horse-drawn, steel-tired traffic, and with the coming of increased wages.

Up to an average daily traffic of about 300 vehicles, the team patrol is undoubtedly the most practical, as this is the one and only all-purpose maintenance unit which is able to perform all necessary operations without supplementary help. *This unit is most efficient on sections not over six miles in length.* In speaking of team patrol I refer to a full-time patrolman on short sections. This should not be confused with the so-called team patrol which I am informed is in use on some of your county systems where one man is responsible for 25 or 30 miles of road which he attends to off and on when not busy on his farm.

The team patrol must be equipped with a wagon for hauling material, slip scraper and hand tools for cleaning drainage lines, mower and scythe for cutting brush and vegetation, and a blade grader or machine for smoothing the road surface. Originally the team patrols were equipped with drags of the split-log type. These soon developed into planers of various designs, and then into light graders. The weight of the graders, however, has increased with the increase in traffic.

The team patrol may not be the most economical in each particular operation. For instance it is entirely possible for a power patrol if operated continuously to do the smoothing at a less cost, or for a gang to cut the weeds for less money, and so on, but to perform each operation in such manner would mean a much more elaborate organization, with consequent additional expense, therefore as the team patrol itself can do all the different kinds of work required, it is the most economical unit *up to the limit of its capacity.* Probably one of the most wasteful features of the team patrol is the time lost in going to and from work, and in making necessary periodic trips over the section.

As the volume of traffic increases it develops that the team patrol on certain roads is not able to keep up its work and it

becomes necessary to supplement it with tractors, tractor patrols, or trucks and in some cases with special work gangs or crews. As the volume and speed of traffic increases, it also becomes more hazardous for the team patrol which naturally makes it more difficult for it to work efficiently. The point has been reached in many cases where the team patrol should be discontinued entirely, but we have been reluctant in making the changes too suddenly, partly out of consideration for the patrolmen but more particularly because of the rapid developments which were taking place in equipment. We have avoided the purchase of large quantities of any one type of equipment at any one time, with the result that we are able to take on the newer developments without suddenly finding that we have on hand a large amount of obsolete equipment which has not been fully charged off.

It is now evident, however, that we will have to discontinue our team patrols at a much faster rate. Our present tendency is to replace them with truck patrols, and a crew of two men, covering from 20 to 25 miles. Our adoption of trucks is at least partly due to the facility with which they can be adapted to snow fighting operations in winter. On account of our snow work and also because they will have to pull graders in smoothing work, the trucks should principally be of 2½ to 3 ton capacity with heavy duty motors. They should be on pneumatic tires and capable of operating economically at both a low speed and also a high speed of about 25 miles per hour. The grader should be of about 5,000 pounds weight with a 10′ or 12′ blade and mounted on rubber tired wheels with roller bearings. A spring blade under the truck is very useful but will not take the place of the blade machine. The dump body on the truck should be equipped with power hoist and should be rather wide in order to be as low as possible to make the loading easier by hand shoveling. It pays to make the work easy for the men.

This unit will serve equally well on the higher type paved roads as on the secondary types and consequently eliminates the necessity of making radical changes as the traffic or type of road changes. It will of course be necessary in some cases to supplement the truck patrol with special gangs or equipment to perform special work. A tractor or power patrol machine will be very useful at times and a limited number should be available to supplement the work of the truck patrols when they are too busy hauling material. A scarifier is also a necessity on any secondary type road and although in some cases a scarifier attachment on the grader pulled by the truck will serve, generally a tractor is necessary for pulling power. On gravel roads the combination grader and scarifier is usually the most practical.

Application of Gravel

A certain amount of the surfacing material on the road is always being thrown off, or worn out by traffic and blown away and must be replaced. This approximates from ¼ to ½ cubic yard per average daily vehicle per mile. Except on light traffic roads the patrol is not able to fully replace this loss without help and it is economical to supplement the patrol work at intervals of two or three years with a truck fleet, which can naturally be organized to deliver gravel for less cost than the single patrol unit.

Regrading work should be handled in the same manner as new construction. The best practice is to deposit the new material in windrows either at one side or in the center of the road and to immediately spread it out with a blade machine, blading it entirely across the road and windrowing on the opposite side of the road all except a thin floating surface. This operation mixes the material thoroughly and gives a uniform product to work with. The material in this windrow is then gradually fed onto the road surface with the smoothing machines, and as fast as the traffic will warrant. This makes it easier to maintain the thin film of floating material on the road, which is so essential in holding a satisfactory surface. In order to keep this thin film in place, it is necessary to blade it very frequently and as the volume of traffic increases more frequent blading is essential. This method of applying surfacing material also makes for greater safety to the traffic by avoiding the dangers of accidents caused by fast moving vehicles suddenly striking deep and loose material.

On new construction our general practice is to place 1,200 to 1,400 cubic yards per mile in windrows and about 400 cubic yards in stock piles. On regraveling operations we ordinarily place about 400 to 600 cubic yards per mile, part of which goes into stock piles. Our patrol units place on an average of about 100 cubic yards per mile per year, principally from the stock piles which are placed at convenient intervals, usually not over a mile apart. With the truck units the stock piles can be placed at greater intervals and more material hauled from pits.

Chatter bumps or rhythmic corrugations usually develop on heavily traveled gravel roads. We do not consider them as anything serious but merely as an indication that the blading has not been frequent enough or severe enough, or that the equipment used is too light.

From the standpoint of safety to traffic, and further to avoid concentrated travel in one track, we endeavor to maintain as flat a crown as possible. We prefer not to exceed a 6″ crown in 30′ width of roadway. Too coarse stone or pebbles and an excess of fine sand must be avoided. All surfacing material should be screened. Our practice is to use a screen with

openings ¾" square or 1" round. Gravel or stone well graded from 1" down to sand is of course the ideal material but as a rule we do not have much choice and are compelled to use material which may be available in the locality. Where the natural material does not have enough binding material it is usually comparatively easy to add clay or other similar binder.

Elimination of Dust

As the volume of traffic increases the dust nuisance increases. Dust represents not only a loss of material but it soon becomes a serious hazard to the traffic. The safety of the traffic alone would probably justify steps to remove this nuisance, but with an average daily traffic of over 500 vehicles it is usually found that the saving of surfacing material alone will pay for the application of dust eliminators.

Calcium chloride treatments are a great help on sandy and very dusty surfaces, and it is our policy to use it especially on roads which are soon to go under paving operations.

On roads where the traffic is too heavy for the untreated gravel and where the possibilities of paving are too far in the future, we are rapidly extending bituminous treatments of both tar and oil.

We have been experimenting with bituminous treatments on gravel roads since 1924, and are now getting good results from both tar and road oil on roads which were originally not considered suitable for such treatments. At the present time, 387 miles of bituminous treated roads are being used to the satisfaction of the traveling public and definite methods of treatment have been established. The experimental work is continuing along the lines of both maintenance and construction.

Tar and cut-back asphaltic oils have been pretty well established for gravel roads. Some methods in practice in Minnesota have been frowned upon by road officials of some states. It must be remembered that conditions in this state are far different from those in states where highways have been built and rebuilt during a long period of years. Gravel roads in this state consist of a thin crust of gravel and clay and not a consolidated or waterbound macadam of six inches to two feet in thickness. Therefore our practice necessarily has to conform to existing conditions.

Application of Bituminous Materials

The roadway is first bladed smooth and true to cross-section, using either a heavy tractor and a 12-foot blade grader or a heavy, motor driven, patrol grader. The former is preferable, as it insures a smoother surface. The loose gravel and cover material is windrowed along the shoulder of the road.

The roadway is not swept in most cases, the bituminous material being applied directly on the grade as bladed.

Half of the roadway is treated at one time so as to carry the traffic at minimum inconvenience. An 8-foot width of oil or tar immediately next to the windrow of gravel is applied at the rate of 0.3 to 0.5 gallon per square yard. One to two miles of roadway is covered in this manner. A power patrol precedes the distributor to blade off as much of the loose material as possible. The prime coat is applied at a temperature of 135° to 150°F. Then a 4 to 8-foot strip is treated adjacent to this strip, varying with the width of roadway to be treated. From one to ten hours is allowed for the tar or oil to penetrate into the road bed.

The other half of the road is treated in a similar manner and traffic carried on the side with the prime coat. The tar or oil does not pick up, but the weak spots show up and can be patched before the seal coat is applied.

When the second half has "set" sufficiently to handle traffic without "picking up", the second or seal coat is in order. Starting next to the windrow of gravel, an 8-foot width is treated at the rate of 0.3 gallon per square yard. This is applied at a temperature of 125°F. A power patrol grader, equipped with rubber tires, immediately pulls the gravel over this application, spreading the material about one to one and one-half inches deep. The seal coat is applied over the entire surface and as soon as the gravel has been spread the roadway is ready to carry traffic.

The traffic will bind the metal into the road but a smoothing machine, preferably a power patrol or blade grader, should go over the road continually for three or four days to insure a smooth riding surface. As soon as the tar or cut-back oil "sets up", blading is discontinued but any weak spots which develop are immediately patched with pre-mixed material, using the same kind of bituminous material and gravel as used in the treatment. This maintenance when done properly will give a good riding quality to the road.

If waviness develops after the road has set up, the corrugations can be removed by cutting the ridges with a heavy grader. This operation should be performed on a hot day and the blade set to secure a shaving action.

A road thus improved costs about $1,500 to $1,800 per mile the first year. The second year the cost is reduced about one-half. In many cases no treatment is required the third year.

It has also been demonstrated that a road treated in this manner can be scarified and reshaped with very little cost and with very beneficial results. One patrol unit can easily patch and maintain twenty miles of road improved in this manner, providing the traffic is not much over 1,000 vehicles per day.

Experiments on Clay and Gumbo Subgrades

In 1925 due to the evidence of diminishing supply of gravel and also the inherent characteristic of certain subsoils to "eat up" gravel, experiments on gumbo and clay were tried, hoping to waterproof the grade in order to hold the gravel up and eliminate the water. It was hoped that gravel consumption could be reduced and the road made more serviceable during all seasons of the year. The roads on gumbo subgrades during the spring and fall, even with 1,600 yards of gravel, are almost impassable. The rains and spring "break-ups" change these roads into muddy, sticky and rutted thorofares requiring excessive expenditures of funds to get traffic through. Frequently these mud holes or "frost boils" have to be planked to accommodate the traveling public.

The first attempt toward the solution of this problem was the use of a road oil applied in two applications of about 0.3 gallon per square yard. This oil was not covered with gravel and difficulties were encountered which discounted the method but the mere fact that the oil did waterproof the road and did stiffen or toughen the crust encouraged further experimenting. The outstanding difficulty was the inability to prevent the "picking up" of the oil, especially by steel tired vehicles. These roads are in rural communities where this class of vehicles are numerous. A road which is oiled and not covered with gravel develops a slippery surface which introduces a hazard, especially in wet weather. The cost of patching and maintenance is higher on this type and more frequent scarifying is necessary, which again requires more oil.

Our present method of subgrade treatment is as follows: The newly graded roadway to be treated is first allowed to take traffic for some time, thereby developing the weak spots in the road. These defective areas, sags or pockets of ununiform material, are filled with the prevailing clay or gumbo, and the roadway is then subjected to concentrated blading or planing to develop a very smooth surface. The inherent ability of this class of soil to pack and harden soon results in a uniform, smooth surface. While this operation is in progress, gravel is windrowed along one shoulder of the road at a rate of 350 to 450 cubic yards to the mile ready to be bladed over when the oil is applied.

When the road is shaped and dry (the latter can not be emphasized too strongly) the oil is applied. Half of the roadway is treated first with a prime coat of as much oil as the material will absorb. This usually is between 0.35 and 0.55 gallon per square yard. It is applied with a power distributor at a temperature of 175° to 200°F. When this oil has penetrated so that it will not pick up, traffic is allowed to use this side of the road and the prime coat is applied on the other half.

After the entire roadway has received the prime coat and is dry, a seal coat is applied starting on the side of the road first primed, which is also the side on which the gravel is windrowed. The application of the seal coat can be at a lower temperature, about 160°F., and at the rate of 0.3 to 0.35 gallon per square yard. Within half an hour after the seal coat has been applied a power patrol equipped with rubber tires and a 12 foot blade pulls the gravel over the oiled surface. The entire surface is covered in this manner and the roadway is then ready to carry traffic without inconvenience.

A thin layer of gravel is kept floating over this treatment and with the exception of a slight discoloration exhibits all the characteristics of an untreated gravel road.

Maintenance, consisting of blading and planing, is started at once and carried on consistently. In some cases power patrols are used but in most cases spring blades mounted on trucks are found very satisfactory on these roads.

During the second year the roadway is bladed free of loose material and a light application of the same kind of oil is applied at the rate of 0.2 to 0.3 gallon per square yard. This is again covered with a thin coat of gravel. About 125 to 150 cubic yards to the mile of additional gravel will serve for this cover. In places where break-ups have occurred or where extreme roughness is in evidence, a light scarifying will remedy the difficulty with little additional cost.

The cost of this treatment ranges between $1,200 and $1,800 per mile the first year, and half that amount the second year. In some cases no treatment is required the third year.

In connection with the maintenance of secondary type roads it is well to give careful consideration to the bridges and other structures. A mistake very easy to make is to renew or replace a structure with one of a permanent nature which in a few years will not handle the traffic, or which will be found to be in the wrong position when it may become necessary to improve the location and alignment of the road. Making it possible for the traffic to move safely at higher speeds is undoubtedly one of the most economical methods of increasing the traffic capacity of a road.

At times we show a tendency to attempt so-called permanent construction, before either we, or the public generally, are ready for it. This frequently results in poor location of a permanent nature which in the end will prove most uneconomical.

The secondary type roads must take up the slack between the primitive roads and the final paved road, and it is undoubtedly the best policy to maintain a road in this class until it is possible to reconstruct it on the best location with a view to future developments.