IMPROVING INDIANA'S GRAVEL AND STONE ROADS

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Good roads are essential to the development of any community, be it county, state, or nation. The natural resources, which are the original source of all wealth, must be developed, and the products of commerce and industry must be moved cheaply, quickly, and conveniently. Our agricultural and industrial products use the highways many times as they move from the land to the factories and then to the consumer. The highways are in constant use by the people who are moving to and fro in the course of their work or in the pursuit of pleasure. Any restriction of the movement of commerce over our highways will retard and cramp the development of the country. It will also increase the cost of conveyance, which would be a burden on the community that few people realize. There is no doubt in my mind that a county organization maintaining a good system of highways is a very valuable asset to the county. This also explains why the vehicle owner is willing to pay a service charge for the use of the roads.

The county highway organizations, as well as the state highway commission, realize the important part they have in contributing to the growth and development of their respective communities. It is their desire to see their county and state increase in wealth and culture, and I am sure they take pride in the realization that they are helping individually toward that end. The reduced cost of operation over their highways is just that much saved for their county. The money thus saved can be put to work in other lines of endeavor.

In my county a neighbor is operating two trucks which usually travel about 60,000 miles per year. On good highways they can operate for 20 cents per mile; but on very poor ones I am sure the cost will increase 5 cents per mile and maybe more. You can readily see that good roads will save the truck owner $3,000 in one year. The saving of this $3,000 will allow him to expand his business, build a new home, purchase bonds, etc. The value of well maintained highways is quite evident.

Indiana has more miles of improved roads than any other state in the Union. She has recognized the necessity for good roads and has met the need. However, as always happens, when one problem is solved, larger and more troublesome ones appear. The development of the motor vehicle has called for a type of road surface superior to our ordinary gravel and stone roads. Thousands of miles of these old roads which served our needs for so long have now become inadequate. They are losing favor with the traveling public. The cost of maintenance to keep them in excellent condition is too high.

They are constantly requiring more dragging and more material. The highway engineers, too, are losing interest in this type of surface. We are now confronted with the problem of what to do with these roads. We have them. We have invested over $200,000,000 in them. We do not have the money with which to construct better ones. Besides, it would not be economical to throw away the $200,000,000 investment. So we must take care of them as best we can and make them serve the public until we can substitute something better in their place.

FORCES WHICH DESTROY ROADS

Highway engineers, always studying better ways and methods, have found that wherever vehicles move on roads they exert four destructive forces which must be met and overcome by the road builder. These forces are abrasion, suction, shear, and impact. *Abrasion* is the wear on the surface caused by the grinding action of the wheels of the vehicle. It is similar to the grinding effect of a grindstone. *Suction* is the pulling of the dust and finely ground aggregate up into the air. The fine particles are swept from the road by the cars, sweeping the surface as would a vacuum sweeper. *Shear* is the bearing of the vehicle wheels on the road, tending to punch a hole in the surface. This force is similar to the force seen in a machine punching holes in an iron plate. *Impact* is the blow given the road surface as the vehicle wheel strikes an obstacle. It is the same action seen at the blacksmith forge when the smith is moulding a piece of red hot iron by pounding it into shape.

The effects of abrasion on any road surface can be materially reduced by fitting the wheels of the vehicle with rubber tires. This, in most cases, has already been done. But on the gravel and stone surfaces there is still considerable grinding as the wheels plow through the loose aggregate. This can be further prevented by treating the loose mineral aggregate with bituminous materials to form a solid, smooth surface.

On stone and gravel roads the loss of material due to suction is quite serious. Tests show that 500 high-speed pneumatic-tired vehicles moving daily for one year over a crushed stone surface will lift off one-half inch of the surface. On a road 18 feet wide this would mean about 147 cubic yards per mile. Not only is the loss of the material serious but the spreading dust is a very objectionable nuisance. Poor visibility because of clouds of dust is the cause of numerous accidents. Then too, clothes, cars, etc., must be cleaned after a trip through the dust. All of this trouble can easily be prevented by treating the surface with bituminous materials.

Shear can best be defeated by making a firm subgrade support and by increasing the thickness of the surface. Good

drainage will help the subgrade, and additional material can be added to increase the strength of a weak surface. Rigid pavements have the strength to resist shear, but the ordinary stone and gravel roads need the firm sub-base support to strengthen them against this force.

Impact is composed of two different blows. Shock impact first occurs when the obstacle kicks the wheel up into the air. Drop impact then follows when the falling wheel strikes upon the road surface. Both kinds of impact are severe and when caused by heavy loads will soon pound a pavement to pieces. The pneumatic balloon tire best combats impact. Next in order comes the high-pressure cord tire; then the semi-solid rubber tire; and last the solid rubber tire, which does the least to combat this force. To save the roads, this latter type of tire must go. The danger from impact is very serious. Many of our rigid pavements constructed only a few years ago are showing the effects of impact, and some of these pavements have already been rebuilt.

Besides equipping vehicle wheels with the correct kind of tires, we must hold loads to a reasonable weight. Another very important way to combat impact is to reduce the obstacles on the surface of the road. If the wheels are not kicked up into the air, they do not fall. So, if the surface is kept firm and smooth, there can be but little impact. Apparently maintenance men do not realize this or they would not let so many holes, bumps, and irregularities remain in the road. When the surface becomes a little rough, it should be repaired at once. Don't let impact have a chance to get in its destructive work.

TYPES OF SURFACE

Now, knowing a little about the forces which tend to destroy road surfaces, can we by some easy and cheap means change the ordinary stone and gravel roads so that they will stand up under the present-day traffic and give fairly satisfactory service which permits the traffic to operate economically? We have found that to combat abrasion we must equip the vehicle wheels with rubber tires and treat the surface of the gravel and stone roads with bituminous materials. To fight suction, we must also treat the surface of the stone and gravel roads with bituminous materials. To stop shear we must stabilize the subgrade and strengthen the gravel and stone surfaces. To prevent impact we must equip the vehicle wheels with pneumatic balloon tires and keep the surface smooth. In other words the road builder, to overcome these destructive forces, must construct a surface strong and smooth, with no loose material lying thereon to be ground up and swept away—a surface which can be readily strengthened if it becomes weak, one which can readily be kept smooth and one which can be built easily and cheaply.

A well-developed system of economically operated highways may contain several types of surfaces. Many different conditions in different localities are encountered. Different kinds of traffic must be provided for. The availability of local materials must be considered. The amount of money available has its effect. To contend that every mile of road in a system of highways should be constructed with one kind of surface is foolish and wrong. There are many types of highways. Among these there are one or more types which will fit in with the requirements of the local conditions. It is a wise engineer who will apply to his work the policy of building the type of surface best fitted to meet the local conditions.

I have in mind a system of highways contained in two entirely different localities. Through one, a road winds across the hills and through the valleys. The population is scarce. There are no cities, few towns, and but an occasional village. The road has poor prospects of ever having much traffic. In the adjacent hills there is plenty of stone for the construction of a good telford macadam base. In the other locality, comprising a long and wide fertile valley, there are many cities, towns, and villages. The road traversing this valley is a U. S. highway. On this road, the engineer constructed a fine high-type surface. He has made a wise selection. The traffic which will use this road calls for the best type of surface which can be built. But why should he construct the same type of surface on the road running through the first locality? Could not some other type of surface have been constructed more economically? Could not the local material have been utilized, giving work to the local inhabitants and thus assisting in the improvement of the community at the same time?

A farmer desiring to tile his farm does not use 16-inch tile in all the drains just because the main drain at the lower end of his farm calls for a 16-inch tile. He knows that the size of the laterals decreases according to the volume of water to be handled. So while he starts with a 16-inch tile where it is needed, he winds up at the end of the various laterals with probably a 4-inch tile.

A trucker hauling merchandise for a number of merchants does not install a fleet of 5-ton trucks to do this hauling just because one merchant handles heavy hardware. He realizes he will be called upon to haul anything from a basket of groceries to a large piece of machinery. So he equips a fleet of trucks ranging in size from a light commercial ¾-ton job up to the 5-ton truck and furnishes the type of truck according to the load to be hauled.

Oil Mats. Among the thousands of miles of gravel and stone roads in Indiana on both the county and state systems, are many places where one particular type of surface can be constructed which will give very satisfactory service, which

can be built easily and cheaply, and which will resist the four destructive forces better than any other type considering the amount of money expended. I am referring to the oil mat top which can be so easily and cheaply constructed on gravel and stone roads.

The oil mats can successfully combat abrasion and suction. They can also withstand shear when constructed on a stable subgrade and fairly strong surface foundation. If found to be weak, they can easily be strengthened by the addition of more gravel or stone or additional oil mat. Because of the ease with which a smooth surface can be constructed, impact can be kept to a minimum.

Oil mats have been constructed on the state highway system during the past three years. They have been giving most excellent results. Drag maintenance costs have been reduced very materially. The public is beginning to comment favorably about them. We believe they will prove to be the best type to fall back upon during these troublesome times of trial and distress. On a gravel or stone road having sufficient strength to withstand shear, an oil mat can be constructed for a sum ranging between $500 and $1,000 per mile, the range in price varying with availability of materials and thickness of the mat to be constructed. An average oil mat will require 200 cubic yards of aggregate per mile and about 0.85 gallon of road oil per square yard of surface, or 9,300 gallons per mile. The aggregate is mixed in place on the road and compacted by traffic. The mixing should be done thoroughly and uniformly.

Several applications of the oil should be made. At first a prime coat of about 0.3 gallon per square yard should be applied to the surface. The aggregate previously windrowed on the shoulders should then be bladed over the oil and the whole mixed thoroughly with maintainers. The second application of oil, about 0.25 gallon per square yard, should be applied to both edges of the traveled way and should cover about one-half the width of the road. The mixture after this application should not be bladed deeply; otherwise the oil will be moved from the dry edges. Another application of oil, covering the whole surface, is then made at the rate of about 0.25 gallon per square yard. The oiled aggregate is then again thoroughly mixed by blades and maintainers and spread uniformly over the surface.

The rest of the oil is used in spotting and patching, and some of it can be barreled for use in later patching. We usually figure on having at least 300 gallons of oil per mile on hand for maintenance patching.

Traffic should not use the road for a week or two so as to avoid the splattering of cars with fresh oil. However, we have been covering the completed work with about 0.35 pound of powdered asphalt per square yard to relieve this situation. We

find this powdered asphalt dries the fresh oil very quickly, and when used allows traffic on the road within three days.

We have found best results are obtained by making the mixture slightly rich with oil and then, as it comes through to the surface, by coating it slightly with chips or a surface-treatment covering. The chipping must be continued until the surface bleeding is checked. This leaves the surface a light-brown color which will not absorb the rays from vehicle lights and thus cause poor vision at night, as would a dead black color. An average oil mat top should last about two years, after which it should be surfaced with a light oil treatment, another oil mat, a surface treatment or mulch top, as the conditions call for. On heavily traveled roads it may be best to surface-treat the oil mat with standard tar or asphalt treatments within a year or two.

Only a general description of the construction of an oil mat top has been given. Detailed specifications, amounts of material, etc., can be obtained by referring to Indiana State Highway Commission Specification B. This specification will be furnished by the central offices of the Highway Commission at Indianapolis.

In conclusion, I call attention again to the 200 millions invested by the ninety-two counties in these gravel and stone roads. We know that many of these roads are not adequate to serve the traffic now using them. We do not have the money to build better types nor do we like to see large sums spent on them annually in drag maintenance. However, something must be done, for the operating costs are excessive and they are draining the communities of their wealth. I have shown how an oil mat surface constructed on these roads will render fairly good service and the cost is so low that every county is able to take advantage of this type of surfacing. No county should pass up the opportunity.

OPERATING AND MAINTAINING ROAD EQUIPMENT

By Clarence Allender, Hancock County Highway Superintendent

We will separate the discussion on operating and maintaining road equipment into four subdivisions; namely, personnel, equipment, repair, and management.

The personnel should be of the highest type obtainable. Efficient operators are always the cheapest. The men should be careful, thoughtful, and sincere—careful with the equipment, thoughtful in all their dealings with the public, and sincerely conscious of their duties as public servants. Much consideration should be given the men who are going to oper-