Getting More Black-Top Miles Per Dollar

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Please do not expect this to be a discourse in highway economy, for I am not posing as an economist.

In 1940 I was persuaded to run for the office of county engineer in Union County, Ohio. After a bitterly contested primary and general election I took office in January 1941 only to find before the year had passed that the second world war was going to cut short many plans and hopes for building new roads in the county.

In Union County the Road Commission had done the grading, construction, and asphalt surfacing of county roads with their own equipment and own forces. Now, out of my mistakes and experience during those years as engineer in Union County, possibly I can alert you to some hazards or troubles encountered in misusing asphalt.

The negative approach is difficult to avoid in the discussion of county road construction problems—just like the name "Skidmore" is not becoming to a district engineer for the Asphalt Institute. So—just as I did not choose my family name, most of you have inherited your problems. How can we make the best of it?

As my purpose, I propose to point out some basic factors or qualities which a road must have if one is to enjoy the most service possible from the dollar invested in an asphalt surface. Nearly every mile of road presents a slightly different problem. If we could look at a specific project I would like to say—spend the dollar where it serves you best; that is, for drainage, base, or surface. Dollars invested in an excellent seal coat or asphalt mat will produce rudely disappointing results if there is no metal or base to support the traffic load or if drainage is inadequate to prevent the subgrade from becoming saturated and unstable in the spring season. My discussion will concern the importance of the various parts of a road structure.

I suppose you are too wise and more diplomatic than to let Joe Dokes bring pressure on the Road Commission or on you to place road

oil (SC-1 or 2) in front of his home to lay the dust. It's done, however. Then the practice spreads year after year until it takes quite a bite out of the road funds. Each fall the potholes in front of these homes become so bad it's necessary to scarify and maintain the road as a gravel surface again. Then, one of the commissioners running for re-election has the brilliant idea—since we oil in front of four homes on that stretch of road past Joe Dokes', the whole thing could be primed and given an asphalt seal coat. It would save the cost of oiling in front of the homes each year and, besides, those living to the south take that road to town.

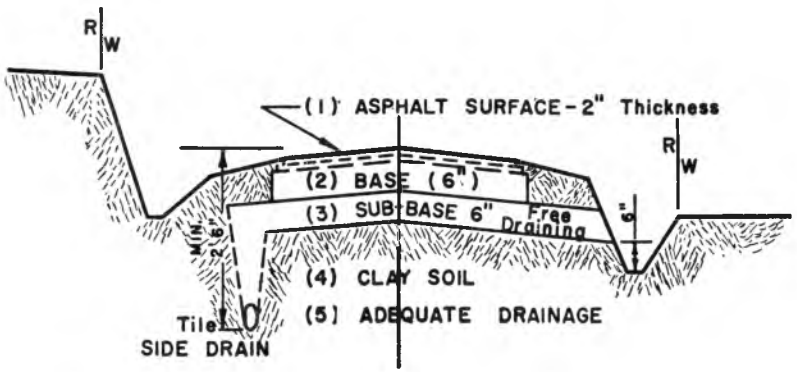
So, it is primed and given a coat of asphalt and chips. Not one person raises a question as to whether the road structure would support the surface. The commissioner is re-elected, but the next spring (it is a bad one) that seal coat breaks up in several spots and several holes developed. The deep holes are patched with some cold patch and later in June about half of the length of Dokes' road is given another seal. Each year there is less to patch. The problem seems licked until one spring when nearly half of it is lost again.

One commissioner is heard to say: "We have just about our limit of black-top in our county. If we had a few more miles treated we wouldn't have time or money to get the holes filled and re-sealed before next winter."

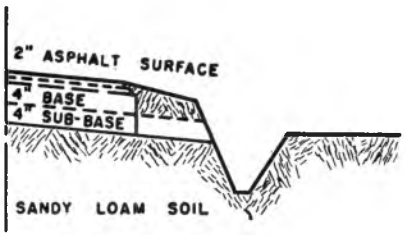
Too many dollars are spent for patching, surface maintenance, and repair that should go toward a more permanent improvement. Last week at a conference in a neighboring state, the question was raised—"What percentage of our road fund are we justified in spending for road maintenance?" You and your road commission should ask this same question each year. Then set about rebuilding a percentage of these problem roads from construction funds each year.

When I ask you to think of a bridge in your county, you think of a structure. It has members connected in such a way that it reaches from support to support or from abutment to abutment and it has strength to carry loads over the stream. Now, let's think of a road. Do you think of a structure? Your road has some relative width. Its length is a part of your vision. But is it often that we think of a road as a structure, a structure put together with specific parts intended to perform a certain function? We readily agree that if we leave just one member out of a bridge structure, it will surely fail. Our concern should be every bit the same for a road structure.

Shall we consider what may be thought of as the essential parts of an asphalt road structure? Refer to Figure 1 (A). First, we think



(A)



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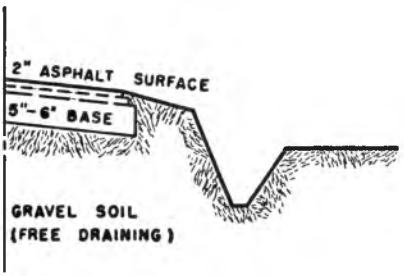

(C)

Fig. 1.

of the (1) SURFACE or wearing course. It is visible to the person driving down the road. He can feel the smoothness or the shape of every irregularity, and to many it is the road. Possibly this is a clue to some of our difficulties. Second, we think of the (2) BASE, generally the greatest thickness of the whole, composed of rock or gravel. At

least, we do think of the base as being essential and as that which provides a service quality to the road. How thick need this base be? Here our vision begins to fade. Do these two items, the surface and the base, alone comprise the road structure? Seldom do they.

Third, we need a (3) SUB-BASE, or lower section, to the aggregate structure. In some areas, particularly deep-frost regions, the sub-base may comprise a greater thickness than the base. Often the sub-base is the *bargain* portion of the road (that is—in the sub-base it is possible to get more value for the dollar spent than in any other part of the road structure). Fourth, the (4) SUB-GRADE, or consolidated soil foundation, must be of concern. The soil in a porous state and open-textured due to frost action must be consolidated so as to provide support to the structure above. Also, muck and undesirable soils need to be replaced with improved material of greater strength that can be compacted.

A fifth essential part needs to be considered, although it is not a layer in this road structure as is the base or sub-base. It is (5) ADEQUATE DRAINAGE. Sometimes two of these members of the road structure can be combined so long as all five functions are provided, but to disregard any one of these functions will surely invite failure as it would to leave a member out of a bridge.

Let's think about rebuilding a road. How do we go about it? How much base do we need? Or, what is this sub-base idea? And what is adequate drainage?

First, what is the soil of the surrounding land or, more specifically, that beneath the road—clay, sandy-loam, or gravel? At what locations did it break up each spring? Let us chart these facts. By a look at the history of the road's past performance, can't we observe just what areas need the greatest attention in the reconstruction?

If we are to reconstruct a road, surely we need to build it to certain minimum standards so that minimum maintenance will be necessary thereafter. A larger portion of our funds can be spent on construction when less maintenance is required on rebuilt roads.

The soil carries the load; therefore, the type of soil beneath a road is the key to the total thickness necessary to be built into the structure. The number and size of vehicles are a factor in the design of primary highways, but we're talking about the *minimum* thickness for local roads with light traffic. Let's say it serves a school bus, milk truck, oil truck, and those people who live on the road.

This *minimum* to which you should build over good farm land, i.e., clay soil, should be 12 inches deep. The exact design can vary some; however, a good practice would be six inches of sub-base, extended through the shoulders to the open ditch; six inches of compacted, graded aggregate, two feet wider than the asphalt surface to be constructed; and a prime with double-sealcoat surface, plus plans for a two-inch, high-type, plant-mix surface to be placed within five or six years. It is likely the improved road will invite traffic to the degree that this added thickness will then be required for maintenance-free service.

If your traffic is to be over 500 vehicles per day, a heavier design probably will be required. Consult an engineer familiar with the Asphalt Institute design procedure for help and recommendations.

Adequate drainage for this road structure of 12-inches depth should provide open ditches that have their flow line no less than six inches below the bottom of the sub-base course. This sub-base course should extend through the shoulder, full width of grade. This is to say that the side ditch should have a depth of no less than 22 inches below the crown of the base course or seal-coat surface. This would allow about four inches of crown in the clay sub-grade. In cut sections side drains are necessary. The sub-base should extend to the sub-drain trench, which should have a porous back fill. Clay soil will not drain rapidly so porous back fill over the tile is necessary.

I am aware that not all engineers concerned with road design agree that a pervious or free-draining sub-base is required. This, I do feel, is a must, for the sub-base gathers all the free water at the surface of a clay grade and should carry it off the grade to an outlet, if the road structure is to perform satisfactorily. In the spring season the clay sub-grade accumulates excess moisture and without the sub-base drainage it will perform about like a clay barnlot at that same time of year.

The sub-base material need not be as high in quality as the aggregate used in the base. It can be sand, gravel, or crushed stone, but keep it free draining. Have sieve analyses made of these materials. To be free draining the portion passing the No. 200 sieve should comprise no more than five per cent of the total. Keep out the clay. Do have the gradation tests made. You can't trust your eyes to determine this.

We have stated that, as a *minimum,* a 120 inch section is necessary for our road over clay soil and that it must be properly built of satisfactory materials. Now let us consider areas where a sandy loam will support our road.

At least eight-inches thickness should be employed over sandy loams. Only the top four inches of this needs to be crushed aggregate. If gravel is used, keep it free of clay and extend the lower portion through the shoulders if the grade tends not to drain readily.

For the third class of soil, the job on top of the gravel ridge where the soil never holds water, six-inch crushed aggregate base course may be sufficient on the well-consolidated sub-grade to provide a structure that will support the asphalt surface. In this case, soil in the grade is nearly the quality of that used for sub-base over the clay soil. Those of you who have this free-draining soil are very fortunate.

Generally, for local county roads the three designs covered in Figure 1 provide a reasonable basis for the selection of a design in keeping with the existing soil conditions and it is expedient to reconstruct with at least the three conditions as a guide.

Frequently the dollar spent for asphalt would go farther if more effort were expended in the preparation of the base course before the asphalt is applied. A well-consolidated aggregate base is to be preferred over one which lacks uniformity. For local roads with light traffic, greater density is likely to be developed by maintaining the base through the first winter as a traffic-bound surface. Considerable watering, blading, and rolling with pneumatic-tire rollers is required if the asphalt surface is to be constructed immediately after the building of the base.

Asphalt prime will be needed on the aggregate base to bind the finer particles and afford a tough and uniform surface on which to apply the more viscuous liquid asphalt film in constructing a double seal coat or on which to lay an asphalt mixture. Some may propose to leave out the prime and stretch the asphalt dollar. It is rare that such a practice can be approved. The aggregate surface must be swept clean of loose fine materials or dust before applying the prime. Uniformity of density in the surface to which the prime is to be applied is most desirable so a thorough cleaning or brooming of the base is necessary to remove the loose material in depressions or pot holes. The prime applied at a uniform rate of application over the surface will not extend through the loose material left in a pot hole so as to tie it to the firm base. Later traffic finds this spot, the loose particles on the base allow movement, and the layer of asphalt and chips over it wrinkle, break, and ravel. I know of one county that makes it a practice to blade the surface of a base to be primed to the depth of all depressions, recompacting with water and pneumatic-tire rollers so as to secure a uniform

surface density before applying the prime. A moist surface will allow more uniform penetration of the prime than will a very dusty surface. A few dollars spent in preparation of the base before application of a prime can result in a more serviceable seal or surface. An MC-O makes a good prime for a very dense base. Indiana State Highway Department specifications also include an asphalt emulsion prime, AE-P. The type and amount of prime should be adjusted to the tightness of the base.

The fact that an asphalt seal is least costly of all asphalt surfaces is no reason for lack of care and concern in selecting proper materials for it or in following sound practice in constructing it. We can't discuss this subject in detail today, but you can refer to published information such as: "Seal Coats and Surface Treatments" by Fred J. Benson, *Proceedings of the 44th Annual Road School,* 1958. We can point out a few pertinent facts. The rate of application of liquid asphalt for a seal needs to be sufficient for embedding the aggregate cover to about one-half the diameter of its average size. The viscosity, the ability of the emulsion or cutback to flow, also determines the film thickness on the road and is of concern. A light application of a high viscosity product can result in ridges or furrows in your asphalt seal. Too fluid a grade will not hold a coarse aggregate, even though a heavy application is made, because it will run off the crown.

Aggregate for the seal coat should be as nearly a one-size material as possible in order to give uniformity. Finer particles, such as sand sizes in gravel chips, cover the asphalt film first and prevent bond to coarser particles. Crushed aggregate (gravel or stone) may afford better retention than rounded particles such as pea gravel in some cases.

Pneumatic-tire rollers on seal coats are desirable over steel rollers and should be used where possible. At least roll the seal in some way. Traffic will not do a thorough job of rolling.

A properly adjusted distributor is necessary for good seals. Angle of nozzles and bar height need to be checked for uniform work.

With increased volume of traffic and heavier wheel loads it becomes necessary to increase the thickness of the asphalt and to improve the character of the surface. There is little question but that well designed and controlled plant mixes can provide maximum stability and greatest uniformity, both of asphalt content and of aggregate gradation, so very important to the long life of an asphalt pavement surface and should be used for this purpose wherever size of the project warrants and will invite competitive bidding. Areas where hot-mix plants are not available

and where the quantities involved will not warrant moving in a plant, a cold-mix or mix-in-place surface will provide more service than seal-coat applications.

The specifications of your State Highway Department provide both hot and cold mixtures of proven serviceability and your local contractors are familiar with them. You are encouraged to follow them as your guide. High-type mixes such as those provided by Sections D3 and D4 in your Indiana specifications are designed for durability and do not require a seal coat. Where a seal coat is part of the design, it most certainly should be used. A seal applied to a cold-mix mat will surely make the dollars invested in the mat go farther.

In conclusion let it be said that getting more blacktop miles per dollar can be realized by reconstructing roads that steal maintenance funds, with special concern for sufficient structure thickness to fit the soil foundation. A clay soil requires *at least* 12 inches of aggregate structure, with the lower course of aggregate extending through to side drains or the open ditch, if an asphalt surface is to give satisfactory service. A carefully prepared base for prime-coat application may be the key to service by a seal coat. A clean, well-adjusted distributor and clean, crushed cover aggregate are highly desirable. High-type plant mixes provide the most desirable surface when plants are within reach and a seal on a cold-mix is a necessity.