Bituminous Concrete Surfaces

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Kentucky is a rural state with many traditions, historical sites, and recreation areas and with many natural resources including timber, coal, and gas. With reference to transportation facilities, there are 18 counties not touched by a railroad, and 35 county seats relying entirely on highway transportation facilities. Louisville is the only city of considerable size.

The topography of the state varies from the mountainous section of the east, through the rolling central region, to the bottomlands of the Cumberland, the Tennessee, the Ohio, and the Mississippi rivers. Many rivers and streams thread their way through the state.

In the mountain section, slides constantly create problems for the highway engineer. Narrow valleys, which include just the mountain, the railroad, the highway, and the river, provide a real problem in highway construction and maintenance. Add to this picture the tearing and destructive effect of flash floods.

I call attention to these facts so that you may see it is necessary to stretch the highway dollar in Kentucky. It sometimes means buying overalls instead of a tuxedo.

The aggregates available for highway construction and maintenance consist of limestone, river and bank gravel, slag, and sandstone. All are used to a considerable extent except sandstone, which is only used occasionally. In certain parts of the state, because locally-available aggregates and railroad facilities are lacking, the cost of road materials is high. In practically all cases, the aggregates used are unwashed.

There are 10,277 miles of highway in the primary state system of which 2,610 miles are high-type pavement (bituminous and concrete), 4,722 miles low-and medium-type bituminous pavement, and 2,945 miles traffic-bound. The traffic-bound roads are maintained by grading, dragging, and adding crusher-run material throughout the year, particularly in the spring and fall periods. After a certain stage is reached in the stabilization of the surface, the addition of certain aggregates does not noticeably increase the surface depth. During the war and since that time, the lack of proper equipment, particularly motor graders, has

made the maintenance problem more acute. Because of these conditions and the dust nuisance, we are applying a light bituminous treatment to a considerable mileage of traffic-bound roads each year, particularly those having a traffic count of 100 to 400 vehicles per day.

Consideration is given in this operation to the depth of the present surface, the type and intensity of traffic, the probable increase in traffic due to the proposed bituminous treatment, weak sections which may require strengthening, and proper drainage. The proposed treatment puts an umbrella over the road, is expected to be about 90 percent satisfactory, and will require some patching and special treatment in limited locations; but has been found to be economical considering the retention of the aggregate on the road, reduction in maintenance cost, and favorable public reaction. It is anticipated that an additional treatment will be placed the following year, at least a seal coat or heavier surface depending on pavement performance.

Stage Construction

The first part of the operation consists in windrowing the loose surface aggregate, and adding a sufficient amount when necessary to provide a minimum of 40 pounds per square yard. A half-gallon prime coat of a light bituminous material, either asphalt or tar, is then applied. After this prime coat has cured sufficiently and has properly penetrated the base, a tack coat of not less than 0.15 gallon of a heavier asphalt is added. Immediately thereafter the loose material in the windrows is bladed over the surface and dragged with a wire or broom drag.

Asphalt at not less than 0.35 gallon per square yard is then applied; approximately 25 pounds of chips per square yard are spread uniformly, and the entire surface is rolled. This is the first step in bituminous stage construction. The cost ranges upward from $1,500 per mile. Operations may be adjusted to the needs of a highway by increasing the amount of bituminous material and aggregates and manipulation thereof, thereby increasing the cost. A program for this type of bituminous surface was launched in 1945, extended in 1946, and will be carried forward in 1947 in the same ratio, i.e., about 300 miles per year.

I do not believe that there is a great deal of difference in the specifications or methods used in various states as to initial, seal coat, surface, or mixed-in-place treatments. Insofar as this discussion is concerned, I will assume that such is the case. In Kentucky, the specifications provide for an allowable variation in aggregate proportioning in mixed-in-place treatments and, when a more open mix is used, a seal

coat is added. However, ordinarily the denser mix is specified, eliminating the need of a seal.

After the light treatment just described, the next step in the development of a bituminous surface is usually a road mix. It occupies a place of its own up to about 75 pounds per square yard. It is used in heavier treatments in many locations, and especially when it is not economical to install mixing plants. Treatment with more than one course is often specified. The road mix may be used to advantage in the correction of irregularities in a road surface, improving riding qualities, and adding pavement strength and stability. Its use is naturally affected by the intensity of traffic encountered. It is not easy to build a road-mix surface under fairly heavy traffic, although this is frequently necessary. In many parts of Kentucky, detours are difficult and sometimes impossible. This has often resulted, in cases where the traffic demanded a substantial highway, in use of a plant-mix surface so that the improvement could be made on half of the road at a time with less inconvenience to traffic.

Bituminous Concrete

In Kentucky, two types of plant-mix bituminous concrete surfaces are commonly used—Bituminous Concrete Surface (hot-mixed, hot-laid asphalt), Class I, and Bituminous Coated Aggregate, Class F. The main difference between the two is that under the Class I specification, closer control of the materials to be incorporated in the mix is required. Both provide a method of specifying various sizes of aggregate properly proportioned in base, binder, and surface. Ordinarily, surfaces of over one and one-half inches in depth are laid in more than one course. Wedge courses are used to take out inequalities in pavement surface. In general, Class I surfaces are specified on city streets and heavily traveled highways. Consideration is also given to the location of permanent mixing plants, as their installation is made for the production of the highest-class material.

Under certain conditions, alternate bids are invited for both road-mix and plant-mix materials. An arbitrary difference in weight is set up in favor of the plant mix. This policy has resulted in healthy competition. The award is made on the low bid. Plant mixes have been placed at a minimum of 75 pounds per square yard and given satisfactory service. In such cases, definite information is necessary in regard to the stability of the surface on which the bituminous concrete is to be placed, as well as the character and density of traffic to which the surface will be subjected. From my own experience, plant-mix surfaces, taken as a

whole, are more uniform in texture than road-mix surfaces. However, many road-mix surfaces compare very favorably with them in this regard.

Summarizing, it appears that bituminous surfaces advance from the light treatment to road-mix and plant-mix with a middle territory where either may be used, subject to consideration of the varying conditions of base and traffic density and character—both before and after the proposed improvement. In addition to the miles of light treatments

Bituminous concrete pavement with Western Kentucky bank gravel in the binder and crushed limestone in the surface course. The base was an old cement concrete pavement. Natural deposits of bank gravel requiring little or no treatment are extensively distributed throughout the portion of Kentucky west of the Tennessee River.

heretofore mentioned, in 1946 were placed 750 miles of road-mix surface and 550 miles of plant-mix surface.

In order to properly appraise the value of this material for use by the state in surfacing work, an experimental section was set up on a heavily traveled highway near Paducah. This highway had originally been constructed of concrete, using Tennessee River gravel as coarse aggregate. As time went on, the maintenance cost had become excessive, and in 1943 it was decided that 2.67 miles of this road should be cov-

ered with a bituminous concrete using bank gravel as a binder and with a specially designed, dense limestone wearing course. Necessary repairs required before placing of the surface were done by the maintenance forces.

The road was divided into two sections, and each section was divided into four parts of equal length. The first section was designed to receive two 150-pound bank-gravel binder courses, and one 75-pound limestone wearing course. The other section was designed to receive one 150-pound gravel binder course and one 75-pound limestone wearing course. The purpose of constructing two different thicknesses of binder course was to determine the required thickness for future use. The purpose of using plant-mix bank gravel for these binder courses was to find out its behaviour under traffic.

The mix design for the bank-gravel binder course was set for 6 percent of bituminous material. Four types of bituminous material were used on this project—Medium Curing Asphalt No. 5, Refined Tar No. 12, Asphalt Cement 85-100 penetration, and Asphalt Cement 120-150 penetration. On the first half of the project, the same bituminous material was used in both binder and surface in each individual case. On the second half of the project, the same four bituminous materials were used in the binder, but Asphalt Cement 120-150 penetration was used in the surface throughout.

The experiment has indicated that bank-run gravel can be used advantageously and economically for base and binder courses. There is no indication of any difference in the strength of this particular pavement as between one binder course and two binder courses. The results of the experiment are such that under heavy traffic a heavy tar or 120-150 penetration asphalt cement is advocated. In lighter traffic, tar or cutback asphalt would render satisfactory service.

A limited amount of bank-run gravel has been used satisfactorily in road-mixes in which the same recommendations are advocated.

We are now experimenting with bank-run gravel as a wearing course. No definite conclusion has been reached. Depending on pavement performance, it may be necessary, after the mix has been tested by traffic for a year or more, to place a bituminous seal coat, using limestone chips or a dense graded bituminous-limestone surface.

Variations in Aggregate and Bituminous Materials

Another experiment which has been of considerable interest has been conducted on Route U. S. 60, a heavily traveled highway between Frankfort and Versailles. This section of highway had a bituminous

surface. During 1942 and 1943, an experimental plant-mix bituminous surface, in which ten different gradations of aggregate were used with each of five grades of asphalt and one grade of tar, was constructed on this road. Limestone coarse aggregate with limestone, river sand, and concrete sand-fine aggregates in varying proportions was used. The bituminous materials used were Rapid Curing Liquid Asphalt No. 5, Medium Curing Liquid Asphalt No. 5, Refined Tar No. 12, 85-100 penetration Asphalt Cement No. 6.

Excellent performance of plant-mix bituminous surface on U. S. 60 near Versailles. The application was about 75 pounds laid over an existing bituminous pavement. Construction—1943; traffic—approximately 5,000 vehicles per day, 1,250 of which are trucks.

The results of this experiment so far indicate advocating the use of a high-penetration asphalt cement on heavily traveled highways. The experiment also indicates that a shift in loads causes the heavier asphalt cements to crack and remain open. The lighter asphalt cements crack but tend to heal. In the case of cutback asphalts, no fracture is indicated but the surfaces tend to shove.

With regard to aggregates, performance seems better when fines are increased to maximum density, and there appears to be less pitting of

surface on sections where limestone fines were used than where sand was used as a fine aggregate. Concrete sand seemed to get better results than the river sand. This experimental project is still being watched and maintenance of the surface is discouraged until results have been fully determined.

In certain parts of Kentucky, sandstone is the only aggregate available. In the eastern part of the state, a highway was built with sandstone base and surface showing some slight evidence of pitting due to fractured units. The surface course was a well-graded and dense mix; 100% of the aggregate passed a ½-inch screen, with 6½% passing a No. 200 mesh screen. The bitumen content was 9%.

Further research is now being conducted by the Highway Research Laboratory at Kentucky University to determine the possibility of further development of this type of surface in order that the state may, if possible, take advantage of this local material. There has been some difficulty in quarrying sandstone because of the severe wear on equipment, and this situation has been aggravated by the equipment and repair parts situation of the past few years.

Don't Overlook Local Materials

You will note that I have listed a limited number of experiments on the use of several types of bituminous materials with various aggregates, some commercially produced and others locally available. It is my own personal opinion that the surface has only been scratched in investigation of the use of aggregates which are locally available and adjustment of bituminous materials to particular situations. It seems to me that the approach to this problem has not been sufficiently broad, and there has been a tendency to require materials to meet the book of specifications rather than to write a specification to make use of local materials that would serve a useful purpose at a considerably less cost. We are cutting our cloth from too few patterns.

On the other hand, in these days of favorable reaction to the use of mixed-in-place and plant-mix bituminous surfaces, we should not overlook the fact that such a surface is not a cure-all for all the diseases of a highway. There is still need for an intelligent and engineering approach to highway surfacing; drainage, base, soil, and other causes of failures need to be surveyed and analyzed in order to arrive at the proper treatment of the patient. In these days of hustle and bustle to get a program under contract, research is sometimes limited in its possibilities for maximum service.