Bituminous Construction
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INTRODUCTION

In a highway program involving 38,000 miles of secondary, or farm-to-market roads, and 8,000 miles of primary and 1,106 miles of interstate highways, forceful attention must be directed to all construction and maintenance practices. In Virginia, which is primarily a rural state, these 47,000 plus miles of highways pose difficult, but not necessarily unusual, problems in financing, construction, and maintenance. We are one of the few—only four or five—states that have all county roads under its jurisdiction. This, coupled with the fact that we are on a pay-as-you-go basis, means pennies are counted and performance must be good.

Allocations of $191,000,000 for our fiscal year, 1960-61, to the various classes of highways anticipates the spending of $100,000,000 in state funds and $91,000,000 of federal aid funds. This is a large sum of money and represents expenditures in which all individuals are vitally concerned. It is not known how this amount of money compares with the funds available for road building purposes in Indiana per year, but regardless of the amount you are also interested in seeing that it is spent wisely, profitably, and to the best interests of the citizens of the state.

Virginia has built the major portion of its primary highways of bituminous type construction. A recent tabulation shows only 369 miles of portland cement concrete and a goodly portion of that has been resurfaced with bituminous concrete. There are 3,389 miles of asphalt plant-mix roads. The balance of the 8,000 miles in the primary system is of either bituminous or waterbound macadam with a surface treatment. Recent trends in construction are toward black-base bituminous concrete roads. Macadam pavement designs are largely eliminated in favor of either 5½" or 7½" black base with 1½" surface or wearing course depending on volume and type of traffic anticipated.

1 Presented as part of a “Symposium on Inspection and Control of Highway Construction.”
With only a reasonable start on the construction of our interstate system, we have 18.5 miles of portland cement concrete pavement completed and 7.3 miles under construction. There are 36.6 miles of bituminous concrete completed and 38.6 miles under construction. You will see this is a ratio of about three miles of bituminous concrete to one mile of portland cement concrete pavement. For economic reasons this ratio is likely to increase as the program advances.

In any type of construction there is always a great deal of engineering study and knowledge which precedes actual field construction. Highway construction is no exception. We have civil engineers, geologists, soil engineers, location and design engineers, etc., all contributing their fair share to the plans and specifications which represent the completed study portion of the project. Generally, from there on to the completion of the pavement, the civil engineer takes over with a big assist from the materials engineers and technicians.

The assumption can be made that the engineer will specify the use of only quality materials. This does not imply the minimum quality that can be tolerated, but the highest quality available, commensurate with the economics of the situation. Many states have learned to use to good advantage those materials which, judged by the standards of another state, are decidedly inferior. Whatever materials are used, it is your money that is being spent for highway construction and you have every right to demand it be spent wisely—for your riding comfort and most of all for your personal safety.

Just what are we looking for or expecting in bituminous concrete construction? Most of all we want a surface on which to ride and to transport articles of trade and commerce. This is expected to be fast, cheap, and safe. It must be economical, not only in first cost but on a cost per year basis, and capable of being maintained with a minimum of interference to those using the facility.

How is this best accomplished? The importance of good standards for materials and the determination of the quality of the materials used has been fully discussed. The proper utilization of the base materials upon which the bituminous concrete will rest and perform has also been fully covered in this symposium. The problem then revolves around the manufacture, handling, and placing of the material on the uppermost part of the pavement structure.

TECHNICIAN TRAINING PROGRAM

We believe that the one outstanding need to insure a good bituminous concrete construction program is an inspector or materials tech-
nician training program. In Virginia we have eight construction districts with a materials engineer in each district responsible for the proper use and control of approved materials in all construction. It is under his direct supervision and through the materials technician that the production of quality materials meeting all specification requirements is assured.

Specific and concentrated instruction is given to selected men over a two-week period during the winter work shut-down. A few years ago we found ourselves teaching relatively large classes of 20 to 25 men at a time, most of whom had never been around a mixing plant, didn't want to be, and for the most part were never assigned any duty around one of the plants or on the road. It was easy to see we were taking care of a large number of men in the wintertime who had nothing to do in the field. In all fairness, these men were probably receiving some benefit from their experience, and it is hoped the state did also, but they were not the men we desired to teach and needed to teach to improve our bituminous program. This has now settled down to a point where only those men who are definitely to be assigned as an inspector or materials technician on bituminous concrete work are accepted. Classes have been limited to groups of eight-ten men divided between two construction districts for a two-week period. This series of classes thus extends over a period of two months with an extra class frequently added.

Classes are held in Richmond and the men are given expenses and transportation to and from their headquarters. While we do not have bona fide teachers or professors to handle the classes, the instructors are well trained in both laboratory and field techniques. As might be expected there are a number of men who are selected for one reason or another to receive repeat or refresher training from year to year. These men are the ones who are primarily responsible for continued improvements in bituminous construction. With our experience added we feel the program is improving yearly and is paying dividends in improved pavement performance.

The general course of instruction includes laboratory training in the properties of the component materials, asphalt, aggregates and fillers, mix design, extraction procedures, plant construction, and the handling of materials on the job. Specifications for the materials are explained, field trips are made to typical mixing plants, and the proper relationship between the contractor and the state representative, all receive proper emphasis. It is not always possible to find an asphalt plant in operation in the wintertime, but some plant gets a good going over by
the group and this is of real benefit to the new men. Having an
opportunity during the instruction period to actually calibrate and set-up
a continuous mixing plant in the field is extremely valuable training.

One of our best training aids is a balsa wood model of a typical
batch mixing plant. This model, shown in Figs. 1 and 2, is an almost

Fig. 1. Near-scale model asphalt plant.

exact scale model of a plant operating in Richmond and was built by
one of our laboratory chemists. It has cut-away features which provide
an insight into plant operation that is difficult to present otherwise.

Another excellent training aid is a small working model of a double-deck screening arrangement. With this model it is possible to feed
actual samples of aggregates onto the top deck much as they would
be delivered from the hot elevator on a plant. This is shown in
Figs. 3 and 4. The various sizes are separated and drop into their
respective bins with all oversize particles scalped off. We had found
it extremely difficult to present clearly to any of our classes exactly how
aggregates are separated into various sizes and put in the proper bin
on a mixing plant before building this model. We use this model
not only to show screening operations but also to assist in solving the
problem of recombining aggregate fractions in the proper proportions
to meet specified job mix formulae.
A session devoted to the use and proper care of the actual testing equipment which will be used in the field is important. Particular effort is made to give the trainees an appreciation of the monetary value of the equipment, its effectiveness when properly used and cared for, and finally its value in maintaining control over a particularly critical and important item in road construction.

OPERATING PROBLEMS

It is considered that plants operating in Virginia compare quite favorably in efficiency and operating conditions with plants in other areas. There is a broad range in mixing and drying capacity and in the age of the plants. Many new plants are now in operation, some fully-automatic with push-button control, others semi-automatic, and the
balance manually operated. The older plants are for the most part still operating effectively due to careful maintenance and inspection requirements. There are between 75 and 80 plants in Virginia, all of which are capable of making specification mixtures.

A well-planned and organized plant will give a minimum number of problems to the inspector. Maintaining stockpiles clean and positively separated from other stockpiles is of benefit in maintaining uniform screening efficiency. At some plants, where space is at a premium, bulkheads may be required between stockpiles and should be provided. It may be decided that the degree of screening efficiency is not important, but it is vital for continuous successful production of mix that it be maintained uniformly. Overcrowding of screens to the point where there is no effective separation of aggregate sizes should never be permitted.
The charging of a plant through the cold feeder bin becomes an efficient operation when a multiple compartment bin is required through which different sized aggregates can be proportioned. Positive locking gates to maintain desired proportioning are of help.

Dryers are generally of the rotating cylindrical type, either single- or double-shell. They should be capable of heating and drying the aggregates to the proper mixing temperature and moisture content. Recent studies in several states have called special attention to the importance of proper moisture control in bituminous mixes. There is no general agreement as to what the actual residual moisture content should be, but the maximum of 0.2 per cent might be considered a practical working limit as well as one not likely to give difficulties in mixing, laying, or performance of the pavement.

Aggregates that are dried, separated, and proportioned for mixing are blended with the bituminous material in accordance with the mix design in a suitable pugmill to produce the desired mixture. There is a real need for more information on what constitutes adequate mixing. Considerable doubt has been placed on the correctness of specifying, for example, a dry mix time of 15 seconds followed by 45 seconds of wet mixing. With the many combinations of pugmill dimensions plus various paddle tip settings, speed of rotation of the shaft, and peripheral
speed of the paddle tips, it is easy to see there can well be variations in mixing efficiency.

It is of particular interest to note the existence of a joint AASHO-ARBA Subcommittee on Mixing Time for Portland Cement and Asphaltic Concrete. H. A. Radzikowski, chief, Development Division, Bureau of Public Roads, is chairman of the group. Other members have been appointed from the AASHO, highway departments, ARBA, NBCA, PCA, and equipment manufacturers. In addition, subcommittees of the Highway Research Board and the ASTM have concerned themselves with the problem of determining when and how well the combinations are mixed.

Temperature of the aggregates, bituminous material, and mixture receive the attention of an alert inspector. It is now recognized that temperatures registered by a pyrometer located in the boot of the hot elevator may give incorrect information. Measurement of the temperature of the coarse aggregate and the fine aggregate separately will give two different results. Actually, we should be more concerned with the temperature of the aggregate in each of the hot bins at the time of mixing.

Just as the fine and coarse aggregate will emerge from the drier at different temperatures, so will the moisture content vary. Prof. Ward K. Parr, at the Highway Research Board's annual meeting in January 1960, presented an informal progress report of work currently underway at the University of Michigan on this important problem. (Title of discussion—"Moisture in Aggregates in Hot Bituminous Mixtures," presented at a joint meeting of project committees, A-2 and D-1, Department of Materials and Construction.) Further results of this work are expected to be formally presented at the next meeting of the board and will certainly be of great value to all in this field of work.

Because of the inherent danger of damage to the properties of the asphalt cement due to overheating, it is desirable to maintain mixing temperatures as low as possible. More and more attention is being given to the viscosity or consistency characteristics of the bituminous material. Current thinking is that the asphalt cement should have a Furol viscosity of from 75-150 seconds for best mixing consistency. As asphalts from various crude sources all have different viscosity—temperature characteristics, it is essential that the plant operator have this information for best mixing results. Too high a consistency can be expected to result in poor distribution of the asphalt on the aggregate. Conversely, too low a consistency indicates that the asphalt may have been overheated and tend to run off the aggregate thus giving poor performance.
The plant operator who purchases aggregates to meet his grading requirements and insists on those being delivered is a wise operator. To handle, dry, and screen aggregates which cannot be utilized in the mix is a most costly operation. To have incorrect materials on hand tends to create a situation where the dishonest man attempts to use the wrong batch weights in order to utilize the improper stone. This causes unfair competition and generally results in poor mixes.

Successful use and performance of quality bituminous concrete depends to a large extent on how it is placed and compacted. Weather and pavement conditions, whether wet, dry, hot, or cold, are important. Although, it is generally accepted by the road inspector that when a base appears to be surface dry or when the atmospheric temperature is above the minimum specified, then conditions are suitable to go ahead with laying the mix. This may not be good practice. In early spring and late fall internal road moisture and low pavement temperatures are critical in the ultimate behavior of the mixture and should be so regarded.

Very frequently we have permitted late construction in order to complete a job so it can carry traffic over a winter. This is usually called a “calculated risk” and frequently no difficulties are encountered. On the other hand failures arising from this practice are hard to justify. We had an unfortunate experience recently where we permitted a contractor to lay a thin final surface course on a construction project. The work extended into early November with fairly warm days but cold nights. By Christmas large areas were scaling and longitudinal joints were ravelling. This work will have to be repaved at a very considerable expense.

OTHER CONSIDERATIONS

There are other important points for consideration when discussing the application of the mixture to the road base. Without question the base should be in proper condition—dry and fully compacted. It is extremely difficult to obtain any desired degree of density in bituminous concrete unless you have something solid to compact against. A good prime or tack coat generally insures a proper bond between successive layers.

Many recent improvements in pavers give the contractors a wide latitude in their selection. Most will do a highly creditable job but their operation must be closely tied in with other job conditions. Speed of travel has been highly publicized, but this is of little value—in fact, it may be a detriment—if the job location, plant production, or
other conditions will not permit continuous operation. It is far better to operate a paver at slow speed without stopping than it is to lay the mixture rapidly for each truck delivery and then have to stop and wait for the next load. Each time the paver stops you will be able to find a small ridge in the completed pavement. These ridges give very poor riding qualities to the pavement.

Pavers should be maintained in perfect condition. Perhaps the most important part of the paver is the screed. Daily check of its condition, crown, and straightness insures better pavement surfaces.

Compaction of the finished mix is accomplished for the most part by steel wheel rollers. Initial rolling is by a ten- to 12-ton three-wheel roller. This is followed by eight- to ten-ton, two- or three-axle tandem rollers. Rolling is continued until the specified density is obtained and to the elimination of all roller marks.

Density requirements vary a great deal between various states. Some require a minimum percentage of a theoretical voidless mix, others a minimum percentage of laboratory density of standard compacted samples, while in other locations this requirement may be nonexistent. There are certain inherent difficulties in any plan. Most of these center on technical aspects of compacting samples, absorption of asphalt into the aggregate, whether bulk or saturated surface dry specific gravity is used, as well as the most important problem of obtaining a satisfactory specimen from the pavement for test.

We have not specified pneumatic tire rolling. There is a lot of study and attention being given to this procedure with the principal emphasis being placed on tire pressures and the contact surface area. There is little doubt but that proper pneumatic tire rolling can be most effective in approaching the pavement density obtained under traffic.

Smoothness of the riding surface is quite important to the travelling public. Our specifications require that the completed base course be smooth and true to grade and cross section, and that irregularities under a 16-ft. straight edge shall not exceed ¼-inch. The surface course shall not contain irregularities in excess of ⅛-in. under a 16-ft. straight-edge.

BLACK BASE PAVEMENTS

Mention has been made of our black base pavement design. A typical design is shown in Fig. 5. You will note the pertinent items of eight-in. select material, six-in. subbase material which extends through the shoulders to the ditchline, 7½-in. bituminous concrete base, 1½-in. bituminous concrete binder, and ½-in. surface course.
Fig. 5. Design for interstate projects with 1000+ trailer trucks and buses per day.

It is of interest to note that the black base bituminous concrete is paid for on a square yard basis. For many years it was the practice to have our materials engineer dig this base and measure the depth of the hole to the subbase. This plan had many drawbacks. It was very hard work; the pavement in the area around the hole was generally distorted making it difficult to measure accurately; and there could be no check on the measurement. We now have a trailer-mounted core drill in each of our construction districts. Cores are drilled and used for checking pavement depths. On a 7½-in. base job it is required that the material be laid in three courses. Very frequently, for the convenience of the contractor, depth checks will be made after the second layer is placed. This frequently saves later problems as shy places can be more readily corrected on the third and final course of the base.

Fig. 6 shows a series of three cores taken from an early black base project. You will note a wide variation in their heights.

Fig. 7 shows three more cores from the same job that are somewhat better, and Fig. 8 shows three cores of reasonable uniformity.

These do not necessarily represent improvement on this particular job due to the use of a core drill for determining pavement depths. However, it is believed they do represent typical conditions that probably exist on many black base projects where pavement depths are not accurately measured. As this base depth is a part of the pavement design and is relied upon to provide the necessary bearing capacity for the pavement, it is essential that it be built into the pavement. To date we are highly pleased with our program of coring these jobs for
depth. Our contractors are also approving this program as a means of having uniform statewide control.

Of possible interest is our specification requirement for the correction of shy pavement depths. Section 325.05 of our 1958 Road and Bridge Specifications reads in part: “For sections of pavement which are deficient in thickness by more than one-quarter inch, the contractor

Fig. 6. Black base pavement cores of variable height.

Fig. 7. Black base pavement cores for depth checks.
shall furnish and lay top course material where the depth of deficiency does not exceed one-half inch. When the deficiency exceeds one-half inch, the contractor shall furnish and lay mixtures made with coarse aggregate to bring the pavement to the specified depth. Where the deficiency in depth is corrected by placing additional material simultaneously with the top course, the rate of deduction from the tonnage allowed for pavement as top course shall be calculated at a weight of 111 pounds per square yard per inch of depth.

"Additional pavement over the contract unit price will not be made for any pavement the average thickness of which determined as herein provided, exceeds the thickness shown on the plans."

**SKID RESISTANCE CONSIDERED**

Safe nonskid surfaces are a must in any paving program. As in many other areas, Virginia has a number of limestone and dolomite aggregates that readily polish under traffic. These aggregates are not permitted to be used in surface course mixtures. It is now standard practice to use a sand-asphalt mix laid at a rate of 60 lbs per sq yd or to specify the use of a special deslicking sand mix laid at the rate of 25 lbs per sq yd. The sand in either type of mix is a silica sand, and in the latter case it is required to have a minimum silica (SiO$_2$) content of 95 per cent.
We have been well pleased with our program of bituminous concrete inspection and construction. The black base adapts itself to ease of construction and with a minimum of inconvenience to traffic. The principles of inspection and construction procedures outlined have permitted us to provide smooth, durable, and safe bituminous concrete pavements.

To those responsible for bituminous construction, we recommend a good training program for inspection personnel, proper checks on all specification details, and the building of a pavement structure having all the durability and safety characteristics essential for modern traffic.