Evaluating and Resurfacing Old Pavements in Virginia

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This paper reports on the methods of evaluating and resurfacing old highway pavements in Virginia. With traffic increasing at the rate of about 5 percent annually, and with 50,000 miles of roads in the state highway system, this maintenance function must have high priority if adequate safety and service are to be provided. The Virginia Department of Highways evaluates the road system by historical performance in areas such as safety, cost to maintain, relation of service to other roads, available funds, and the most economical methods of restoring roads to original condition. Types of resurfacing are based on results of experience gained by research and materials use and by availability of materials. Because the road system is so extensive and varies from heavy-volume Interstate routes to light-volume secondary roads, it is necessary that the approach to evaluating and resurfacing remain flexible to take advantage of all possible economies. The department believes it has developed a satisfactory method of evaluating and restoring old surfaces by using historical data, by using the judgment of the resident, district, and maintenance engineers in each case, and by having specialists in materials and research available for detailed investigations if necessary.

•OF FIRST PRIORITY in our resurfacing program is resurfacing roads that have been determined to be slick and have a predicted skid-resistant coefficient reading of less than 0.40. Although we do not have at the present time a complete log of all road surface coefficients, this program is under way by our Research Council. All skid-resistant coefficient readings are correlated to a predicted car reading at 40 mph.

Of second priority is the resurfacing of roads that are at accident-prone locations where the road surface may be in poor condition, have improper superelevation, not be sufficiently wide, lack deceleration lane, or have excessive dips.

After allocations for these priorities are made from the funds available, the following procedure is used.

The resident engineer reviews the need for resurfacing of the Interstate, primary, and secondary mileage under his jurisdiction and furnishes the district engineer his recommendations for the Interstate and primary highway systems. This recommendation is based on the visual condition of the surface and performance of the road in question. Information as to the road base and surface are available to him. The type and amount of the last treatment and surface maintenance costs for the road are also available for consideration. Recent instructions state that chip-seal treatments will generally not be placed on any Interstate or primary road (Class 1 or arterial) unless the previous treatment was a chip seal. After the recommendations are made to the district engineer, one of the maintenance division engineers reviews the requests with the district engineer and the resident engineer. The district materials engineer and others are called in when special conditions exist or a more thorough investigation of the road failure is determined necessary before a decision is made to resurface.

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Because we are endeavoring to improve our system of evaluation and determinations for resurfacing, we are looking at some of the studies currently under way in other states. Most current studies, with which we are familiar, use a combination of means to arrive at a figure that relates to need. In all cases so far, there is a provision for a judgment factor. In an interim report concerning the AASHO road test findings applied to flexible pavements in Virginia, N. K. Vaswani of the Virginia Highway Research Council indicated a correlation could be established by using the deflections of the road to determine the thickness of the overlay.

For the present, we feel that, by having the historical data on the road and by using the judgment of 3 engineers for general conditions, plus having our specialists in both the Materials Division and at the Research Council available for any detailed investigation, we have arrived at a very satisfactory method for evaluating and restoring old surfaces.

Unless something exists out of the ordinary, the retreatment program on the secondary system is left to the resident engineer with some efforts being made to review in the office his recommended course of action.

TYPES OF TREATMENT

Realizing the need for new methods and materials in the resurfacing of highways, we have been developing different approaches to the control of bituminous plant-mixed material. Because bituminous paved roads in Virginia have traffic volumes ranging from a high in excess of 90,000 vehicles per day on some sections of the Interstate System to a low of 50 vpd on a secondary road, we have to allow for the maximum amount of flexibility in order to provide the necessary services within funds available.

Our first prerequisite for an overlay, be it chip seal, slurry seal, or plant mix, is that, if the traffic count is above 1,000 vpd, the surface material will be manufactured with a nonpolishing aggregate. This criterion has been modified slightly now since our Research Council, Materials Division, and Maintenance Division have been and are trying mixes using various percentages of a combination of polishing and nonpolishing aggregates, which so far are proving satisfactory. This has had a tendency to decrease the cost of overlays in areas of the state where nonpolishing aggregate material is not locally available. The dividing line of 1,000 vpd is not firm but is generally the maximum range for use of polish-susceptible aggregates in wearing courses.

Plant-mix overlays are not restricted to any particular road system; however, the decision to upgrade a secondary road surface and service is a decision to be made by the district engineer with concurrence by the Secondary Roads Division and with the recommendation of the Maintenance Division being considered.

On high-type primary and Interstate routes, the basic cause for resurfacing has been the failure of the surface to perform as a satisfactory wearing course and sealer of the base. When this occurs, we normally recommend and apply at 100 lb/sq yd our toughest and best performing mix, designated S-5 (Appendix C). This reestablishes the structural integrity of the base by sealing the surface while providing a suitable wearing surface.

On roads carrying traffic volumes of up to 5,000 vpd, we permit the use of plant mix designated S-4 (Appendix C). To correct surface failures, we apply this mix at approximately 100 lb/sq yd.

With the exception of the Interstate System, when a combination of surface failure and base distortion takes place, the rate of application is increased to the point of reestablishing a reasonable road section with a mix designated I-2 (Appendix C). On the Interstate System, we increase the rate of application of our S-5 mix.

With the I-2 mix for the past 6 years, we have been using a combination of polish-resistant coarse aggregate and polish-susceptible fine aggregate to obtain a skid-resistant surface in areas of the state that do not have locally available polish-resistant aggregates. Previous experienee has defined polish-resistant and polish-susceptible aggregates; however, in the very near future we expect to define the aggregates by chemical means, which would be more exact and allow for the use of some materials in selected instances that are considered unacceptable now.

We are using a combination of sand and No. 10 polish-resistant stone screenings for a tough plant-mix seal coat on roads that are essentially sound but need a new surface. This is being used on curb and gutter sections to a good advantage as well as on some high-type primary roads. We have successfully applied this mix at approximately 60 lb/sq yd on roads with a reasonably good cross section (Appendix D). In the area of the state where polish-resistant stone screenings are not available, we have designed a mix that is a combination of 50 percent sand and 50 percent stone screenings to be used on roads carrying traffic volumes up to 2,000 vpd (Appendix D). Based on experience and information available from various research projects, some by our own Council, it was decided to use this procedure to verify the skid-resistant quality of the mix during its life, which at the present time is expected to be from 6 to 10 years.

Local pit materials in combination with asphalt have been used and have produced a good plant-mixed seal on some of the low-type primary roads and some secondary roads.

Because a large percentage of all roads in Virginia are surface treated with either chip seals or plant mix, this is our area of greatest surface rehabilitation. You may recall I mentioned that our first priority for resurfacing is to cover sections of road that have been determined to be slippery. This is generally done using 30 lb/sq yd of plant-mixed treatment consisting of either silica sand or slag sand and asphalt, our designation S-1 or S-2 (Appendix C). These 2 mixes are used only to deslick an existing surface that is otherwise in good condition. The use of this mix is decreasing each year since we have been requiring a skid-resistant aggregate in all surface courses on roads with traffic volumes in excess of 1,000 vpd for the past 10 years.

In order not to become involved with requiring nonpolishing materials in a low-cost mix, it was decided that we could design a more economical plant-mixed material that would generally be utilized on roads carrying less than 750 vpd. This, however, does not rule out the possibility of using this material on roads carrying higher traffic volumes by the use of an additional polish-resistant surface course.

One major factor leading to the production of a low-cost plant mix would be utilizing a material that was readily available at most of the aggregate sources in the state. It was noted that, because of the extensive seal-treatment program in the state, most plant mix would be utilized on roads needing additional strengthening. The type of treatment normally used on roads of this nature consists of mixed-in-place or penetration-surface treatments. After conducting tests on random stone samples in the laboratory, it became evident that a product equal to these surface treatments could be obtained by using a ¾-in. crusher-run material.

The next step was to advise everyone that, by relaxing certain controls, there was a calculated risk of getting what may appear to be a substandard material. However, these odds had to be weighed against the savings that could be effected by virtue of the fewer controls.

The Materials Division was requested to determine what we could expect from various aggregate producers should we proceed in this direction. Samples of No. 26 dense-graded aggregate were obtained from 17 aggregate suppliers and represented materials available in all of the 8 districts. To establish the qualities a crusher-run mix would have, our Bituminous Section proceeded conducting Marshall design experiments in the laboratory with generally good results (Appendix E).

The results from this original testing showed to our satisfaction that we could expect a high percentage of good mixes that should provide good service. It was decided to draft a specification that would allow for the wide variation in material and still be reasonably certain of obtaining a satisfactory product.

Since 1958 the department has an established policy of providing for the resealing with chip seals of secondary surface-treated roads every 5 years. Since it went into effect, we have not had any major spring breakups. This is partly attributable to this policy. In addition, regular surface maintenance costs have continued downward. As a side benefit, we are able to use our forces for other maintenance activities and services. Chip-seal treatments on the secondary system amount to about 95 percent of all treatments of this type in Virginia. For the fiscal year 1969-70, a total of 17 million gal of bituminous material and 650 thousand tons of cover material were awarded to contract for chip-sealing approximately 4,500 miles of road.

The decision on which roads in the secondary system are to receive a chip seal rests entirely with the resident engineer. His determinations are weighed against the general policy, road conditions, and funds available. Essentially maintenance is considered first in the preparation of secondary county budgets; therefore, there is seldom any problem in providing for the necessary treatments.

Seal treatments to be applied to the primary system are generally restricted to low-class primary routes but are occasionally applied to high-type primary roads when there is a need for a seal treatment to maintain the road for a short period of time until more funds are available to place a plant-mix surface or in some instances until the road is reconstructed. It is in this area that the district engineer with the concurrence of the maintenance engineer has to make the final decision. This would be an instance when, in addition to the road condition itself, the priority of funds available and the overall highway program will dictate the treatment.

Slurry seals have been used in Virginia for approximately 4 years. Each year we have expanded their use, particularly in urban areas on subdivision streets, which are classed as secondary roads. This past year slurry seals were placed on some high-speed primary roads in the 2,000-vpd category and are proving to be satisfactory. The cost of this type of seal has been consistently about 20 cents/sq yd. The decision to use a slurry seal instead of a chip seal on secondary roads develops from a recommendation of the resident engineer with concurrence of the district engineer and the secondary roads engineer. This type of treatment has been of tremendous help, particularly in our program of resealing in subdivisions where some roads with higher traffic volumes have a plant-mix surface, and public reaction to chip seals has caused us to change to slurry seal. This and other benefits as described by available literature have to be weighed against the cost, which is somewhat higher. During this current year, approximately 1.3 million sq yd of slurry-seal treatment were applied. With the advent of a rapid-curing system, it is anticipated that more of this type of material will be used, provided the cost remains competitive. It is the recommendation of the district engineer with the concurrence of the maintenance engineer that determines whether a slurry-seal treatment will be used on the primary system of highways.

We have found in Virginia that, to do a good job of overlaying portland cement concrete pavement, we must clean and seal all joints in the pavement prior to placing an overlay. This has a tendency to reduce the amount of joint blowups. We have decided after considerable experimenting that all present methods suggested, such as sanding and paper covering of joints prior to overlaying, do not reduce the chance of reflective cracks showing through. We have been accomplishing more mudjacking and concrete patching repair work to existing concrete pavement in order to maintain the pavement as a concrete road. Recently, we have overlaid concrete pavement when pavement widening was being done in conjunction with the overlay work. On most of the roads where this is done, the concrete pavement is anywhere from 20 to 30 years old and badly cracked and slightly distorted. We have not considered seriously the complete breaking up of the pavement before overlaying because in most cases the roads involved are commuter roads with a very light volume of heavy truck traffic; however, any short section that needs more attention is corrected by removal or additional build-up, depending on which is the more economical and the safest to perform under traffic conditions at the time.

Because of the urbanization taking place in Virginia and the ever-increasing traffic volumes and loads on the roads, we are confronted with roads that need more attention than just spot-patching and covering with a thin overlay. In some of the earlier subdivisions, it is necessary to undertake corrective action that will not raise the elevation of the road surface because curbs and gutters are in place. In these instances, it was decided to scarify and remove any excess material from the roadway and then add either hydrated lime or portland cement in amounts determined by tests to be adequate, remix, compact, and seal. The seal serves as a curing membrane. Then this is covered with approximately 125 lb/sq yd of bituminous plant mix. This same procedure is used on other types of roads where it is determined that rehabilitating the base will justify the expenditure of funds and be the most economical method of repair.

SUMMARY

The Virginia Department of Highways essentially evaluates the road system by historical performance including safety, cost to maintain, relation of service to other roads, money available, and most economical method to restore the road to original condition. The final decision is the result of engineering judgment from at least 3 levels in the department's organization. The type of resurfacing is based on results of experience gained by research, material usage, and material availability. Because the road system in Virginia varies from the Interstate System to the secondary system (farm-to-market roads), it is necessary that the approach to evaluating and resurfacing remain flexible to take advantage of all possible economies to provide for a safe, usable facility.

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Appendix A

FINANCING

To completely understand the reasoning of our approach to updating road surfaces, you first have to understand our method of financing, which is a little different for each of our 4 systems of roads: Interstate, primary, urban, and secondary.

The Maintenance Division prepares preliminary estimates for anticipated maintenance needs based on personal observations of all of the field engineers and those in the Maintenance Division for the Interstate and primary systems of highways and presents them to the director of operations with the request that funds in the amount requested be made available for the next fiscal year. When the Highway Commission decides on a final figure, an allocation is made for maintenance on these 2 systems of highways as a lump-sum allocation.

The urban system (within incorporated limits of cities and some towns) receives funds on a per-mile basis as set forth by the Legislature for the maintenance of roads and streets within the corporate jurisdiction.

Our secondary system funds are allocated by lump sum for the maintenance and construction of all secondary roads over which the department has control. The amount is determined by formula as arranged by the acts of the Legislature.

More specifically, the funding of maintenance replacement activities, one of which is the restoration of existing road surfaces by resurfacing, is provided as follows:

1. Interstate System—All Interstate maintenance funds are pooled. From this total, funds for fixed expenditures are provided for in each district, then anticipated maintenance replacement funds are set aside based on estimates for the amount of work needed. The remainder of the maintenance funds are allocated to the district on the basis of vehicular traveled-miles and lane-miles of road.
2. Primary system—Maintenance funds received are for all practical purposes distributed to the districts on a factor basis in a lump-sum amount for further distribution to the counties by the district.
3. Urban system—Funding is handled by the local governments.
4. Secondary system—The distribution to each county is by formula and on a lump-sum basis. The resident engineer has instructions in preparing his budget to provide first for the necessary ordinary maintenance funds, then for maintenance replacement funds, and then for construction funds. Once funds are allocated to a county, they remain allocated. All surplus or deficits are carried forward to be either redistributed

or financed from the following year's funds. (The secondary system of highways includes farm-to-market roads, subdivision streets, and streets in towns of less than 3,500 population that are not otherwise included in the primary system.) At the time the state was obtaining control over these roads, 2 counties chose not to come under state control. In these 2 counties, the secondary system is still constructed and maintained by the county.

Appendix B

ORGANIZATION

A brief discussion of the Virginia Department of Highways' organization might help explain some of the reasons behind our operational policies.

The Highway Commission is composed of 8 members appointed by the governor representing each of the 8 districts of the state.

The commissioner is appointed by the governor and serves on a full-time basis as head of the department and chairman of the commission. The chief engineer, who is also the deputy commissioner, is the head administrative officer of the department. Directly under him are 4 directors, each supervising the functions of their assigned divisions. The abbreviated organizational chart shown in Figure 1 may help explain the functional levels of the department.

The district is the highest operational unit of the department and generally oversees the residency's operations on construction and maintenance.

The residency unit, headed by the resident engineer, is responsible for the proper execution of department policies and procedures for the areas under its jurisdiction

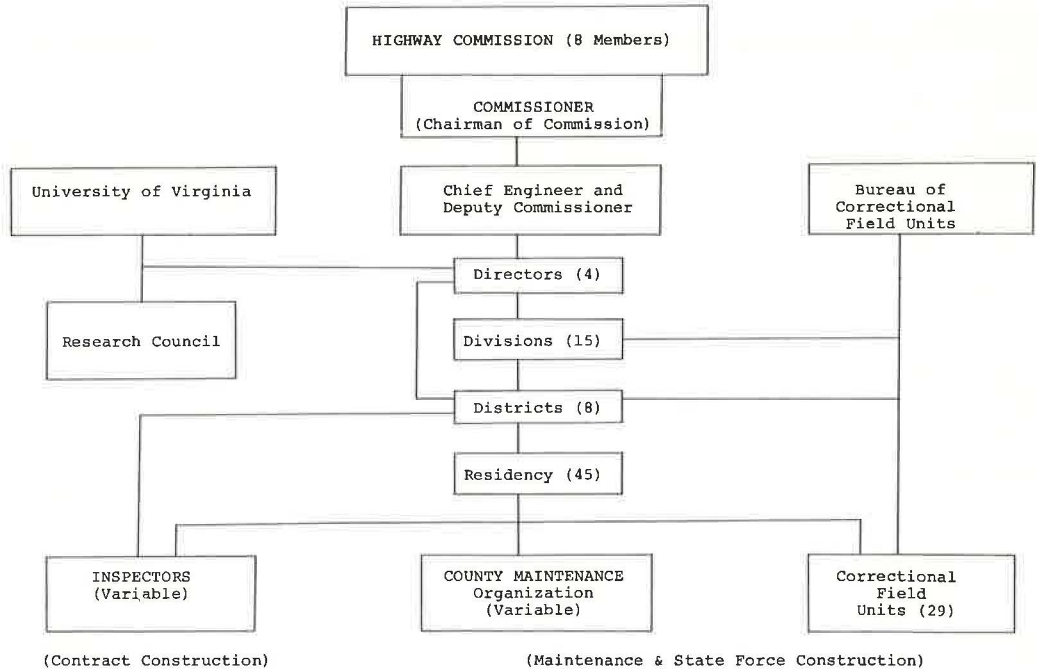

Figure 1. Organization of the Virginia Department of Highways.

as they relate to maintenance and construction. This may vary from 1 county to as many as 4 counties. The resident engineer usually has at least 1 assistant, a residency maintenance supervisor, and a project engineer to directly oversee both maintenance and construction activities.

Appendix C

STANDARD SPECIFICATIONS

Type S-1 Bituminous Concrete (Deslicking Mix)

Type S-1 bituminous concrete shall consist of sand and asphalt cement AP-3, unless otherwise specified. A heat stable additive shall be added to the asphalt cement prior to introduction into the mix. The mix shall be proportioned in accordance with Table 1.

The sand shall have a minimum sand equivalent value of 70, as determined by the AASHO Designation T 176, or have a proven performance record of no service failures, and shall have a minimum silica (SiO_2) content of 95 percent.

A heat stable additive shall be added as specified by the engineer. This material shall meet the following requirements:

1. General requirements—The material shall contain no ingredient harmful to the bituminous material or to the operator and shall not appreciably alter the specified characteristics of the bituminous material when added in the recommended proportions. It shall be capable of thorough dispersion in the bituminous material in storage indefinitely at temperatures normally encountered without detrimentally affecting the bituminous material, or losing its effectiveness as an asphalt antistripping compound and without any discernible settlement or stratification.
2. Acceptance test—The material shall be subjected to the following test to determine acceptance: One hundred grams of asphalt cement AP-3, treated with the heat stable additive at the manufacturer's recommended percentage, not to exceed 1.0 percent, shall be placed in a clean container and heated to 275 F. The container shall be sealed securely and placed in an oven that will hold this temperature for 96 hours. The sample shall then be removed from the oven and stirred thoroughly. Upon removal from the oven, 28.5 grams of asphalt so treated shall be mixed with 271.5 grams of the fine aggregate to make a total mix of 300 grams. After complete coating, the mixture shall be placed in boiling water and boiling continued for 10 minutes. The water shall then be drained from the mixture and the mixture removed and placed on a paper towel. After 12 hours the sand grains shall maintain a glossy black appearance with no signs of stripping. Combinations of sand and asphalt plus a heat additive failing to meet these requirements will not be acceptable.

Type S-2 Bituminous Concrete (Deslicking Mix)

Type S-2 bituminous concrete shall consist of slag, heat stable asphalt additive, combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1. Type S-2 bituminous concrete shall conform to the requirements of Section 212.10 except as otherwise specified.

Type S-3 Bituminous Concrete

Type S-3 bituminous concrete shall consist of natural sand, granite, slag, gravel, or gravel or granite screenings, or a combination thereof, combined with asphalt cement AP-1, unless otherwise specified, and be in accordance with Table 1.

TABLE 1

BITUMINOUS CONCRETE MIXTURES

Type	Percentage by Weight Passing Square Mesh Sieves*												Per Cent Bitumen	Mix Temperature (At Plant)
	2	1½	1	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 50	No. 100	No. 200		
S-1	-	-	-	-	-	-	100	95-100	50-95	25-65	8-25	0-8	8.5-10.5	225-300°F
S-2	-	-	-	-	-	100	95-100	60-85	20-40	10-30	8-25	2-10	9.5-12.0	225-300°F
S-3	-	-	-	-	-	100	90-100	70-95	25-55	15-35	6-22	2-12	6.5-10.5	200-240°F
S-4	-	-	-	-	100	90-100	75-90	60-80	25-45	10-30	4-14	2-10	5.5-9.5	225-300°F
MS-4	-	-	-	-	100	-	-	60-80	25-45	10-30	-	2-10	5.5-9.5	225-300°F
S-5	-	-	-	-	100	80-100	50-70	35-55	15-30	7-22	3-15	2-10	5.0-8.5	225-300°F
MS-5	-	-	-	-	100	-	-	35-55	15-30	-	-	2-10	5.0-8.5	225-300°F
I-1	-	-	100	90-100	-	85-100	75-100	60-95	25-60	12-35	3-17	2-12	5.0-7.5	225-300°F
I-2	-	-	100	95-100	-	60-80	40-60	25-45	-	5-14	2-9	-	4.5-8.0	225-300°F
MI-2	-	-	100	-	-	-	40-60	-	-	5-14	2-9	-	4.5-8.0	225-300°F
B-1	-	-	100	90-100	-	-	70-100	55-95	25-65	12-40	1-20	0-10	3.0-6.5	225-300°F
B-2	-	100	-	50-75	-	-	20-35	15-25	-	-	-	0-5	4.0-6.0	200-240°F
B-3	-	100	-	72-87	-	-	35-50	28-38	-	-	-	2-6	4.0-7.0	225-300°F
B-4	100	90-100	-	70-100	-	-	35-80	25-70	15-45	-	-	3-15	2.5-4.0	225-300°F
P-1	-	-	-	-	-	100	85-100	65-95	25-55	12-38	4-26	2-12	6.5-9.5	125-175°F
P-2	-	-	-	-	100	80-100	50-70	35-55	15-30	6-20	3-14	2-10	6.5-8.5	125-175°F
P-3	-	-	-	100	-	60-80	35-55	20-35	-	-	-	0-5	5.5-7.5	125-175°F

* In inches, except where otherwise indicated. Numbered sieves are those of the United States Standard Sieve Series.

Type S-4 Bituminous Concrete

Type S-4 bituminous concrete shall consist of natural sand, granite, slag, gravel, or gravel or granite screenings, or a combination thereof, combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1.

The combination of aggregate and asphalt shall have a minimum Marshall stability of 1,000 lb at 140 F. If this value cannot be obtained, the addition of mineral filler conforming to Section 201 in an amount not to exceed 5 percent of the completed mixture will be permitted in order to obtain this minimum stability. If the mixture still lacks stability, another source of aggregate will be necessary.

Type S-5 Bituminous Concrete

Type S-5 bituminous concrete shall consist of crushed stone, crushed slag, or crushed gravel and sand, or slag or stone screenings, or a combination thereof, combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1.

The combination of aggregate and asphalt shall have a minimum Marshall stability of 1,450 lb at 140 F and a flow of between 0.05 and 0.20 in. If this value cannot be obtained, the addition of mineral filler conforming to Section 201 in an amount not to exceed 5 percent of the completed mixture will be permitted in order to obtain this minimum stability. If the mixture still lacks stability, another source of aggregate will be necessary.

Whenever the amount of aggregate passing the No. 200 sieve exceeds 5 percent, a minimum of 15 percent sand (minimum grade B) may be required to be added to the mix.

Type I-1 Bituminous Concrete (Local Material)

Type I-1 bituminous concrete shall consist of local pit material combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1.

The combination of local pit material and asphalt shall have a minimum Marshall stability of 500 lb at 140 F. If this value cannot be obtained with the local pit material,

the addition of gravel, slag, or stone screenings will be permitted provided the gradation of the final mix is within the limitations provided in Table 1. If the stability value still cannot be obtained, mineral filler will be permitted in order to obtain this minimum stability. If the mixture still lacks stability, another source of local pit material will be necessary.

Type I-2 Bituminous Concrete

Type I-2 bituminous concrete shall consist of crushed stone, crushed slag, or crushed gravel, coarse aggregate and sand, or stone or gravel screenings, or a combination thereof, combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1.

Type B-1 Bituminous Concrete (Local Material)

Type B-1 bituminous concrete shall consist of local pit material combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1.

The combination of local pit material and asphalt shall have a minimum Marshall stability of 400 lb at 140 F. If this value cannot be obtained with the local pit material, the addition of gravel, slag, or stone screenings will be permitted provided the gradation of the final mix is within the limitations provided in Table 1. If the stability value still cannot be obtained, mineral filler in an amount not to exceed 5 percent of the completed mixture will be permitted in order to obtain this minimum stability. If the mixture still lacks stability, another source of local pit material will be necessary.

Type B-2 Bituminous Concrete

Type B-2 bituminous concrete shall consist of crushed stone, crushed slag, or crushed gravel, coarse aggregate and sand, slag, or stone or gravel screenings, or a combination thereof, combined with asphalt cement AP-1, unless otherwise specified, and be in accordance with Table 1.

Type B-3 Bituminous Concrete

Type B-3 bituminous concrete shall consist of crushed stone, crushed slag, or crushed gravel, coarse aggregate and sand or slag, or stone or gravel screenings, or a combination thereof, combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1.

Type B-4 Bituminous Concrete Subbase Course

Type B-4 bituminous concrete subbase course shall consist of natural sand, granite, slag, gravel, or gravel or granite screenings, or a combination thereof, combined with asphalt cement AP-3, unless otherwise specified, and be in accordance with Table 1. The aggregate shall conform to the requirements of Section 209.03.

Type P Bituminous Concrete

Type P bituminous concrete mixes shall consist of crushed stone, crushed slag, or crushed gravel, coarse aggregate and sand, or slag or stone screenings, or a combination thereof, combined with asphalt MC-800, unless otherwise specified, and be in accordance with Table 1.

All other requirements of Section 212 shall be adhered to except the following: (a) after the aggregate has been properly dried, it shall be allowed to cool until the temperature is within a range of 125 to 175 F; and (b) at the time of mixing, the temperature of the asphalt shall be between 125 and 175 F.

Appendix D

SPECIAL PLANT-MIX SPECIFICATIONS

Maintenance Mixture MI-3

The maintenance mixture shall conform to the requirements of Section 212 of the 1966 edition of the Road and Bridge Specifications as amended in the following:

Aggregate—(a) Aggregate shall conform to the requirements of Section 206, Crusher Run Aggregate, except that the first paragraph of Section 206.01 is amended to read:

> Crusher run aggregate shall consist of crushed stone, slag, or crushed gravel. It shall be the complete product of a crusher, essentially free of overburden and only oversize removed to conform to gradings as specified.

(b) All aggregate shall meet the gradation requirement of dense-graded aggregate size No. 26 unless otherwise designated. (c) Section 212.02(d) and (e) are deleted from this contract. (d) Section 212.03 is amended so that the job-mix formula is to indicate grading band for No. 26 aggregate. Gradation tolerances for aggregate will not apply.

Bitumen—(a) The optimum bitumen content for this mixture shall be determined by using Marshall design procedures and expressed as percent, by weight, of the total mixture. (b) The type of bitumen shall be AP-3 unless otherwise designated. (c) Section 212.03 is amended so that the asphalt content tolerances for this mixture shall be ±0.7 percent.

Mixture—(a) Proportioning the combination of aggregate and asphalt shall have a minimum Marshall stability of 700 lb at 140 F. (b) Marshall density results of the mix shall be between 90 and 98 percent of theoretical density unless otherwise waived. (c) Temperature of the mixture at the plant shall be between 225 and 300 F.

Special Mixture MS-7

The special mixture designated in the proposal shall conform to the requirements of Section 212.13 (Type S-4) of the 1966 Specifications as amended in the following:

Fine Aggregate—The use of fine aggregate from local deposits will be permitted in the special mixture provided such source of material is approved by the department.

Bitumen Content—The bitumen content for the special mixture shall be 7.0 to 9.0 percent, by weight, of the total mixture.

Mineral Filler—The quantity of mineral filler used in the special mixture shall be 4.0 to 8.0 percent, by weight, of the total mixture.

Mixture—Proportioning the combination of aggregate, asphalt, and mineral filler shall have a minimum Marshall stability of 250 lb at 140 F when used on secondary routes and 300 lb at 140 F when used on primary routes.

Screening Mixture MS-8

The screening mixture shall conform to the requirements of Section 212 of the 1966 Specifications as amended in the following:

Aggregate—(a) Aggregate for this mixture shall consist of approximately 50 percent No. 10 screenings and approximately 50 percent of a nonpolishing sand. (b) Stone screening shall not exceed 55 percent of the aggregate in the mixture. (c) Gradation tolerances for aggregate will not apply.

Bitumen—(a) The optimum bitumen content for this mixture shall be determined by using Marshall design procedures and expressed as percent, by weight, of the total mixture. (b) The type of bitumen shall be AP-3 unless otherwise designated.

Mixture—(a) Proportioning the combination of aggregate and asphalt shall have a minimum Marshall stability of 700 lb at 140 F. (b) Marshall density results of the mix shall be from 85 to 98 percent of theoretical density unless otherwise waived. (c) Temperature of the mixture at the plant shall be between 225 and 300 F.

Screening Mixture MS-9

The screening mixture shall conform to the requirements of Section 212 of the 1966 Specifications as amended in the following:

Aggregate—(a) Aggregate for this mixture shall consist of a combination of polish-resistant No. 10 stone screenings, polish-resistant sand, and a mineral filler, if required. (b) Gradation tolerances for aggregate will not apply.

Bitumen—(a) The optimum bitumen content for this mixture shall be determined by using Marshall design procedures and expressed as percent, by weight, of the total mixture. (b) The type of bitumen shall be AP-3. (c) Heat stable additive shall be added if required by the engineer.

Mixture—(a) Marshall density results of the mix shall be from 90 to 98 percent of theoretical density. (b) Proportioning of the aggregate and bitumen shall result in the mixture having a minimum Marshall stability of 700 lb at 140 F. (c) Temperature of the mixture at the plant shall be between 225 and 300 F.

Expanded Shale Mixture MS-10

The expanded shale (known at local sources as clinchlite, solite, and weblite) and screening mixture shall conform to the requirements of Section 212 of the 1966 Specifications as amended in the following:

Aggregate—(a) Aggregate for this mixture shall consist of a combination of No. 10 limestone screenings not to exceed 75 percent by weight of the total aggregate. The remainder of the aggregate shall consist of expanded shale meeting the gradation requirements for No. 68 open-graded coarse aggregates. (b) No more than 8 percent by weight of the total aggregate retained on the No. 4 sieve shall be limestone screenings.

Bitumen—(a) The optimum bitumen content for this mixture shall be determined by using Marshall design procedures and expressed as percent, by weight, of the total mixture. (b) The type of bitumen shall be AP-3. (c) Heat stable additive shall be added if required by the engineer.

Mixture—(a) Marshall density results of the mix shall be from 90 to 98 percent of theoretical density. (b) Proportioning of the aggregate and bitumen shall result in the mixture having a minimum Marshall stability of 700 lb at 140 F. (c) Temperature of the mixture at the plant shall be between 225 and 300 F.

Modified Mix

This mixture shall conform to the requirements of Section 212 of the 1966 Specifications as amended in the following:

Aggregate—(a) Maximum top size of aggregate used shall not exceed two-thirds of the thickness of the layer being applied. (b) No more than 7 percent by weight of the total aggregate shall pass the No. 200 sieve. (c) The sand equivalent of the material shall not be below 25.

Bitumen—(a) The optimum bitumen content for this mixture shall be determined by using Marshall design procedures and expressed as percent, by weight, of the total mixture. (b) The type of bitumen shall be AP-3.

Mixture—(a) Marshall density results of the mix shall be from 90 to 98 percent of theoretical density. (b) Proportioning of the aggregate and bitumen shall result in the mixture having a minimum Marshall stability of 700 lb at 140 F. (c) Temperature of the mixture at the plant shall be between 225 and 300 F.

Appendix E

NO. 26 DENSE-GRADED AGGREGATE SAMPLES

Samples of No. 26 dense-graded aggregate were obtained from 17 suppliers and represented materials available in all of the 8 districts. The gradation and test results of these samples are given in Tables 2 and 3.

TABLE 2

GRADATION OF 17 SAMPLES OF NO. 26 AGGREGATE

	SAMPLE NUMBER																	
Screen	1	2	3	4	5	6	7	*8	9	10	11	12	13	14	15	16	17	Range Hi - Low
3/4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100-100
1/2	82	82	83	91	86	88	67	34	85	88	70	80	92	61	81	82	95	61-95
3/8	69	68	71	80	76	76	49	18	73	73	53	63	63	46	62	62	83	46-83
#4	46	47	48	65	52	55	37	5	57	49	42	43	30	27	31	34	55	27-65
#8	30	32	33	27	35	35	24	3	44	35	29	34	20	17	19	24	36	17-36
#30	12	13	12	6	14	11	13	2	26	16	14	24	9	7	10	9	13	6-26
#50	8	9	7	4	11	7	11	2	20	11	9	17	7	4	8	5	8	4-20
#100	5	6	5	2	8	4	8	2	12	7	5	8	4	3	6	3	4	2-12
#200	3	4	3	2	6	3	5	1	6	4	2	3	3	2	4	2	3	1-6

* Rejected - DID NOT MEET GRADATION REQUIREMENTS

TABLE 3

RESULTS OF TESTS ON 17 SAMPLES OF NO. 26 AGGREGATE

SAMPLE NO.	ASPHALT	MARSHALL	FLOW	DENSITY	:	SAMPLE NO.	ASPHALT	MARSHALL	FLOW	DENSITY
1	4.0	2463	11	96.3	:	9	4.0	1705	9	92.1
	5.0	1874	10	97.0	:		5.0	2251	10	95.7
	6.0	1877	11	99.2	:		6.0	2718	11	97.8
2	4.0	1953	9	94.3	:	10	4.0	2015	9	91.1
	5.0	2067	11	99.1	:		5.0	2505	10	94.6
	6.0	1890	11	99.5	:		6.0	2260	11	97.4
3	4.0	2099	11	94.1	:	11	4.0	1483	9	92.7
	5.0	1973	11	95.2	:		5.0	1875	11	95.1
	6.0	1704	10	96.9	:		6.0	2046	11	98.3
*4	4.0	987	12	92.8	:	12	4.0	2255	10	95.2
	5.0	978	12	92.1	:		4.5	2935	10	97.6
	6.0	574	13	91.8	:		5.0	2535	10	98.8
					:		5.5	2350	10	100.0
**5	6.0	2081	11	97.0	:	13	4.0	1667	11	95.7
	7.0	1326	24	97.1	:		5.0	1587	11	94.7
	7.5	1174	35	97.9	:		6.0	1257	10	95.0
6	4.0	1640	10	92.0	:	14	4.0	1418	17	92.5
	5.0	1676	11	92.2	:		5.0	2060	16	91.5
	6.0	1666	10	95.1	:		6.0	1567	17	92.5
7	4.0	2220	10	96.5	:	15	4.0	1865	9	94.5
	5.0	2461	11	98.5	:		5.0	2291	10	96.9
	6.0	2583	15	100.0	:		6.0	1896	9	97.6
8	Rejected, did not meet #26 dense graded aggregate gradation requirements.				:	16	4.0	1579	10	93.5
					:		5.0	1603	11	95.0
					:		6.0	1690	10	96.7
* Material Not Cohesive					:	17	4.0	1436	12	92.1
** Poor Coating of Aggregate at 4 & 5% Asphalt - about 80% coated at 6.0% Asphalt					:		5.0	1719	12	93.3
					:		6.0	1513	12	95.4