SELECTION OF MATERIALS FOR BASE AND SURFACE TREATMENTS

N S ANDERSON,
Maintenance Engineer, South Carolina State Highway Department

During and since 1923, the South Carolina State Highway Department has surface treated approximately 235 miles of its more heavily traveled highways. The old surfacing material on most of this mileage was what is known locally as "top-soil," which typically a very small sized gravel with a sand-clay mixture as binder and occurs usually to depths of 8 to 12 inches, chiefly on hills or knolls often under cultivation, where part of the clay from the sand-clay soil has washed away, leaving the little pebbles and large grains of sand in place On nearly all of the remaining mileage it was either "sand clay," a natural or artificial mixture of sand and clay, or "clay-gravel," the latter having few pebbles over ⅓ of an inch in diameter and a sand-clay mixture as binder. No difference in treatment was found necessary for these three different types and the following remarks apply primarily to selected earth type road surfacing materials of a similar nature.

MATERIALS USED IN BITUMINOUS SURFACE TREATMENT

The bituminous surface treatment used the first year (1923) consisted of ¼ gallon per square yard of light tar (Specification No. 1, see Appendix) followed about twenty-four hours later by ⅓ gallon of heavy tar (Specification No 4) which was immediately covered with forty-five pounds per square yard of crushed granite graded from 1¼-inch down to ¼-inch and rolled with a power roller.

On part of the next year's work this same treatment was used but with an additional so-called "seal coat" applied several months later and consisting of ⅕ gallon per square yard of light tar (Specification No. 1) covered with coarse local sand but not rolled. Some seven other surface treatments were also tried out that year, using both tars and asphalts, among which was one the same as the above, except that asphalt (Specification No. 9) was used in place of the heavy tar and a fairly light asphaltic oil (Specification No. 6) instead of the light tar in the seal coat. Both of these two treatments gave satisfactory results but the latter, with minor modifications, has been used on most of our subsequent work. These modifications include the substitution of a 150-200 penetration asphalt for the

hot application, which slightly increases the amount of crushed stone necessary, and a change in the oil used in the seal coat that was made in order to obtain a surface on which automobiles were less likely to skid during either a drizzle or the first few minutes of a harder rain

Our present method of bituminous surface treatment, which we consider very satisfactory for our conditions, is as follows.

After thorough sweeping apply ¼ to ⅓ gallon per square yard of light tar of 8 to 13 specific viscosity, Engler, 50 cc at 40° C (Specification No 1) About twenty-four hours later apply hot ⅓ to 4/10 gallon of asphalt of from 150 to 200 penetration (Specification No. 11), cover immediately with 45 to 50 pounds of crushed stone graded from 1¼-inch down to ¼-inch and roll with 5 ton power roller. Several months later, but preferably before the first winter, apply the seal coat consisting of ⅕ gallon per square yard of fairly light asphaltic oil (Specification No. 12) and cover with 20 to 25 pounds per square yard of coarse sand

The main results of our experience so far with this type of treatment are as follows:

1. The light tar prime of 8 to 13 specific viscosity is usually satisfactory but if the road surface is very porous we prefer to use a slightly heavier grade of tar (Specification No 1A) of 13 to 18 specific viscosity during warm weather.
2. The 150 to 200 penetration asphalt is satisfactory, can be applied fairly easily and holds the crushed stone very well.
3. The grading of 1¼-inch to ¼-inch for the crushed stone cover spread over the hot asphalt, is satisfactory for our granite, but if a good quality limestone or other crushed aggregate that does not crush up much under a 5 ton power roller is used, the maximum size should be reduced. Crushed aggregate has given us altogether better results than the small sized gravel that we have tried, which is probably due to its keying action and resultant stability.
4. The fairly light asphaltic oil used in our seal coat is not always entirely satisfactory. Our specification is based on the old OC-2 specification of the Department of Agriculture, on which we have attempted to tighten up somewhat, but even at that, oils from different sources of supply sometimes give noticeably different, although fairly satisfactory, results In one respect this oil has given uniformly good results in that when used

with the usual sand cover, the resulting mat has a gritty surface that largely prevents the skidding of rubber tired motor vehicles.

SELECTION OF BASES

Our experience with treated bases, which in nearly all cases have been "top-soil," "sand-clay," or "clay-gravel," surfaced roads that have been under traffic for a considerable length of time, may be summed up briefly but adequately in two sentences.

1 That it is highly desirable to have a base porous enough so that the light tar prime will penetrate at least ¼ of an inch.
2. That it is absolutely essential that the base be well enough bonded to have sufficient supporting strength, when protected from surface water by the bituminous surface treatment mat to prevent appreciable deformation under the wheel loads of ordinary traffic.

High clay content often gives us trouble, for high clay content means very little penetration of the tar prime. An excessive amount of mica is harmful, for mica in excess means poor bond Sandy soils of fine grained sand clay, particularly when the clay is of poor binding quality, and bases that may be satisfactory when dry but become unstable when neglected drainage increases the moisture content, all give trouble; but those are merely other ways of describing poor bond or insufficient supporting strength in the base Keeping in mind the fact that the bituminous mat is ordinarily only about ¾ of an inch thick, it is apparent why adequate strength in the base is so vital.

MIXED BITUMINOUS TREATMENT

Where supporting strength is lacking in the base we make no attempt to use the surface treatment described above but during the past year have done a considerable amount of experimental work in an effort to increase the strength of the base by the admixture in place on the road, of bituminous material to a depth of from two to four inches. Both light tars (Specifications Nos. 1 and 1A) and asphalts of 85 to 100 (Specification No. 13) and 150-180 (Specification No. 14) penetration cut back with heavy naphtha to a consistency suitable for cold application with a pressure distributor, have been used and mixed with the base by the use of scarifiers, disc harrows and road machines After the bituminous mix has "set up,"

generally under traffic, it has been our practise to give it one of several kinds of bituminous surface treatments, usually using crushed stone as cover material, so as to form a mat capable of standing the wear of traffic.

Our experience with this mixed treatment has been mostly on work done during the past year and more time is needed for definite conclusions. The results so far tend to show the following:

1. That bases of poor quality sand-clay or even sand without enough clay to properly bond, can be strengthened by being mixed in place on the road with bituminous material, so that they will adequately support a bituminous surface treatment at least temporarily.
2. That bases of different compositions make necessary large variations in the percentage of bituminous material that should be used, some soils needing 75 per cent more than others, and that it is consequently difficult to obtain a satisfactory mix unless the base treated is fairly uniform in composition.
3. That with poor quality sand clays containing no aggregate coarser than medium-sized sand grains, it is difficult or impossible to obtain a stable mix that is rich enough in bitumen to stand the wear of traffic.
4. That by keeping the amount of bitumen in the mix less than that necessary to make it stand the wear of traffic, a mix that is stable, at least temporarily, can be obtained and can be adequately protected against wear by a bituminous surface treatment.
5. That when this surface treatment is placed before the mix has hardened too much, the use of 1¼-inch to ¼-inch crushed stone cover, which partially penetrates the mix under the roller, has a decidedly stabilizing effect.

RESEARCH NEEDED

In concluding, it is my opinion that additional research is needed in connection with an asphaltic prime that will both penetrate freely and give good bond, with an asphaltic oil for seal coat that will give a more nearly skid-proof surface when used with sand cover and with the strengthening of inferior sand clays or other soils by the admixture of bitumen, coarse aggregate, or other suitable material so as to make these bases capable of supporting the ordinary types of bituminous surface treatment.

APPENDIX

Specifications of Bituminous Materials Used

No 1 The tar shall conform to the following requirements

(a) Water, not more than 2 00 per cent

(b) Specific Viscosity, Engler, 50 cc at 40° C (104° F) 8 to 13

(c) Distillation test on water-free material

Total distillate, by weight, 0 to 170° C (32 to 338° F), not more than 7 00 per cent

Total distillate, by weight, 0 to 235° C (32 to 455° F), not more than 20 00 per cent

Total distillate, by weight, 0 to 270° C (32 to 518° F), not more than 30 00 per cent

Total distillate, by weight, 0 to 300° C (32 to 572° F), not more than 35 00 per cent

(d) Specific gravity at 25°/25° C (77°/77° F) of total distillate to 300° C (572° F), not less than 1 01

(e) Softening point (Ring-and-Ball Method) of residue from distallation test, not more than 60° C (140° F)

(f) Total Bitumen (soluble in carbon disulphide) 88 to 97 per cent

No 1A Same as No 1 except

Specific viscosity, Engler, 50 cc at 40° C (104° F) 13 to 18

No 4 The tar shall conform to the following requirements·

(a) Water, 0 00 per cent

(b) Float test at 32° C (89 6° F), 150 to 210 sec

(c) Distillation test

Total distillate, by weight, 0 to 170° C (32 to 338° F), not more than 1 00 per cent

Total distillate, by weight, 0 to 235° C (32 to 455° F), not more than 10 00 per cent

Total distillate, by weight, 0 to 270° C (32 to 518° F), not more than 15 00 per cent

Total distillate, by weight, 0 to 300° C (32 to 572° F), not more than 25 00 per cent

Residue by weight, not less than 75 00 per cent

(d) Specific gravity at 25° C (77° F) of total distillate to 300° C (572° F), not less than 1 03

(e) Softening point (Ring-and-Ball Method) of residue from distallation test, not more than 65° C (149° F)

(f) Total Bitumen (soluble in carbon disulphide) 78 to 95 per cent

	Min.	Max.
No 6 Specific Gravity 60° F	935	965
Beaume Gravity 60° F	16	19
Weight per gal 60° F lbs	7.85	
Penetration 77° F 100 gr 5 sec	too soft	
Viscosity, Saybolt	400	500
Viscosity, Engler (Specific)	2 4	3 0
Flash point (Open Cup) ° F	200	
Volatility 20 gr 5 h 325° F %		16
Asphalt 100 pen at 500° F % .	55	
Soluble in carbon disulphide %. .	99.8	

		Min		Max
No 9	Specific Gravity at 60° F	1 00		1 02
	Beaume Gravity at 60° F			
	Penetration, 77° F, 100 gr 5 secs			
	Weight per gallon, 60° F, lbs		8.38	
	Viscosity, Saybolt (Temp)	1700	(212° F)	2300
	Viscosity, Engler Spec (Temp)	47	(212° F)	66
	Flash, Open Cup, °F	365		
	Volatility, 50 gr, 5 hrs, 325° F %			4 0
	Asphalt 100 pen at 500° F %	80		
	Solubility, carbon disulphide, %	99 8		

No 11 The asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C (347° F)

Physical and chemical properties

It shall meet the following requirements

(a) Specific gravity 25°/25° C (77°/77° F), not less than 1 00

(b) Flash point not less than 175° C (347° F)

(c) Penetration at 25° C (77° F) 100 gr 5 secs, 150 to 200

(d) Loss at 163° C (325° F) 50 grs 5 hours not more than 2 0%
Penetration of residue at 25° C (77° F) 100 g, 5 secs, as compared to penetration before heating, not less than 60%

(e) Bitumen (soluble in carbon disulphide) not less than 99 5%
Organic matter insoluble not more than 0.2%

No 12 The road oil shall be homogeneous, free from water

It shall meet the following requirements

1 Specific gravity 25°/25° C (77°/77° F), 0 935 to 0 970

2 Flash point, not more than 90° F

3 Specific viscosity at 25° C (77° F), 80 to 100

4 Loss at 163° C (325° F), 5 hours, between 18 and 30%

a Float test of residue at 50° C (122° F), between 90 sec and 200 sec

5 Total bitumen (soluble in carbon disulphide), not less than 99 5%

6 Per cent of total bitumen insoluble in 86° B naphtha, not less than 6 0%

7 Per cent 100 penetration asphalt, 60 to 70%

8 Per cent naphtha, not less than 18%

No 13 The asphalt base shall be a straight run product, homogeneous, free from moisture, and shall conform to the following specifications

1 Specific Gravity at 60° F not less than 1 02

2 Penetration at 77° F, 100 g 5 sec 85 to 100

3 Flash Point (open cup), (minimum) 450° F

4 Ductility at 77° F (minimum) 32

The cut-back material shall be a straight run naphtha which shall conform to the following specifications

1 Specific gravity, 53° Baume, maximum

2 Distillation·
Starting point not less than 60° C
Off at 105° C not more than 8% (by volume)
Off at 140° C not more than 30% (by volume)
Off at 200° C not more than 80% (by volume)

The finished product shall be made from the above ingredients in such proportions as to conform to the following specifications·

1 Specific Gravity (min) 0 92

2 Specific viscosity (Engler) at 50° C 15 to 25

3 Flash point (open cup) not less than 90° F
4 Loss by evaporation, 50 g 5 hrs at 163° C not less than 25%
5 Solubility CCl_4, not less than 99.8%
6 Distillation
Total Distillate at 100° C not more than 5% (by volume)
Total Distillate at 150° C not more than 17% (by volume)
Total Distillate at 205° C not more than 37% (by volume)
Asphalt content at 100 penetration, 63 to 75%

No. 14 The asphalt base shall be a straight run product, homogeneous, free from moisture, and shall conform to the following specifications

1 Specific Gracity at 60° F not less than 1 02
2 Penetration at 77° F, 100 g 5 sec 150 to 180
3 Flash point (open cup) (minimum) 410° F
4 Ductility at 77° F (minimum) 32

The cut-back material shall be a straight run naphtha which shall conform to the following specifications

1 Specific gravity, 53° Baume, maximum
2 Distillation
Starting point not less than 60° C
Off at 105° C not more than 8% (by volume)
Off at 140° C not more than 30% (by volume)
Off at 200° C not more than 80% (by volume)

The finished product shall be made from the above ingredients in such proportions as to conform to the following specifications

1 Specific gravity (min) 0 92
2 Specific viscosity (Engler) at 50° C 15 to 25
3 Flash point (open cup) not less than 90° F
4 Loss by evaporation, 50 g 5 hrs at 163° C not less than 23%
5 Solubility CCl_4, not less than 99 8%
6 Distillation
Total Distillate at 100° C not more than 5% (by volume)
Total Distillate at 150° C not more than 15% (by volume)
Total Distillate at 205° C not more than 35% (by volume)
Asphalt content at 150 penetration—65 to 75%