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Seal Coats and Surface Treatments

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The construction, as here discussed, consists of an application of bituminous material to a prepared surface followed by an application of aggregate. In the Southwest the term seal coat is used to describe a single application of bitumen and aggregate over an existing bituminous surface. The term surface treatment is used to describe an application on new construction where it is placed on a prepared base. Single surface treatments are single applications of bitumen and aggregate. If the process is repeated the surface treatments are referred to as double or triple surface treatments depending upon the number of applications.

The surface treatment is a very economical type of surfacing for roadways carrying light to moderate traffic. The life expectancy of a surface treatment placed on a good base course is quite good. In Texas such surfaces have shown an average life of about 14 years and Bureau of Public Roads surveys show a life expectancy for the nation as a whole of about 11 years.

A surface treatment does not have much structural value; the load carrying capacity is primarily dependent upon the quality of the underlying base. On the other hand the surface treatment is very flexible and will take a higher base deflection before cracking than the higher types of bituminous pavements.

The most important functions which the surface treatment accomplishes are: (1) to provide a waterproof layer and (2) to provide a nonskid surface adequate to stand traffic abrasion. In addition the seal coat may serve to seal cracks and liven existing dry, cracked, bituminous surfaces.

AGGREGATE CHARACTERISTICS

Any reasonably sound aggregate can be used for surface treatments. Gravel, both crushed and uncrushed, crushed stone, and slag can all be used successfully.

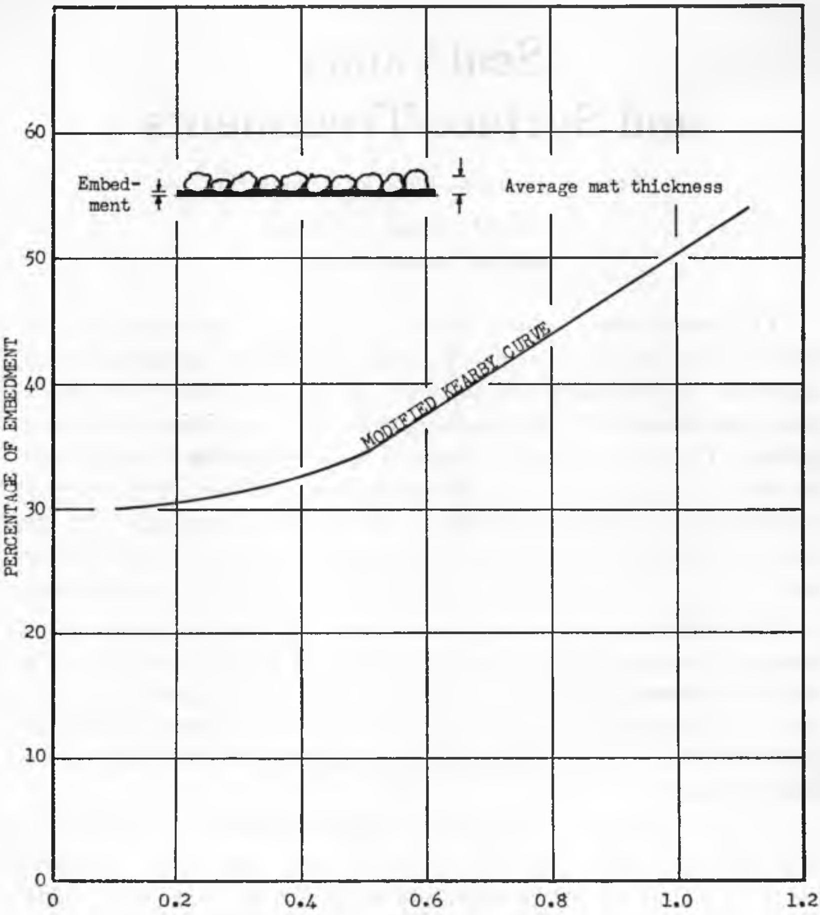

Figure 1. Relation of per cent embedment to average mat thickness for determining quantity of asphalt.

If the aggregate is smooth or wears smooth under the action of traffic it may produce a relatively slick surface. A rough texture will contribute to nonskid characteristics.

Aggregate should be abrasion resistant; a maximum Los Angeles abrasion loss of 35 per cent is commonly specified. However, aggregates with losses up to 40 per cent have been used successfully.

The grading of the aggregate for surface treatments is very important. The construction procedure is such that only one layer of aggregate can be stuck as is illustrated by Figure 1. If there is an appreciable variation in aggregate size the smaller particles may be completely submerged in the bitumen while the larger sizes are inadequately held. For this reason the aggregate should be uniformly graded. A good general rule is that the ratio of maximum to minimum size should be 2:1 with a reasonable tolerance for undersize or oversize. An example specification would be:

Passing ¾-in. sieve	100%
Passing ½-in. sieve	95-100%
Passing No. 3 sieve	0-5%

It is often possible to obtain surface treatment or seal coat aggregates quite economically from scalping operations for concrete aggregates.

Particle shape is of some importance. The ideal shape would probably be uniform pyramidal or cubical particles. A predominance of flat and elongated particles is undesirable.

Good adhesion between aggregate and bitumen and the ability to retain this adhesion in the presence of water is very important. Experience is probably the best test for this quality of aggregates although there are a number of reasonably good laboratory tests.

Cleanliness is essential. Bitumen will not adhere well to dusty aggregate.

Field conditions are generally such that aggregates contain some moisture. While the presence of moisture is detrimental to adhesion, it presents no particular problem when the work is accomplished in warm dry weather. There is considerable evidence that the results with dusty aggregates are better when the aggregate is damp at the time of placement.

Precoated aggregates, consisting of gravel or stone coated with a very thin film of bituminous material, have been quite popular in Texas in recent years. Precoating solves the dust problem and virtually guarantees good adhesion of bitumen to the aggregate. The disadvantages are the added cost and the fact that the resulting surface is very dark in color.

AGGREGATE QUANTITY AND MAT THICKNESS

The quantity of a given aggregate for a single application can be determined readily by direct trial. A representative sample of the material is spread on any reasonably uniform surface in a layer one stone thick covering a known area; one sq yd is quite convenient. The aggregate is recovered and weighed. It is good practice to average three trials and use the resulting value as the "spread quantity" in pounds per square yard for the aggregate. Plywood square yard spread boards are used in the A. and M. College of Texas laboratory which are quite convenient for this purpose. Accurate results can, however, be obtained with much less elaborate equipment.

In order to take into account field inaccuracies in spreading, the "spread quantity" should be increased by 10 per cent to obtain the "field quantity." If a volume basis is desired, computations may be based on the loose unit weight of the aggregate. As an example, assume that a given aggregate has a loose unit weight of 94 lb per cu ft and the "spread quantity" is 18.3 lb per sq yd. The field quantity would then be 18.3×1.1 which is 20 lb per sq yd or $27 \times 94/20$ which is a surface area of 127 sq yd per cu yd of aggregate.

The average mat thickness is the average thickness of the surfacing (See Figure 1). It can be computed by assuming that the aggregate in the one stone layer will have the same arrangement as is found in the loose unit weight. This is undoubtedly not true but the calculation provides a good theoretical method for determining average surface thickness and computing the proper quantity of bitumen. Consider the aggregate of the preceding paragraph. A mat one inch thick would require $3 \times 3 \times \frac{1}{12} \times 94$ lb per sq yd. Hence the average mat thickness for 18.3 lb per sq yd is $18.3/0.75 \times 94$ which is 0.26 inches. The average mat thickness is used to determine the proper quantity of bitumen, since the aggregate is held by embedding it in the bitumen a certain percentage of the average mat thickness. The ideal situation is maximum embedment without producing a bleeding condition due to excess bitumen.

BITUMEN SELECTION

There are two primary requirements for bitumen for surface treatments. First, the bitumen must be of such character that good adhesion to the road surface and to the aggregate is insured. Second, the bitumen must hold the aggregate firmly. For initial adhesion the bitumen must be in a reasonably soft condition since low viscosity promotes wetting of the aggregate by the bitumen. For good final retention a relatively hard bitumen with good ductility is most desirable. The ideal bitumen for surface treatment thus should be quite fluid initially to allow time for placing the aggregate and then revert to a harder condition rather rapidly to hold the aggregate firmly. From the standpoint of durability there is a preference for the softer bitumens. This is true because the highly exposed state in this type surface promotes oxidation and resultant hardening in the bitumen, and the softer bitumens will withstand weathering for longer periods of time before becoming sufficiently hard to develop cracking.

The fundamental requirements for bitumens are reasonably well satisfied by the rapid curing cutbacks, the rapid setting emulsions, the softer asphalt cements, and the intermediate to hard grades of road tars.

In Texas most surface treatments are placed with asphalt cements in the penetration range 120 to 250. When the work is accomplished during the hot summer months, with rapid field operations, these materials are sufficiently fluid initially to adhere well to the aggregate; they develop a high degree of holding power in a short time.

Temperature is a very important factor in the proper selection of bitumen. Cool weather will require initially softer materials hence the cutbacks and emulsions are preferred under such conditions. Where aggregates have high moisture content the use of emulsions is advantageous.

BITUMEN QUANTITY

The quantity of bitumen required is that quantity which will satisfy the absorption requirements of the surface plus the amount necessary to produce sufficient embedment to hold the aggregate firmly. Figure 1 shows the embedment depth, in terms of average mat thickness, considered adequate in Texas. For cooler climates somewhat greater percentages of embedment are probably warranted. In a given area, for instance, here in Indiana, the proper embedment depth can be determined from a few successful jobs.

Surface absorption for freshly primed bases or seal coats on normal bituminous surfaces may be taken as 0. If the surface is porous and cracked an allowance of .05 to .10 gal per sq yd should be made for absorption. On an existing rich surface or on a very heavy prime a reduction up to .05 gal per sq yd in bitumen may be called for.

Suppose that a single surface treatment is to be applied to a primed surface. The cover stone shows a spread quantity of 20 lb per sq yd, a loose unit weight of 90 lb per cu ft and a specific gravity of 2.65.

Average Mat Thickness $= 20/0.75 \times 90 = 0.30''$

Embedment Depth $= 32\%$ (Figure 1) $= 0.32 \times 0.3 = 0.096''$

Proportion of Voids $= 1 - \dfrac{90}{2.65 \times 62.4} = 0.456$

Volume of Bitumen $= \dfrac{0.096}{12} \times 3 \times 3 \times 0.456 = 0.0328$ cu ft

$= 0.0328 \times 7.48 = 0.25$ gal per sq yd

When cutback asphalts or emulsions are used the quantity of material to be used should be increased to account for loss of volatiles or water. Thus if a cutback asphalt containing 20 per cent cutter stock is to be used the proper quantity would be 0.25/.8 or 0.31 gal per sq yd of cutback asphalt.

MULTIPLE SURFACE TREATMENTS

Multiple surface treatments provide a greater thickness of surfacing than do single surface treatments. Larger aggregate is used for the first course, and the desired surface texture is obtained by using smaller sized aggregates for second and third courses. The bitumen-aggregate relations for multiple surface treatments are quite complex. This type of construction is fundamentally a combination of embedment and penetration.

The aggregate for multiple surface treatments is selected to give approximately a 2-1 ratio between succeeding courses. Thus a double surface treatment might utilize 1″-½″ aggregate for the first course and ½″-¼″ aggregate for the second course. The addition of a third course consisting of aggregate in the ¼″ to No. 8 sieve size range would produce a satisfactory triple. This selection of aggregates promotes the meshing of each succeeding layer with the one below it. The proper quantity of each aggregate is the quantity required to cover a square yard one stone thick without allowance for spreading inaccuracy, i.e., the spread quantity.

Limited studies indicate that the proper bitumen quantity for double surface treatments is 130 to 140 per cent of that required for the first course stone as computed by the method illustrated herein. For three course surface treatments the quantity required will be 140 to 150 per cent of that for the first course stone. The manner of distribution of bitumen application between the various courses does not seem to be particularly significant. As an example, consider the aggregate for which computations were previously made; the quantity of bitumen for a double surface treatment would be $1.35 \times 0.25 = 0.34$ gal per sq yd. Application rates of 0.17 gal per sq yd for each course or 0.20 for the first cover and 0.14 for the second would both be reasonable.

CONSTRUCTION PROCEDURES

In Texas surface treatment construction is considered to be hot weather work. Insofar as is possible all such construction is done in the hot, dry season of the year. The construction season for most of the state is April 15 to October 15.

When the surface treatment is to be placed on a new base course, a prime coat should be applied before the surface treatment is placed. Existing bituminous surfaces should be carefully cleaned prior to application of a seal coat.

Careful distributor operation to secure uniform application of the bitumen to the surface is a must. Attention should be given to proper functioning of the distributor including proper spray bar setting. Shots should start and stop on paper. When the entire roadway width cannot be covered in one application, careful attention must be given to side lap. The distributor should always be guided with properly set string lines along the roadway.

An important requirement for proper application of bitumen is that of proper viscosity at the time of application. Texas practice indicates a Saybolt-Furol Viscosity of 40-60 secs. at the time of application. Other authorities suggest 30 to 100 secs. If 50 secs. be taken as the optimum value the variation in application temperature for asphalt cements in the 210-250 penetration range used in Texas is 270F to 325F. This is illustrated in Figure 2.

Length of shots should be fixed by the amount of cover aggregate available to cover the shot. It is quite important that aggregate be applied as soon as possible after application of the bitumen, except that

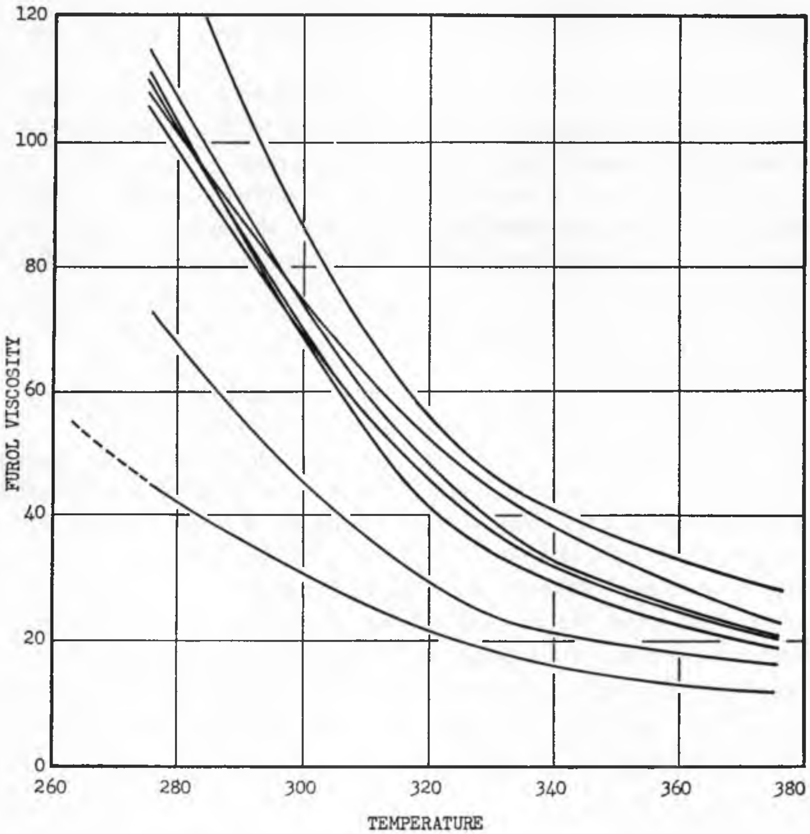

Figure 2. Viscosity and temperature relations for OA-230 asphalt.

when cutback asphalts are used rapid aggregate application is not as critical.

Aggregate should be spread uniformly with mechanical spreading devices. A recent development has been the self-propelled aggregate spreader which permits continuous, uniform spreading of aggregates.

Rolling is accomplished with either the flat wheel or pneumation roller or a combination of the two. Any procedure which secures good bond of the aggregate in the bitumen is satisfactory. Texas experience indicates that rolling is effective for several days if carried on during the heat of the day. A drag broom, operated very slowly (below 4 mph) can be used to distribute loose aggregate.

Aggregate which is not stuck creates problems when the surface is opened to traffic. Excess aggregate can be removed by brooming lightly with a power broom during the early morning hours when the surface is cool.

Surface color can be varied by proper selection of aggregates for surface treatments. In Texas we have some very good red, gray, and black surfaces.

Dusty aggregate, when it must be used, should be dampened to insure that the dust will bond to the aggregate and not be distributed over the surface of the bitumen when the aggregate is spread.

When it is necessary to place seal coats or surface teatments in cold weather, very fluid bitumens must be used or the aggregate must be heated. Hot aggregates will adhere well even to thoroughly chilled layers of bitumen.

PRODUCTION RATES

Production rates for surface treatments and seal coats are dependent upon a number of variables. Examination of the production rates on a number of contracts for the Texas Highway Department show that rates for new construction are normally in the range of 30,000 to 40,000 sq yd per 10-hr day for single surface treatments. Rates for double surface treatments will be 15,000 to 20,000 sq yd per day and for triple surface treatments 10,000 to 13,000 sq yd per day.

In recent years the Texas Highway Department has followed the practice of letting contracts for seal coat operations which cover an entire highway district and include 100 to 300 mi of highway. On these contracts rates of 90,000-120,000 sq yd per day have been achieved with self-propelled aggregate spreaders.