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Surface Area Method of Slurry Seal Design

This method of estimating the theoretical asphalt content of emulsified asphalt slurry seals is presented here for reference as one method suggested in ISSA TB #111. As presented, it is a direct excerpt from "Instruction Report S-75-1, Slurry Seal Surface Treatments" by Len Godwin, Soils and Pavements Laboratory, U.S. Army Engineer, Waterway Experiment Station, P.O. Box 631, Vicksburg, Mississippi 39180.

Caution: *Subsequent work indicates that this method is not universally applicable. 8 micron film thicknesses are usually too thick for heavy traffic and voids may be overly filled using certain high-fines aggregate gra -dations. Ed.*

Surface Area Design Method

The surface area design method will be presented in three sections which discuss the calculation of the amount of bitumen required to coat the surface area of the job aggregate, the absorption characteristics of the aggregate, and the total bitumen content.

1.0 Surface Area Asphalt Calculation

1.1 The surface area of the job aggregate is determined by multiplying the percent of aggregate passing a given sieve by a surface area factor based on the sieve size (Table A1). The surface area of the aggregate is deter- mined for each particle size (group) and then summed to obtain the total surface area. The surface area units are given in square feet per pound of aggreagate(ft^2/lb) and square meters per kilogram (m^2/kg). The surface area factors are shown in Table A1. The total surface area (SA) is then corrected to obtain a corrected surface area (CSA);CSA = SA x 2.65/ASG, where ASG is the appar- ent specific gravity of the aggregate. Knowing the sur- face area and the desired bitumen film thickness, the volume of bitumen required can be obtained. From these parameters, the bitumen required to coat the sur- face area is calculated. The equation for calculation of the surface area bitumen is as follows:

$$SAB = CSA_{ft^2/lb} \times t \times 0.02048 \times SG_B \text{ or}$$
$$SAB = CSA_{m^2/kg} \times t \times 0.09996 \times SG_B$$

where

SAB = surface area bitumen, percent of dry aggregate weight
CSA=corrected surface area, of dry aggregate
t = bitumen film thickness, microns
SG_B = specific gravity of the bitumen
0.02048 and 0.09996 are conversion coefficients for the units of the equation

1.2 If the specific gravity of the bitumen is not known, the bitumen required to coat the aggregate may be calculated by assuming SG_B = 1.0. The error that results from assuming SG_B = 1.0 is small and will not greatly affect the final design requirements..

1.3 Based on laboratory testing, substantiated by field performance, and recommendation by other researchers[1], a bitumen film thickness of 8 microns is recommended for slurry seal design.

2.0 Aggregate Absorption

2.1 The absorption requirements of the aggregate are determined by using the Centrifuge Kerosene Equivalent Test (CKE)[2]. In this test, 100 g of minus No. 4(4.75 mm) material is centrifuged in the presence of kerosene for 2 minutes. The amount of kerosene retained by the aggregate is assumed to approximate the amount of bitumen that the aggregate will absorb. The kerosene absorbed (KA) by the aggregate is converted to a percentage of the dry weight of the aggregate.

3.0 Total Bitumen

3.1 The total bitumen requirement is obtained by adding the percent bitumen required for the film thickness and the percent bitumen required for absorption. All percentages are based on the dry weight of the aggregate. The total is obtained as follows:

$$BR = SAB + KA, \text{ or}$$
$$BR = (CSA_{ft^2/lb} \times t \times 0.02048 \times SG_B) + KA, \text{ or}$$
$$BR = (CSA_{m^2/kg} \times t \times 0.09996 \times SG_B) + KA$$

where

BR=total bitumen required, percent of dry aggregate weight
KA=kerosene absorbed percent of dry aggregate weight

3.2 The required percentage of emulsion can be calculated by dividing the total bitumen required for the aggregate by the percentage of bitumen residue in the emulsion. A sample calculation for determining the bitumen content is shown in Appendix B.

Table A1
Factors Used In Calculating
Surface Area Of
Slurry Seal Aggregate[2]

Sieve Size	Surface Area Factors*	
	ft^2/lb	m^2/kg
3/8-in. (9.5 mm)	2	.41
No. 4 (4.75 mm)	2	.41
No. 8 (2.36 mm)	4	.82
No. 16 (1.18 mm)	8	1.64
No. 30 (600 µm)	14	2.87
No. 50 (300 µm)	30	6.14
No. 100 (150 µm)	60	12.29
No. 200 (75 µm)	160	32.77

*Surface area factors shown are applicable only when all the above-listed sieves are used in the sieve analysis.

Appendix B: Sample Calculation of Bitumen Requirements For A Slurry Seal Aggregate Calculation Of Surface Area²

1. ASG = 2.96; 2 percent Portland cement included in aggregate gradation.

Sieve Size	Percent Passing	x	Surface Area Factor ft²/lb	Surface Area Factor m²/kg	=	Surface Area ft²/lb	Surface Area (m²/kg)	Aggregate
3/8-in. (9.5 mm)	100.0		2	.41		2.00	(0.410)	
No. 4 (4.75 mm)	99.5		2	.41		1.99	(0.408)	
No. 8 (2.36 mm)	95.6		4	.82		3.82	(0.784)	
No. 16 (1.18 mm)	77.8		8	1.64		6.22	(1.276)	
No. 30 (600 µm)	52.0		14	2.87		7.28	(1.492)	
No. 50 (300 µm)	24.5		30	6.14		7.35	(1.507)	
No. 100 (150 µm)	10.7		60	12.29		6.42	(1.315)	
No. 200 (75 µm)	6.4		160	32.77		10.24	(2.100)	
					Total SA =	45.32	(9.292)	

Corrected SA, CSA = SA x 2.65/2.96=40.57 ft²/lb (8.319 m²/kg) aggregate

Aggregate Absorption Requirements²

2. Two percent Portland cement included in aggregate gradation

Cup No. (a)	Tare Weight g (b)	Sample Weight g (c)	Weight Before Centrifuging g (d=b+c)	Weight After Centrifuging g (e)	KA (%) (f = e-d)
1	215.3	100.0	315.3	321.0	5.7
2	215.9	100.0	315.9	321.6	5.7

Average KA=5.7%

Total Bitumen Requirements

Bitumen = SS-1h asphalt emulsion
Design film thickness (t) = 8 microns
Apparent specific gravity of aggregate (ASG) = 2.96
Specific gravity of bitumen (SG_B) = 1.028
Kerosene absorption (KA) = 5.7%
Corrected surface area (CSA) = 40.57 ft²/lb aggregate
Total bitumen required (BR) = ($CSA_{ft^2/lb}$ x t x SG_B x 0.02047) + KA, or
(BR) = ($CSA_{m^2/kg}$ x t x SG_B x 0.09996) + KA
BR = (40.57 x 8 x 1.028 x 0.02048) + 5.7 = 6.833 + 5.7 =12.53%, or
BR = (8.319 x 8 x 1.028 x 0.09996) + 5.7 = 6.838 + 5.7 = 12.54%
(percentages are slightly different due to rounding)
BR = 12.53% of dry aggregate weight
Residue asphalt content in emulsion = 63% by weight

$$\text{Emulsion required} = \frac{\text{BR} \times 100}{\text{Residue asphalt content in emulsion}}$$

$$\text{Emulsion required} = \frac{12.53 \times 100}{63} = 19.9\% \text{ of dry aggregate weight,}$$

i.e.,19.9 lb of emulsion is required for every 100 lb of dry aggregate
or 199 kg of emulsion is required for every 1000 kg of dry aggregate.

References:

1. Kansas DOT Laboratory Procedures for Slurry Design
2. Asphalt Institute Manual Series 2—Mix Design Methods for Asphalt Concrete (MS-2), CKE Method.