
Standard Practice for

**Emulsified Asphalt Scrub Chip Seal
Design**

AASHTO Designation: R xxx-18¹

Technical Section: 5b, Bridge and Pavement Preservation

Release: Group 1 (April 2018)

WORKING DRAFT



**American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001**

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1. SCOPE

- 1.1. This standard practice determines application quantities for applying aggregate chips and emulsified asphalt for scrub seals. A scrub chip seal is the application of emulsified asphalt, followed immediately by a scrub broom to push the emulsion into the cracks in the pavement finished with an application of a single layer of cover aggregate, with the option of including a fog seal to help with chip retention.
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2. REFERENCED STANDARDS

- 2.1. *AASHTO Standards:*
- MP XX-15, Materials for Emulsified Asphalt Rejuvenating Scrub Seals
 - T 19M/T 19, Bulk Density ("Unit Weight") and Voids in Aggregate
 - T 84, Specific Gravity and Absorption of Fine Aggregate
 - T 85, Specific Gravity and Absorption of Coarse Aggregate
- 2.2. *State Agency Guidance Documents:*
- Minnesota Seal Coat Handbook (2006, MnDOT)
 - Minnesota Pavement Distress Manual (2003, MnDOT)
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3. TERMINOLOGY

- 3.1. *Definitions:*
- 3.1.1. *average least dimension*—Reduction of median particle size to account for flat particles by using flakiness index. Represents the sealcoat thickness in the wheel path where traffic forces flat aggregate to orient on its flattest side.
- 3.1.2. *badly pocked, porous, oxidized*—Severe raveling of surface with much cracking.
- 3.1.3. *flushed-bleeding*—Free asphalt on the pavement surface with little or no texture.
- 3.1.4. *median particle size*—Theoretical aggregate size that corresponds to 50 percent passing on the gradation curve.
- 3.1.5. *medium cracking*—Medium severity transverse, longitudinal, and/or longitudinal joint cracking. Spalling is observed at the crack edge and some cracks have begun to become interconnected.
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Block cracking, with cracks creating sections approximately 1 to 3 ft in width also falls under this distress category.

- 3.1.6. *severe cracking*—High severity transverse, longitudinal, and/or longitudinal joint cracking. There is significant spalling at crack edges and cracks have become interconnected. Alligator cracking is also included in this distress category. Use caution in applying maintenance treatments on pavements with severe cracking distress.
- 3.1.7. *slight cracking*—Single or well-spaced low severity transverse or longitudinal cracks. Also includes low severity longitudinal joint cracking.
- 3.1.8. *slightly pocked, porous, oxidized*—Raveling beginning to show with moderate cracking.
- 3.1.9. *smooth, non-porous*—Some free asphalt on the pavement surface, but with some cracking.

4. SIGNIFICANCE AND USE

- 4.1. This standard practice may be used to determine the quantities of materials required for the construction of emulsified asphalt scrub chip seals. Practitioners may select one of the two design methods detailed in this practice.

5. EMULSIFIED ASPHALT CHIP SEAL DESIGN REQUIREMENTS

- 5.1. *Materials*—emulsified asphalt and aggregate used in the design should meet M xxx specifications and be representative of the materials used for the project.
- 5.2. *Modified Kirby Design Method:*
 - 5.2.1. *Aggregate Application Rate*—Fabricate a board measuring 3 ft by 1½ ft. Three quarter-in. thick particle board works well for this item. Attach 1 in. by 2 in. pine wood strips to the edge of the board to create a raised edge. Weigh the completed board and record the weight in pounds. Place the chips to be used on the project on the board. The quantity will vary depending on the gradation, shape, and crushed content of the chips but should be no less than 5 lb and no greater than 25 lb. Try to fit as many chips on the board within the confines of the edging as possible. The chips should not overlap each other and should be only one stone thick. Push the chips against the edge of the board. Place as many chips as possible onto the board until every gap is filled. Reweigh the board containing the chips in pounds. Subtract the weight of the empty board from the weight of the board with chips. Multiply this value by 2. This is the quantity of chips to be used on the chip seal in pounds per square yard. Record this quantity as *Q*.
 - 5.2.2. *Emulsified Asphalt Application Rate* —The emulsified asphalt quantity for a conventional chip seal is estimated by calculating the amount of asphalt needed to fill the voids between the chips to a specific embedment depth. That relationship is expressed as follows:

$$A = \frac{\left\{ 5.61e \times d \times \left[1 - \left(\frac{W}{6.24G} \right) \right] T \right\} + V}{R} \quad (1)$$

where:

- A = emulsified asphalt quantity, gal/yd²;
- e = percent embedment from Figure 1 expressed as a decimal;
- d = 1.33 *Q*/W;
- Q* = quantity of chips from the board test, lb/yd²;

- W = dry loose unit weight of chips, pcf (see T 19M/T 19, Section 12 on shoveling);
- G = dry bulk specific gravity of chips (see T 84 and T 85);
- T = traffic correction factor from Table 1;
- V = pavement surface correction factor; and
- R = emulsion residue, expressed as a decimal, e. g., 0.65 = 65 percent.

The result of the calculation for Equation 1 is the estimated emulsified asphalt spray rate.

Table 1—Traffic Correction Factor, T

Traffic Correction Factor, T	AADT ^a			
	<100	100–250	250–500	500–1000
	1.20	1.15	1.10	1.05

^a From 1000 to 5000 AADT requires no correction. Greater than 5000 AADT has not been evaluated sufficiently to develop a recommended traffic correction factor.

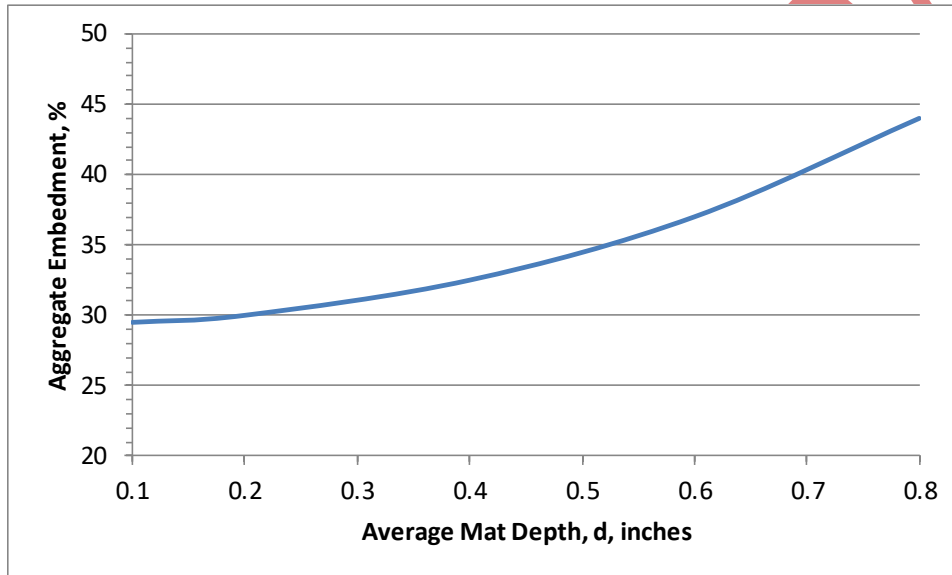


Figure 1—Aggregate Embedment, percent, e (before rolling)

Table 2—Substrate Surface Condition, V

Existing Surface Condition	Correction Factor, V , gal/yd ²
Flushed-bleeding	-0.06
Smooth, non-porous ^a	-0.03
Slightly porous, slightly oxidized	0.00
Slightly pocked, porous, oxidized ^b	+0.03
Badly pocked, porous, oxidized ^b	+0.06

^a A quantitative method using the ball penetration test has also been reported in NCHRP Report 680.

^b A quantitative method using the sand patch test has also been reported in NCHRP Report 680.

5.3. *McLeod Design Method:*

5.3.1. *Aggregate Application Rate:*

- 5.3.1.1. Measure gradation (T 11 and T 27), unit weight (T 19M), and specific gravity (T 84 and T 85) of cover aggregate.
- 5.3.1.2. Estimate median particle (*M*) size by identifying the location of 50 percent passing on the aggregate gradation (percent passing vs. sieve size) curve and drawing a vertical line to the x-axis.
- 5.3.1.3. Determine aggregate flakiness index in inches using procedure FLH T 508.
- 5.3.1.4. Determine aggregate average least dimension (*H*) using Equation 2.

$$H = \frac{M}{1.139285 + (0.011506 \times FI)} \quad (2)$$

where:

- H* = average least dimension;
- M* = median particle size; and
- FI* = flakiness index.

- 5.3.1.5. Determine the voids in loose aggregate according to AASHTO T19M/T19.
- 5.3.1.6. Determine the cover aggregate application rate using Equation 3.

$$C = 46.8 \times [1 \times (0.4 \times V \times H \times G \times E)] \quad (3)$$

where:

- C* = cover aggregate application rate, lb/yd²;
- V* = voids in loose aggregate, %;
- G* = bulk specific gravity of aggregate; and
- E* = wastage factor for traffic whip-off, Table 3.

Table 3—Aggregate Wastage Factor, *E*
(*MnDOT Seal Coat Manual*)

Percentage Waste Allowed for ^a	Wastage Factor, <i>E</i>
1	1.01
2	1.02
3	1.03
4	1.04
5	1.05
6	1.06
7	1.07
8	1.08
9	1.09
10	1.10
11	1.11
12	1.12
13	1.13
14	1.14
15	1.15

^a Due to traffic whip-off and handling.

Note 1—Calculated application rate can be verified by fabricating a board measuring 0.5 yd² in area (3 ft by 1½ ft) with 1 in. by 2 in. pine wood strips attached to create a raised edge. Weigh the completed board and record the weight in pounds. Place the chips to be used on the project on the board in the quantity determined in Section 5.2.7. The chips should not overlap each other and

should be only one stone thick. Push the chips against the edge of the board. If necessary, add chips onto the board until every gap is filled. Reweigh the board containing the chips in pounds. Subtract the weight of the empty board from the weight of the board with chips. Multiply this value by 2. This is the quantity of chips to be used on the chip seal in pounds per square yard.

5.3.2. *Emulsion Application Rate:*

5.3.2.1. Calculate the target emulsion application rate for wheelpath areas and non-wheelpath areas using Equation 4.

$$EAR = \frac{[2.224 \times (H, M) \times T \times V] + S + A}{R} \quad (4)$$

where:

EAR = emulsion application rate, gal/yd²;

H = aggregate average least dimension, in., used to calculate *EAR* for wheelpath areas;

M = aggregate median particle size, in., used to calculate *EAR* for non-wheelpath areas;

T = traffic factor, Table 5;

S = surface condition factor, Table 6;

A = aggregate absorption factor, Table 4; and

R = residual asphalt content of emulsion, percent.

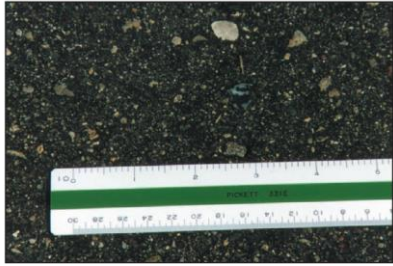


Table 4—Aggregate Absorption Factor

Aggregate Absorption	Correction Factor
<1.5%	0
≥1.5%	0.02

Table 5—Traffic Correction Factor—McLeod Method

	Average Annual Daily Traffic (AADT)				
	<100	100–500	500–1000	1000–2000	>2000
Traffic Factor, <i>T</i>	0.85	0.75	0.70	0.65	0.60

Table 6—Surface Condition Factor

Condition	Example	Correction (gal/yd ²)
Black, flushed asphalt Smooth, non-porous	N/A 	-0.01 to -0.06 0.00
Slightly porous and oxidized		+0.03
Slightly pocked, porous, and oxidized		+0.06
Badly pocked, porous, and oxidized		+0.09

- 5.3.3. Determine the design emulsion application rate, defined as the average of the wheelpath and non-wheelpath emulsion application rates.
- 5.4. Adjustment for Cracking—Increase the design emulsion application rate determined in Section 5.3 or 5.4 by multiplying the design application rates by the factors provided in Table 7. Select distress level based on state highway agency practice for the project location.

Table 7—Emulsion Application Rate Adjustments Based on Severity and Extent of Cracking

Type and Amount of Cracking	Added Emulsion
Slight	1.06
Moderate	1.10
Severe	1.20

5.5. Maintain an application rate of target rate ± 0.05 gal/yd². Adjust as needed according to project specific conditions.

Note 2—Field adjustments to application rate can be made to ensure at least a 4-in. wave of emulsion remains in front of the lead broom.

Note 3—Severe cracking is indicative of a structural issue in the pavement that will not be fully addressed by selection of a maintenance treatment. Reduce expectations for extension in service life of the pavement when maintenance treatments are placed over pavements with high extent/severity of cracking.

5.6. *Extra Chips to Avoid Roller Pick-Up*—Some extra aggregate should be spread during scrub seal construction with emulsions than is actually needed to produce a one-stone layer. This extra material is applied to aid in reducing the potential for chips to be picked up by pneumatic rollers during construction. The amount of excess material will vary, but should be approximately 5 to 10 percent and never more than 10 percent. Adjustment up or down is necessary based on when the rollers begin to pick up the chips.

5.7. All design work will be carried out using aggregate either directly from the job site stockpile or equivalent material from the same source and having substantially the same material properties.

6. REPORT

6.1. *Report the following:*

6.1.1. Design method used.

6.1.2. Aggregate spread rate, Q , in pounds per square yard to the nearest 1.0 lb/yd².

6.1.3. Report the emulsified asphalt spray rate, A , in gallons per square yard to the nearest 0.01 gal/yd².

7. KEYWORDS

7.1. Modified emulsion; pavement maintenance; rejuvenator; surface treatment.

¹ New standard endnote TBD. (Different for provisional vs. full standard.)