



Standard Test Method for Centrifuge Kerosine Equivalent¹

This standard is issued under the fixed designation D5148; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This test method determines the centrifuge kerosine equivalent (CKE) of aggregate used in bituminous mixtures.

1.2 Units of Measure:

1.2.1 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard. An exception is made in the values used for mass because this standard was originally developed using even values of grams, and use of ounces as a standard would make those measures cumbersome.

1.2.2 Regarding sieves, per ASTM Specification E11 Section 1.2, “the values stated in SI units shall be considered standard for the dimensions of the wire cloth openings and the diameter of the wires used in the wire cloth. The values stated in inch-pound units shall be considered standard with regard to the sieve frames.” When sieve mesh sizes are referenced, the alternate inch-pound designations are provided for information purposes and enclosed in parentheses.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see 7.1.

2. Referenced Documents

2.1 ASTM Standards:²

[C127 Test Method for Relative Density \(Specific Gravity\) and Absorption of Coarse Aggregate](#)

[C128 Test Method for Relative Density \(Specific Gravity\) and Absorption of Fine Aggregate](#)

¹ This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.51 on Aggregate Tests.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

[C702 Practice for Reducing Samples of Aggregate to Testing Size](#)

[D75 Practice for Sampling Aggregates](#)

[D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials](#)

[D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing](#)

[E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves](#)

[E832 Specification for Laboratory Filter Papers](#)

3. Terminology

3.1 Symbols:

3.1.1 *C*—coarse aggregate fraction, that portion of the sample which passes the 9.5 mm ($\frac{3}{8}$ in.) sieve and is retained on the 4.75 mm (No. 4) sieve.

3.1.2 *F*—fine aggregate fraction, that portion of the sample which passes the 4.75 mm (No. 4) sieve.

3.1.3 *SA*—surface area. The sum, ft^2/lb (m^2/kg), obtained by adding the products of the percent passing each sieve and its corresponding factor, (see 11.1) and dividing by 100.

3.1.4 *K factors*—values determined as described in 3.1.5 through 3.1.8 and identified as K_c , K_f , or K_m .

3.1.5 K_c —determined from the percent of SAE No. 10 oil retained, which represents the total effect of the aggregate’s absorptive properties and surface roughness of the aggregates coarse fraction.

NOTE 1—Based on comparative testing in California, the same results can be obtained substituting Shell Tellus No. 100 oil for SAE No. 10 oil.

3.1.6 K_f —determined from the following factors:

3.1.7 Percent of kerosine retained, which represents the total effect of superficial area, the aggregate’s absorptive properties and surface roughness of the aggregate’s fine fraction.

3.1.7.1 Computed surface area, based on particle size.

3.1.7.2 Percent of aggregate passing 4.75 mm (No. 4) sieve.

3.1.8 K_m —the “mean” or composite value of *K* for a given combination of coarse and fine materials on which K_c and K_f have already been determined independently.

4. Significance and Use

4.1 The CKE furnishes an index, designated as the *K* factor, that indicates the aggregate particle roughness and surface capacity based on porosity.

4.2 The CKE is used as part of the Hveem mix design procedure to determine the approximate bitumen ratio (ABR), as shown in Appendix X1. However, there are other applications such as determining the coarse aggregate fraction constant (*K_c*) for use as an aid in selecting a bitumen content for open-graded friction courses.

NOTE 2—The quality of the results produced by this standard are dependant upon the competence of the personnel performing the procedure and the capability, calibration, and the maintenance of the equipment used. Agencies that meet the criteria of Standard Practice D3666 are generally considered capable of competent and objective testing / sampling / inspection / etc. Users of this standard are cautioned that compliance with D3666 alone does not completely assure reliable results. Reliable results depend on many factors: following the suggestions of D3666 or similar acceptable guideline provides a means of evaluating and controlling some of those factors.

5. Apparatus

5.1 Centrifuge, power driven, capable of exerting a force of 400 ± 8 times gravity (400 G) on a 100-g sample.

The required $r/\min(\pm 10)$ of the centrifuge head = $\sqrt{(14,000,000/r)}$
 r = radius to center of gravity of sample, in.
 (r) = radius to center of gravity of sample/25.4, mm

5.2 Centrifuge Cups, 2¹³/₁₆ ± 1/16 in. (71.4 ± 1.6 mm) in height and 2¹/₁₆ ± 1/16 in. (52.4 ± 1.6 mm) inside diameter (see Fig. 1) complete with perforated brass plate 0.031 ± 0.001 in. (0.787 ± 0.03 mm) thick with a minimum of 100 holes, 0.062 ± 0.001 in. (1.575 mm ± 0.03 mm) in diameter, per square inch (15 holes/cm²).

5.3 Balance—A balance having a minimum capacity of 500 g and meeting the requirements of Specification D4753, Class GP2.

5.4 Metal Funnel, top diameter 3⁷/₈ ± 1/16 in. (98.4 ± 1.6 mm), height 4⁵/₁₆ ± 1/16 in. (109.5 ± 1.6 mm), orifice 1/2 ± 1/16 in. (12.7 ± 1.6 mm), with a piece of 2.0 mm (No. 10) sieve soldered slightly above the orifice (Fig. 2).

5.5 Tin Pan, round, 4¹/₂ ± 1/16 in. (114.3 ± 1.6 mm) diameter, 25.4 ± 1 ± 1/16 in. (1.6 mm) deep.

6. Materials

6.1 Kerosine.

6.2 Lubricating Oil, SAE No. 10 (see Note 1).

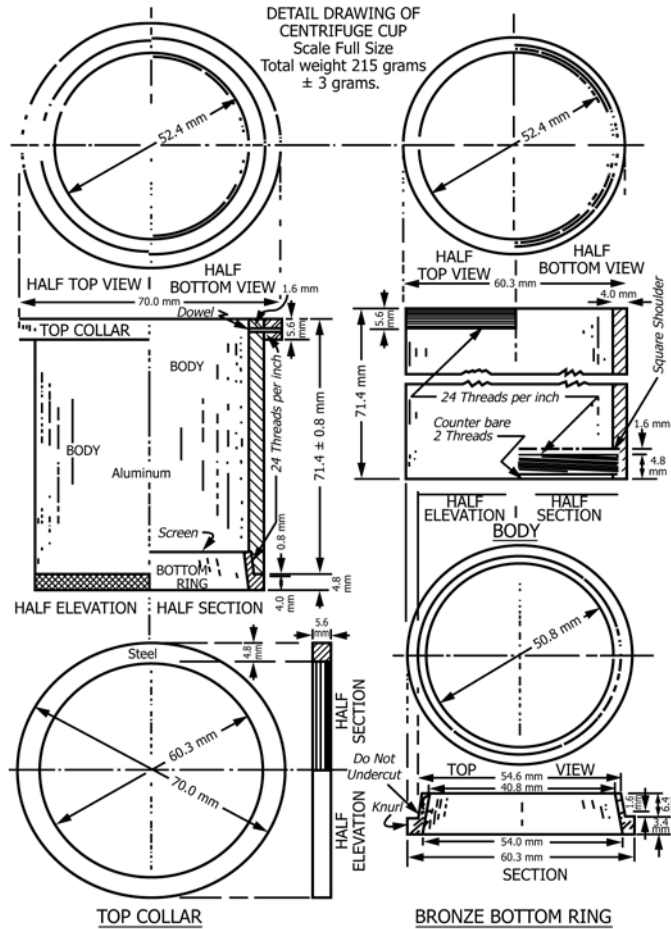


FIG. 1 Detailed Drawing of a Centrifuge Cup

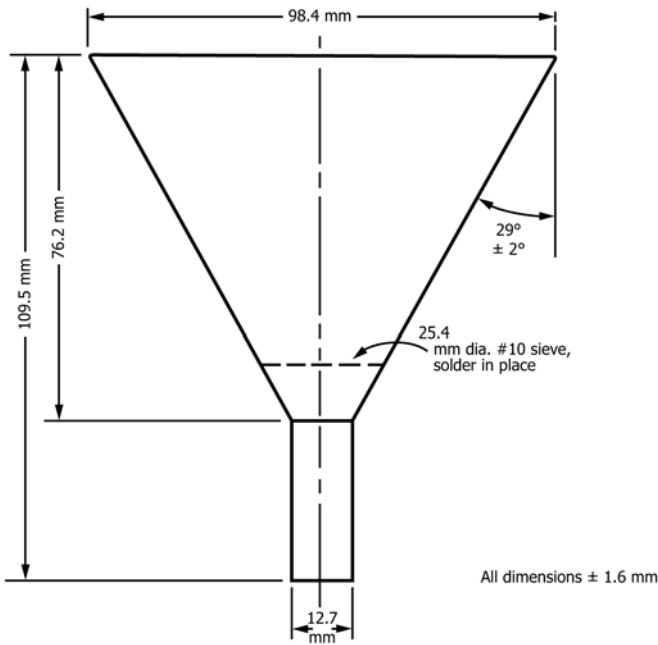


FIG. 2 Detailed Drawing for Metal Funnel

6.3 *Filter Paper*, size 5½-cm diameter, Type 1, Class B.

NOTE 3—VWR Guide No. 613 satisfies ASTM grade Type 1, Class B, Specification E832.

7. Hazards

7.1 **Warning**—Kerosine is flammable, and therefore caution should be used in storage and use.

8. Sampling

- 8.1 Sampling is done in accordance with Practice D75.
- 8.2 Reduce the sample in accordance with Practice C702.

9. Preparation of Sample

9.1 Determine the bulk specific gravity of the coarse aggregate (4.1) and apparent specific gravity of the fine aggregate (4.2), using Test Methods C127 and C128, respectively.

NOTE 4—Apparent specific gravity is used for the fine aggregate because it is easier to determine than the bulk specific gravity, and its use does not affect the CKE results.

9.2 *Specific Gravity*—Calculate the average specific gravity for the aggregate based upon the design grading by the following formula:

$$G = \frac{1}{\frac{P_c}{100G_c} + \frac{P_f}{100G_f}} \quad (1)$$

where:

G = average specific gravity,

- P_c = coarse aggregate present in the original sample, weight %,
- P_f = fine aggregate present in the original sample, weight %,
- G_c = bulk (oven dry) specific gravity of the coarse aggregate, and
- G_f = apparent specific gravity of the fine aggregate.

9.3 Separate the aggregate into two size groups, “C” material (used for K_c determinations) passing the 9.5 mm (¾ in.) sieve and retained on the 4.75 mm (No. 4) sieve, and “F” material (for K_f determination) all passing the 4.75 mm (No. 4) sieve.

10. Procedures

10.1 *Procedure for Fine F:*

10.1.1 Quarter or split out approximately 105 g for each sample, representative of the material passing 4.75 mm (No. 4) sieve.

10.1.2 Place on hot plate or in 230 ± 9°F (110 ± 5°C) oven and dry to constant weight.

10.1.3 Allow to cool.

10.1.4 Place 100.0 ± 0.1 g in each of the tared centrifuge cups fitted with the perforated metal disk underlying a disk of filter paper.

10.1.5 Place centrifuge cups containing samples in pan with sufficient kerosine ½ ± ⅛ in. (12.7 ± 3.2 mm) deep to saturate the sample. When specimens are thoroughly saturated (by capillary action), place the cups with samples in centrifuge. Samples should be tested in pairs, placed opposite of each other to avoid damage to the centrifuge.

10.1.6 Spin in centrifuge for 2 min at a force of 400 G.

10.1.7 Reweigh each cup, containing samples, to nearest 0.1 g and subtract original weight. The difference is the percent of kerosine retained (based on 100 g of dry aggregate). The percent of kerosine retained is the CKE value. Record the average of the two values for duplicate samples.

10.2 *Procedure for Coarse C:*

10.2.1 Quarter or split out approximately 105 g for each sample, representative of the material passing ¾ in. (9.5 mm) and retained on 4.75 mm (No. 4) sieve material.

10.2.2 Dry sample on hot plate or in 110 ± 5°C (230 ± 9°F) oven to constant weight and allow to cool to room temperature.

10.2.3 Weigh out 100.0 g ± 0.1 g and place in funnel (see 5.4).

10.2.4 Completely immerse specimen in SAE No. 10 lubricating oil for 5 min (see Note 1).

10.2.5 Place the funnel in a container, maintaining the axis in a vertical position and allow to drain for 2 min.

10.2.6 Place funnel containing sample in 140°F (60°C) oven for 15 min of additional draining, remembering to keep the funnel axis in a vertical position.

10.2.7 Pour sample from funnel into tared pan, cool to room temperature, and reweigh sample to nearest 0.1 g. Subtract

original weight and record difference as percent of oil retained (based on 100 g of dry aggregate).

11. Determination of KFactors

11.1 Use the following surface area factors to calculate surface area based upon design grading as follows:

Sieve Size Passed	ft ² /lb	(m ² /Kg)
Maximum size	2	(0.41)
No. 4 (4.75 mm)	2	(0.41)
No. 8 (2.36 mm)	4	(0.82)
No. 16 (1.18 mm)	8	(1.6)
No. 30 (600 μm)	14	(2.9)
No. 50 (300 μm)	30	(6.1)
No. 100 (150 μm)	60	(12.3)
No. 200 (75 μm)	160	(32.8)

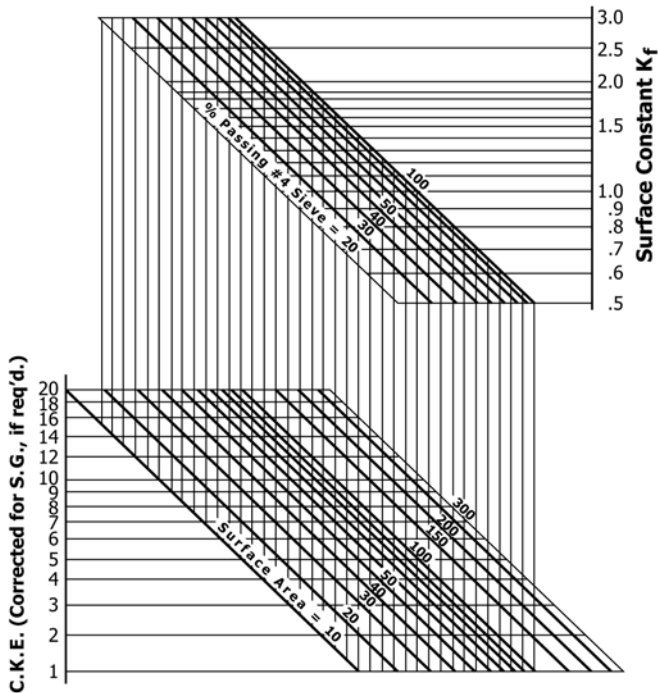
11.1.1 All surface area factors must be used in calculations; thus, if a sample passes 4.75 mm (No. 4) sieve 100 %, include in calculations 100 × 2 ft²/lb (0.41 m²/kg), for passing maximum size as well as 100 × 2 ft²/lb (0.41 m²/kg) for passing 4.75 mm (No. 4) sieve.

11.2 Use the chart shown in Fig. 3 for determination of K_f.

11.2.1 If the apparent specific gravity for F is greater than 2.70 or less than 2.60, make correction to percent of kerosine retained, using the following formula:

$$\begin{aligned} & \text{Percent of kerosine retained} \quad (2) \\ & \times (\text{apparent specific gravity } F/2.65) \end{aligned}$$

CHART FOR DETERMINING K_f FROM C.K.E.



NOTE: C.K.E. Corrected for S.G. = % ker. ret. (C.K.E.) × $\frac{\text{app. S.G. (f)}}{2.65}$

FIG. 3 Chart for Determining K_f from CKE

= CKE corrected for specific gravity

11.2.2 Start in lower left hand corner of chart in Fig. 3 with value for CKE corrected for specific gravity, following straightedge horizontally to right to the intersection with calculated surface area, hold point, move vertically upward to the intersection with the percent passing the 4.75 mm (No. 4) sieve, hold point, and follow straightedge horizontally to right. The value obtained will be the surface constant for the passing 4.75 mm (No. 4) fraction F and is known as K_f.

11.3 Use chart shown in Fig. 4 for determination of K_c.

11.3.1 If the bulk (oven dry) specific gravity for C is greater than 2.70 or less than 2.60, apply correction to oil retained, using formula at top of chart in Fig. 4.

11.3.2 Start at the bottom of chart in Fig. 4 with the corrected percent of oil retained, follow straightedge vertically upward to intersection with the diagonal line, hold point, and follow the straightedge horizontally to the left. The value obtained will be the surface constant for the retained fraction C and is known as K_c.

11.4 Use the chart shown in Fig. 5 to combine K_f and K_c for determination of K_m.

$$K_m = K_f + \text{correction to } K_f \quad (3)$$

11.4.1 The “correction to K_f” value obtained from Fig. 5 is positive if (K_c - K_f) is positive and is negative if (K_c - K_f) is negative.

11.4.2 No correction needs to be applied for asphalt viscosity.

NOTE 5—When there is 20 % or less coarse material in a sample, the K_c is not used; therefore, the K_f and K_m are the same.

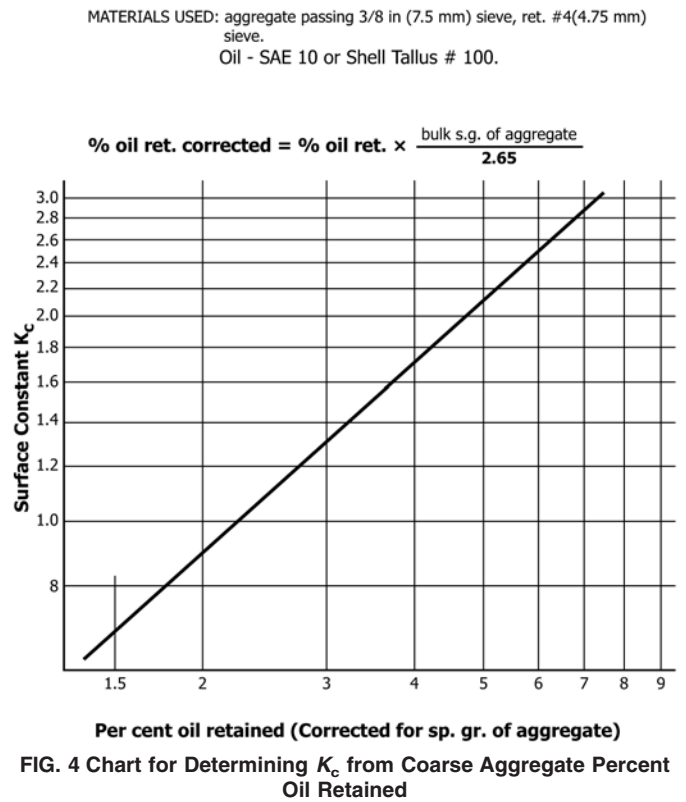


FIG. 4 Chart for Determining K_c from Coarse Aggregate Percent Oil Retained

If ($K_c - K_f$) is neg., corr. is neg.
 If ($K_c - K_f$) is pos., corr. is pos.
 $K_m = K_f + \text{corr. to } K_f$

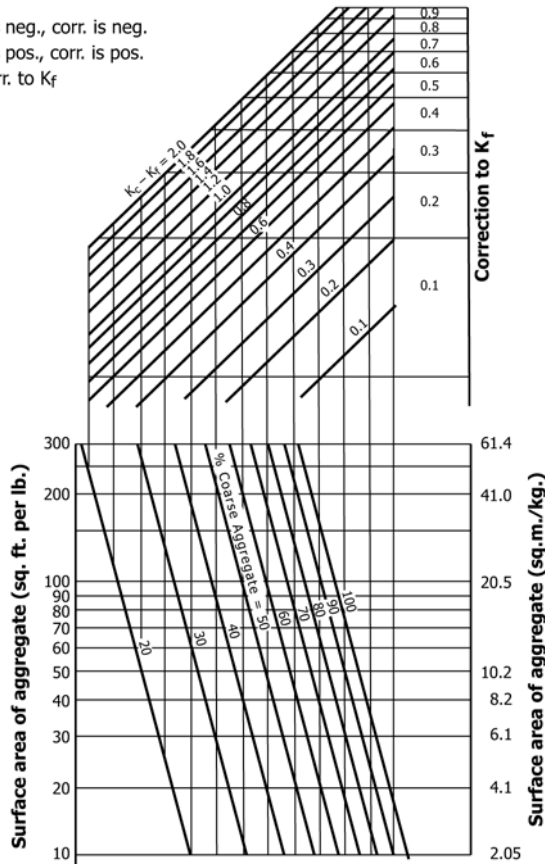


FIG. 5 Chart for Combining K_f and K_c to Determine K_m

11.4.3 The determination of K_m is shown in the following example:

$$K_c = 1.0, K_f = 1.8, SA = 25 \text{ ft}^2 (5.12 \text{ m}^2/\text{kg}), \text{ passing } 4.75 \text{ mm (No.4)} = 60\% \quad (4)$$

11.4.3.1 Using the chart in Fig. 5 start in lower left corner with $SA = 25 \text{ ft}^2/\text{lb}$ ($5.12 \text{ m}^2/\text{kg}$), follow straightedge horizontally to percent of coarse aggregate (40 %), hold point, follow straightedge vertically upward to intersection with the difference between K_c and K_f (0.8), hold point, and follow straightedge horizontally to right to a “correction to K_f .” In this example, the correction is 0.2. Because $K_c - K_f$ ($1.0 - 1.8$) is negative, the correction is negative; therefore, $K_m = 1.8 - 0.2 = 1.6$. If K_c had been 1.8, and K_f 1.0, $K_c - K_f$ would have been positive (+0.8), and the correction (0.2) would have been positive. In this case, K_m would be $1.0 + 0.2 = 1.2$.

12. Report

12.1 Report percent kerosine retained, percent oil retained, K_f , K_m , and K_c .

13. Precision and Bias

13.1 Precision:

13.1.1 Estimates of variations within a laboratory cannot be made with available data because in several cases the same operator did not conduct all the tests from which the data were generated. However, the following is an estimate of variation between laboratories based on a test result that is the average of two samples.

	Variation Between Laboratories	
	Standard Deviation	Acceptable Range of Two Results
Kerosine retained, %	0.34	0.962
Oil retained, %	0.416	1.206

13.1.2 The precision statement is based on an interlaboratory study of 19 laboratories that tested two aggregates twice with an interval of one week. The same operator conducted the first series of tests on both aggregates but did not necessarily conduct the second series of tests. More specifically, the results are based on using an SAE No. 10 oil.

13.2 Bias—The procedure in this test method has no bias because the values of the kerosine retained and the oil retained are defined in terms of this test method.

14. Keywords

14.1 aggregates; bitumin content; centrifuge kerosine equivalent; surface roughness

APPENDIX

(Nonmandatory Information)

X1.

X1.1 Scope

X1.1.1 The K_f and K_c constants for an aggregate are used in bituminous mix design procedures to determine an approximate bitumen ratio (ABR). When used in this manner in the Hveem mix design procedure for dense-graded bituminous mixtures, other mix properties are also considered such as appearance (for flushing condition), voids, and Hveem stability and cohesion. The ABR calculated for open-graded friction courses from acceptable relations should also be verified by conducting an asphalt drainage test.

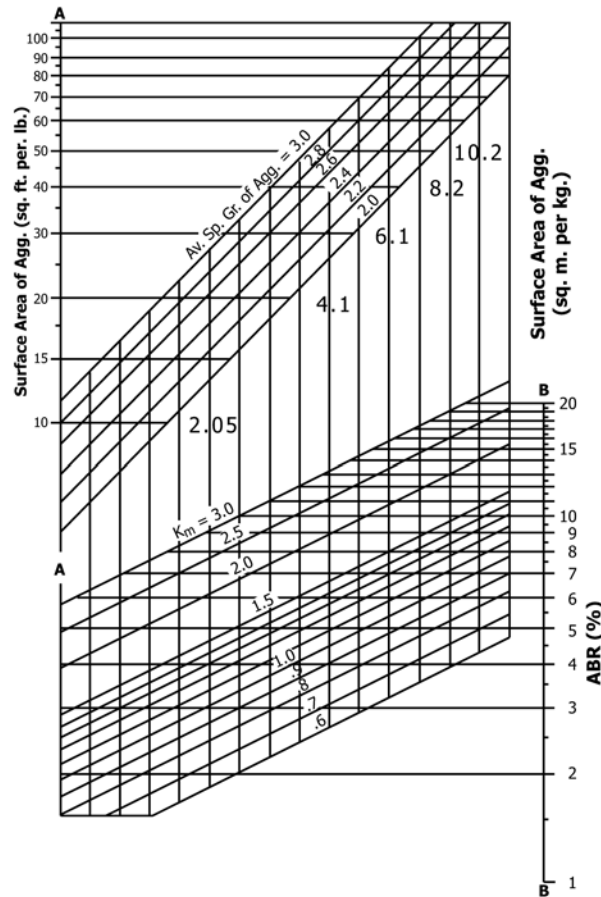
X1.1.2 The ABR for dense-graded bituminous mixtures is determined by use of Fig. X1.1.

X1.1.3 Fig. X1.2 is used for correcting the bitumen requirement for paving asphalts.

X1.1.4 The ABR for open-graded mixtures can be calculated from $ABR = 2K_c + 4.0$ and correcting for aggregate specific gravity.³⁴

³ Federal Highway Administration, "Design of Open-Graded Asphalt Friction Courses," Report No. FHWA-RD-74-2, January 1974, Washington, DC, Suppl. No. 1, July 11, 1975.

⁴ White, Thomas D., "Field Performance of Porous Friction Course," miscellaneous paper S-76-13, April 1976, US Army Engineer Waterways Experiment Station, CE, Vicksburg, MS; and Report No. FAA-RD-73-197, February 1975, Federal Aviation Administration, Washington, DC.



PROCEDURE

Find surface area on scale A. Proceed horizontally to curve corresponding to av. sp. gr. of aggregate, then down to curve corresponding to K_m then horizontally to scale B for Approximate Bitumen Ratio.

ABR = lbs. of oil per 100 lbs. of aggregate and applies directly to oil of SC-250 MC-250 and RC-250 grades. A correction must be made for heavier liquid or paving asphalts, Fig. 5.

FIG. X1.1 Chart for Computing Approximate Bitumen Ratio (ABR) for Dense-Graded Bituminous Mixtures

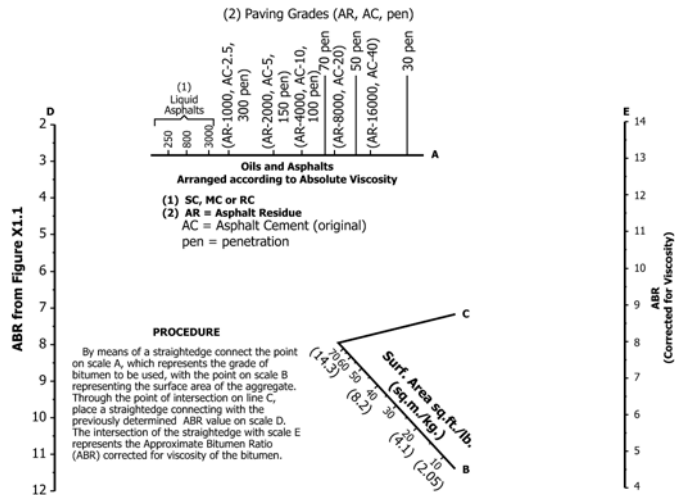


FIG. X1.2 Chart for Correcting ABR for Grade of Asphalt

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