Designation: D 4469 – 01

Standard Practice for Calculating Percent Asphalt Absorption by the Aggregate in an Asphalt Pavement Mixture[1]

This standard is issued under the fixed designation D 4469; 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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides equations for calculating percent asphalt absorption by the aggregate in an asphalt paving mixture, expressed as percent of the oven-dry mass of the aggregate in the paving mixture. This calculation is based on measured values for components and properties of an oven-dry asphalt paving mixture.

1.2 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate[2]

C 128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate[2]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[2]

D 1559 Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus[3]

D 1560 Test Methods for Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of Hveem Apparatus[4]

D 2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures[4]

D 2172 Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures[4]

D 3289 Test Method for Density of Semi-Solid and Solid Bituminous Materials (Nickel Crucible Method)[4]

3. Summary of Test Method

3.1 The percent asphalt absorption for an oven-dry paving mixture (expressed as percent of the oven-dry mass of the total aggregate in the paving mixture) can be calculated by means of equations in which measured values for the theoretical maximum specific gravity of an oven-dry paving mixture, its asphalt content (expressed either as percent of the total mass of a sample of oven-dry paving mixture, or as percent of the mass of oven-dry aggregate in a sample of oven-dry paving mixture), the apparent specific gravity of the asphalt and the weighted average ASTM bulk specific gravity of the oven-dry total aggregate in the paving mixture (Note 1), has been substituted.

NOTE 1—Whenever it is referred to in this practice, the phrase, "weighted average ASTM oven-dry bulk specific gravity of the aggregate," refers to the weighted average of the ASTM oven-dry bulk specific gravities of the coarse and fine aggregates as determined by Test Methods C 127 and C 128. The fine aggregate ordinarily includes the mineral dust portion of the fine aggregate that passes the No. 200 sieve. The weighted average ASTM oven-dry bulk specific gravity of the total aggregate is to be calculated by means of the equation given in the calculation section of Test Method C 127.

4. Significance and Use

4.1 The amount of asphalt absorbed by the aggregate contributes little or nothing to the durability of an asphalt pavement in service other than possibly providing greater resistance to stripping in the presence of water.

4.2 Percent asphalt absorption can be an indicator of changes that may occur in plant mix production during construction.

4.3 The calculated percent asphalt absorption can be used for calculating percent air voids during paving mixture design.

5. Procedure

5.1 Determine percent asphalt absorption by the aggregate in a paving mixture for a sample of oven-dried paving mixture that is prepared in a laboratory, taken from a pavement, or obtained for quality control during construction.

5.2 Establish percent asphalt absorption by the aggregate in a sample of oven-dried paving mixture from values for the sample that have been obtained in accordance with the following ASTM test methods:

5.2.1 Test Method D 2041, theoretical maximum specific gravity of the sample of oven-dry paving mixture.

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[1] This practice 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] *Annual Book of ASTM Standards*, Vol 04.02.

[3] Discontinued. See *1997 Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 04.03.

5.2.2 Test Methods D 2172, asphalt content. For samples of paving mixture obtained for quality control during construction, or taken from a pavement, determine the asphalt content of each sample by Test Methods D 2172. For samples of hot-mixed asphalt paving mixture prepared in the laboratory with oven-dried aggregate according to Test Methods D 1559 and D 1560, use the asphalt content that was added during the preparation of the paving mixture.

5.2.3 Test Method D 3289, the apparent specific gravity of the asphalt in the sample of paving mixture.

5.2.4 Test Methods C 127 and C 128, the respective ASTM dry bulk specific gravities of the coarse and fine aggregates in the sample of paving mixture.

5.2.5 Test Method C 136, to establish the percentages of coarse and fine aggregates employed for or recovered from the sample of paving mixture, and thereby enable the weighted average ASTM oven-dry bulk specific gravity for the total aggregate in the sample of paving mixture to be calculated (using the equation given in the calculation section of Test Method C 127).

6. Calculation

6.1 *Paving Mixtures for Which Asphalt Content is Expressed as Percent by Mass of the Total Mix in a Sample of Oven-Dry Paving Mixture*:

6.1.1 When the values for the various items in 5.2 become available, calculate the asphalt absorption as percent of the oven-dry mass of the total aggregate in the sample of oven-dry paving mixture, by substituting the relevant values in the following equation:

$$Aac = 100\left[\frac{P_{tac}}{100 - P_{tac}} + \frac{G_{ac}}{G_{ag}} - \frac{100G_{ac}}{(100 - P_{tac})G_{tm}}\right] \quad (1)$$

where:

Aac = absorbed asphalt as percent by mass of the oven-dry aggregate.

P_{tac} = asphalt content as percent by mass of the total mix in the sample of oven-dry paving mixture.

G_{ac} = apparent specific gravity of the asphalt in the paving mixture sample.

G_{ag} = weighted average ASTM oven-dry bulk specific gravity of the total aggregate in the sample of paving mixture.

G_{tm} = theoretical maximum specific gravity of the sample of oven-dry paving mixture.

6.2 *Paving Mixtures for Which Asphalt Content is Expressed as Percent of the Mass of the Oven-Dry Total Aggregate in a Sample of Oven-Dry Paving Mixture*.

6.2.1 When the values for the various items in 5.2 become available, calculate the asphalt absorption as percent of the oven-dry mass of the aggregate in the sample of oven-dry paving mixture by substituting the relevant values in the following equation:

$$Aac = 100\left[\frac{P_{aac}}{100} + \frac{G_{ac}}{G_{ag}} - \frac{(100 + P_{aac})(G_{ac})}{100\,G_{tm}}\right] \quad (2)$$

where:

P_{aac} = asphalt content as percent of the mass of the oven-dry total aggregate in a sample of oven-dry paving mixture.

and = the other symbols have the significance designated for them in 6.1.1.

NOTE 2—The calculated percent asphalt absorption increases with an increase in theoretical maximum specific gravity of a paving mixture, increases with an increase in its asphalt content, decreases with an increase in the apparent specific gravity of the asphalt, and decreases with an increase in the total aggregate's weighted average ASTM oven-dry bulk specific gravity.

7. Report

7.1 Report asphalt absorption as percent of the oven-dry mass of the total aggregate in the sample of oven-dry paving mixture to the nearest 0.1 %. The precision of the reported value for percent asphalt absorption depends on the accuracy of the value measured for each of the four variables that are included in either Eq 1 or Eq 2. Errors in these measured values can have a major influence on the value for percent asphalt absorption. The influence of these errors on the calculated value for percent asphalt absorption is illustrated by the data in X1.2.1 in Appendix X1.

7.2 Report the value for each of the four variables that are included either in Eq 1 or Eq 2 as follows:

7.2.1 Theoretical maximum specific gravity of the oven-dry sample of paving mixture.

7.2.2 Asphalt content as percent of the mass of the oven-dry sample of paving mixture, Eq 1, or asphalt content as percent of the mass of the oven-dry total aggregate in a sample of oven-dry paving mixture, Eq 2.

7.2.3 Apparent specific gravity of the asphalt in the sample of paving mixture.

7.2.4 Weighted average ASTM oven-dry bulk specific gravity for the total aggregate in the sample of paving mixture.

8. Keywords

8.1 aggregate-asphalt absorption; asphalt absorption; asphalt mixture

APPENDIX

(Nonmandatory Information)

X1. SAMPLE CALCULATIONS

X1.1 Sample Calculations for Percent Asphalt Absorption

X1.1.1 The usefulness and bias of Eq 1 and Eq 2 for determining the percent asphalt absorption by the aggregate in a sample of asphalt paving mixture is illustrated by the following sample calculations:

X1.1.2 *Numerical Calculation*—Assume the following:

X1.1.2.1 Theoretical maximum specific gravity of an oven-dry sample of paving mixture = 2.501.

X1.1.2.2 Asphalt content of oven-dry paving mixture sample expressed as percent by mass of total mix = 6.2 (for use with Eq 1).

X1.1.2.3 Corresponding asphalt content of oven-dry paving mixture sample expressed as percent by mass of the oven-dry total aggregate in the sample

$$= \frac{6.2}{93.8} \times 100 = 6.61 \text{ (for use with Eq 2).}$$

X1.1.2.4 Apparent specific gravity of asphalt in paving mixture sample = 1.015.

X1.1.2.5 Weighted average ASTM oven-dry bulk specific gravity of the total aggregate in the paving mixture sample = 2.673.

X1.1.2.6 Basis of calculation—100 cc of paving mixture at its theoretical maximum specific gravity.

X1.1.2.7 Mass of 100 cc of paving mixture = 250.1 g

X1.1.2.8 Mass of asphalt = $^{6.2}/_{100} \times 250.1 = 15.51$ g

X1.1.2.9 Volume of asphalt = $^{15.51}/_{1.015} = 15.28$ cc

X1.1.2.10 Mass of aggregate = $^{93.8}/_{100} \times 250.1 = 234.59$ g

X1.1.2.11 Volume of aggregate = $^{234.59}/_{2.673} = 87.76$ cc

X1.1.2.12 Volume of asphalt plus volume of aggregate = 15.28 + 87.76 = 103.04 cc

The difference between 103.04 cc and the original 100 cc represents the volume of asphalt absorbed into the pores of the individual aggregate particles.

Consequently:

$$\text{Volume of absorbed asphalt} = 103.04 - 100 = 3.04 \text{ cc}$$

$$\text{Mass of absorbed asphalt} = 3.04 \times 1.015 = 3.09 \text{ g}$$

$$\text{Percent asphalt absorption} = \frac{3.09}{234.59} \times 100 = 1.32$$

NOTE X1.1—The above sample calculation employed asphalt content expressed as percent of mass of oven-dry total mix. An identical percent asphalt absorption value is obtained when the calculations are based on asphalt content expressed as percent by mass of the total oven-dry aggregate in the oven-dry paving mixture sample.

X1.1.3 *Substitution in Eq 1*:

$$Aac = 100\left[\frac{P_{tac}}{100 - P_{tac}} + \frac{G_{ac}}{G_{ag}} - \frac{100G_{ac}}{(100 - P_{tac})G_{tm}}\right]$$

$$Aac = 100\left[\frac{6.2}{93.8} + \frac{1.015}{2.673} - \frac{(100)(1.015)}{(93.8)(2.501)}\right]$$

$$= 100(0.066 + 0.380 - 0.433)$$

$$= 100(0.446 - 0.433)$$

$$= 100(0.013) = 1.3\ \%$$

X1.1.4 *Substitution in Eq 2*:

$$Aac = 100\left[\frac{P_{aac}}{100} + \frac{G_{ac}}{G_{ag}} - \frac{(100 + P_{aac})}{100G_{tm}}(G_{ac})\right]$$

$$= \left[\frac{6.61}{100} + \frac{1.015}{2.673} - \frac{(106.61)(1.015)}{(100)\ (2.501)}\right]$$

$$= 100(0.066 + 0.380 - 0.433)$$

$$= 100(0.446 - 0.433)$$

$$= 100(0.013) = 1.3\ \%$$

Therefore, by means of either Eq 1 or Eq 2, the percent asphalt absorption into the pores of the aggregate particles in a sample of asphalt paving mixture can be determined as soon as each of the four variables that are included in these equations have been evaluated.

X1.2 Influence of Errors in Each of the Four Variables Included in Either Eq 1 or Eq 2 on Percent Asphalt Absorption

X1.2.1 The influence of errors in the measurement of each of the four variables *(a)* the theoretical maximum specific gravity of an oven-dry paving mixture, *(b)* its asphalt content expressed either as percent of the mass of the sample of oven-dry paving mixture, Eq 1, or as percent of the mass of oven-dry total aggregate in the sample of oven-dry paving mixture, Eq 2, *(c)* the apparent specific gravity of the asphalt in the paving mixture, and *(d)* the weighted average ASTM bulk specific gravity of the oven-dry total aggregate in the paving mixture, is illustrated for each variable in turn in the following table, for which it is assumed that the correct value for each of these four variables for a typical asphalt paving mixture is listed in the first row (previously used for the sample calculations in X1.1.2). It should be particularly noted that the relatively small range of errors recorded for each variable in the table that follows, is within the limits of the ASTM precision statement for reproducibility for that variable. In Table X1.1, the effect on asphalt absorption of these limited errors in each of the four variables, is shown for each variable in turn while the other three variables are held constant. Each variable being changed in turn within its range of reproducibility is marked by the symbol (a).

X1.2.2 The minimum and maximum values or percent asphalt absorption that could occur on the basis of the data in Table X1.1 due to the most fortuitous combination of errors listed for the determination of the four variables are shown in Table X1.2.

X1.2.3 Consequently, even when errors in each variable in Eq 1 or Eq 2 for asphalt absorption are within the ASTM

TABLE X1.1 Effect of Measurement Errors on Calculated Percent Asphalt Absorption

Theor. Max. Spec. Grav.	Asphalt Content % [A]	Asphalt App. Spec. Grav.	Weighted Average ASTM Oven-Dry Bulk Spec. Grav. of Total Agg.	% Asphalt Absorption
2.501	6.2	1.015	2.673	1.32
2.482(a)	6.2	1.015	2.673	0.98
2.491(a)	6.2	1.015	2.673	1.14
2.511(a)	6.2	1.015	2.673	1.49
2.520(a)	6.2	1.015	2.673	1.64
2.501	5.39(a)	1.015	2.673	0.77
2.501	5.7(a)	1.015	2.673	0.98
2.501	6.7(a)	1.015	2.673	1.66
2.501	7.01(a)	1.015	2.673	1.85
2.501	6.2	1.013(a)	2.673	1.33
2.501	6.2	1.017(a)	2.673	1.31
2.501	6.2	1.015	2.615(a)	2.16
2.501	6.2	1.015	2.635(a)	1.86
2.501	6.2	1.015	2.653(a)	1.61
2.501	6.2	1.015	2.663(a)	1.46
2.501	6.2	1.015	2.683(a)	1.18
2.501	6.2	1.015	2.693(a)	1.03
2.501	6.2	1.015	2.713(a)	0.76
2.501	6.2	1.015	2.731(a)	0.51

[A] Based on mass of a sample of oven-dry total mix (kg of asphalt per 100 kg of oven dry total mix).

TABLE X1.2 Minimum and Maximum Calculated Percent Asphalt Absorption Due to Measurement Errors

Theor. Max. Spec. Grav.	Asphalt Content %[A]	Asphalt App. Spec. Grav.	Weighted Average ASTM Oven Dry Bulk Spec. Grav. of Total Agg.	% Asphalt Absorption
For Minimum Asphalt Absorption				
2.482	5.39	1.017	2.731	−0.38
For Maximum Asphalt Absorption				
2.520	7.01	1.013	2.615	3.05

[A] Based on mass of a sample of oven-dry total mix (kg of asphalt per 100 kg of oven dry total mix).

reproducibility precision limits for that variable, in the case of the sample calculations illustrated in X1.1.2, X1.1.3, and X1.1.4, the reported value for percent asphalt absorption could range from − 0.38 to 3.05 as extreme limits.