Method of Test For
ASPHALT VOLUMETRIC CALCULATIONS
DOTD DESIGNATION: TR 331-14

Scope

1. This method of test is intended to be a guideline for hot mix asphalt volumetric calculations and other calculations used in hot mix asphalt design and production.

2. Reference Documents
   A. AASHTO T 84 – Specific Gravity and Absorption of Fine Aggregate
   B. AASHTO T 85 – Specific Gravity and Absorption of Coarse Aggregate
   C. DOTD TR 304 – Determination of Specific Gravity and Density Characteristics of Compressed Asphaltic Mixtures
   D. DOTD TR 306 – Determination of Percentage of Crushed Particles for Coarse Aggregates
   E. DOTD TR 309 – Mechanical Analysis of Extracted Aggregate
   F. DOTD TR 327 – Theoretical Maximum Specific Gravity of Asphaltic Concrete Mixtures

Calculations

1. Specific Gravity of Aggregate and Mineral Filler for Asphaltic Mixtures

A. Coarse Aggregate (AASHTO T 85)

Bulk Specific Gravity, Aggregate

$$Bulk\ Specific\ Gravity = \frac{A}{(B - C)}$$

where
A = mass of oven-dry test sample in air, g
B = mass of saturated-surface-dry test sample in air, g
C = mass of saturated test sample in water, g
Note: To nearest 0.001

Apparent Specific Gravity, Aggregate

$$Apparent\ Specific\ Gravity = \frac{A}{(A - C)}$$

where
A = mass of oven-dry test sample in air, g
C = mass of saturated test sample in water, g
Note: To nearest 0.001

Average Specific Gravity Values

$$G = \frac{1}{\frac{P_1}{100 * G_1} + \frac{P_2}{100 * G_2} + \cdots \frac{P_n}{100 * G_n}}$$

where
G = average specific gravity
P_1, P_2, P_n = mass percentages of each size fraction present in the original sample
G_1, G_2, G_n = appropriate specific gravity values for each size fraction
Note: To nearest 0.001

Water Absorption, Aggregate

$$Absorption(\%) = \left[\frac{B - A}{(A)}\right] * 100$$

where
A = mass of oven-dry test sample in air, g
B = mass of saturated-surface-dry test sample in air, g
Note: To nearest 0.1%

B. Fine Aggregate (AASHTO T 84)

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Bulk Specific Gravity, Aggregate

$$Bulk\ Specific\ Gravity = \frac{A}{(B+S-C)}$$

where
A = mass of oven-dry test sample in air, g
B = mass of pycnometer filled with water, g
S = mass of saturated surface-dry specimen, g
C = mass of pycnometer with specimen and water to calibration mark, g
Note: To nearest 0.001

Apparent Specific Gravity, Aggregate

$$App\ Specific\ Gravity = \frac{A}{(B+A-C)}$$

where
A = mass of oven-dry test sample in air, g
B = mass of pycnometer filled with water, g
C = mass of pycnometer with specimen and water to calibration mark, g
Note: To nearest 0.001

Water Absorption, Aggregate

$$Absorption(\%) = \left[\frac{S-A}{(A)}\right] * 100$$

where
A = mass of oven-dry test sample in air, g
S = mass of saturated surface-dry specimen, g
Note: To nearest 0.1%

2. Percentage of Crushed Particles for Coarse Aggregates (DOTD TR 306)

Percent Crushed

$$\%Crushed = \left[\frac{Crushed\ Agg}{Total\ Coarse}\right] * 100$$

where
%Crushed = % of crushed aggregate single or double face in test sample
Crushed Agg = mass of crushed aggregate, g
Total Coarse = mass of plus 4.75 mm (No.4) aggregate
Note: To nearest 1%

Percent Double Faced Crushed

$$\%DFCrush = \left[\frac{DFCrush\ Agg}{Total\ Coarse}\right] * 100$$

where
%DFCrush = % of crushed aggregate double face in test sample
DFCrush Agg = mass of double face crushed aggregate
Total Coarse = mass of plus 4.75mm (No.4) aggregate
Note: To nearest 1%

3. Asphalt Absorption Factor and Effective Asphalt Content

Asphalt Absorption

$$AC_a = 100 * \left(\frac{G_e - G_b}{G_e * G_e}\right) * G_a$$

where
AC_a = absorbed asphalt, % by weight of aggregate
G_a = specific gravity of asphalt
G_b = bulk specific gravity of aggregate
G_e = effective specific gravity of aggregate
Note: To nearest 0.1%

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Effective Asphalt Content

$$AC_e = AC_m - \left(\frac{AC_a}{100} * AGG\right)$$

where

AC_e = effective asphalt content, % by total weight of mixture

AC_m = asphalt content, % by total weight of mixture, taken from JMF

AC_a = absorbed asphalt, % by weight of aggregate

AGG = aggregate, % by total weight of mixture, taken from JMF

Note: To nearest 0.1%

4. Theoretical Maximum Specific Gravity of Asphalt Concrete Mixtures (DOTD TR 327)

Theoretical Maximum Specific Gravity, G_{mm}

$$G_{mm} = \frac{A}{(A + D - E)}$$

where

A = mass of oven-dry sample in air, g

D = mass of container filled with water at 25°C (77°F), g

E = mass of container filled with sample and water at 25°C (77°F), g

Note: To nearest 0.001

Average Theoretical Maximum Specific Gravity

$$G_{mm} = \frac{G_{mm\,a} + G_{mm\,b}}{2}$$

where

$G_{mm\,a}$ = Theoretical Maximum Specific Gravity of sample "a"

$G_{mm\,b}$ = Theoretical Maximum Specific Gravity of sample "b"

Note: To nearest 0.001

5. Specific Gravity and Density Characteristics of Compressed Asphalt Mixtures (DOTD TR 304)

Bulk Specific Gravity, G_{mb}

$$D = \frac{A}{(B - C)}$$

where

A = mass of specimen in air, g

B = mass of saturated-surface-dry specimen in air, g

C = mass of specimen in water, g

Note: To nearest 0.001

Water Absorption, Asphalt

$$\%Water\ Absorbed = \left[\frac{B - A}{B - C}\right] * 100$$

where

%Water Absorbed = percentage of water absorbed by volume

A = mass of specimen in air, g

B = mass of saturated-surface-dry specimen in air, g

C = mass of specimen in water, g

Note: To nearest 0.1%

Note: If the percent of water absorbed by the specimen exceeds 2.0 percent use ???

Percentage of Theoretical Maximum Specific Gravity, %G_{mm}

$$G = \frac{D}{F} * 100$$

where

D = bulk specific gravity of sample, G_{mb}

F = average theoretical maximum specific gravity, G_{mm}

Note: To nearest 0.1%

Note: Also referred to as Percent Pavement Density

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Percentage of Air Voids, V_a

$$H = 100 - G$$

where

G = percent theoretical maximum gravity, $\%G_{mm}$

Note: To nearest 0.1%

Percent Voids in Mineral Aggregate, %VMA

$$J = 100 - \frac{(D * P_a)}{G_{sb}}$$

where

D = bulk specific gravity of sample, G_{mb}

P_a = aggregate content, percent by total weight of mixture from JMF

G_{sb} = bulk specific gravity of the total aggregate from JMF

Note: To nearest 0.1%

Percent Voids Filled with Asphalt, %VFA

$$K = \frac{(J - H)}{J} * 100$$

where

H = Percent voids, V_a

J = Percent voids in mineral aggregate, %VMA

Note: To nearest 1%

Average Percent Density of Roadway Cores, Avg PD

$$Avg\ PD = \frac{\sum PD_n}{N}$$

where

PD_n = Percent pavement density of each core for the lot

N = Number of cores for the lot

Note: To nearest 0.1%

6. Moisture Content of Asphaltic Concrete (Loose Mix)

Moisture Content

$$Moisture\ Content\ (\%) = \left[\frac{M_i - M_f}{M_i}\right] * 100$$

where

M_i = mass of initial, moist test sample, g

M_f = mass of final, dry test sample, g

Note: To nearest 0.1%

7. Asphalt Content of Asphaltic Mixture by Ignition Method

Asphalt Content

$$AC\ (\%) = \left[\frac{M_i - M_f}{M_i} * 100\right] - C_F - MC$$

where

AC = percent asphalt content

M_i = total mass of HMA specimen prior to ignition, g

M_f = total mass of aggregate remaining after ignition, g

C_F = correction factor, percent by mass of HMA specimen

MC = moisture content of the companion HMA specimen (if specimen was oven dried prior to initiating the procedure, MC = 0)

Note: To nearest 0.1%

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8. Bitumen Content of Paving Mixtures by Centrifuge or Reflux Extractor (DOTD TR 307)

Mass of Mineral Matter (Ash) in Total Volume of Extract

$$W_4 = G * \left[\frac{V_1}{(V_1 - V_2)}\right]$$

where
W_4 = mass of mineral matter in total volume of extract, g
G = ash in aliquot, g
V_1 = total volume, mL
V_2 = volume after removing aliquot, mL
Note: To nearest 0.1g

Bitumen Content

$$BC\ (\%) = \left[\frac{(W_1 - W_2) - (W_3 + W_4 + U)}{W_1 - W_2}\right] * 100$$

where
BC = percent bitumen content
W_1 = mass of test portion, g
W_2 = mass of water in test portion, g
W_3 = mass of extracted mineral aggregate, g
W_4 = mass of the mineral matter in the extract, g
U = increase in mass of filter, g
Note: To nearest 0.1%

9. Mechanical Analysis of Extracted Aggregate (DOTD TR 309)

Percent Deviation of the Accumulated Total from Initial Dry Total Weight

$$\%Difference = \frac{W - Z}{W} * 100$$

where
W = initial dry total weight of sample
Z = accumulated total weight
Note: To nearest 0.01%

Percent of Material Retained on each Sieve

$$PR_x = \frac{WR_x}{Z} * 100$$

where
WR_x = weight of oven-dry aggregate passing one sieve and retained on the next smaller size sieve
Z = accumulated total weight
Note: To nearest 0.01%

Percent of Coarser Than Each Sieve

$$PC_x = PR_1 + PR_2 + \cdots + PR_x$$

where
PR_1 , PR_2 , PR_x = percent retained in each particular sieve
Note: To nearest 0.01%

Percent of Passing Each Sieve

$$PP_x = 100 - PC_x$$

where
PC_x = percent coarser than each particular sieve
Note: To nearest 0.01%

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