DETERMINATION OF AIR VOIDS IN COMPACTED BITUMINOUS MIXTURES

(A Modification of AASHTO Designation T 269)

1. SCOPE

1.1 This procedure is used to determine the air voids in compacted bituminous mixtures. It is applicable for specimens which are either laboratory compacted or field compacted (for example, cores).

1.2 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. CALCULATION

2.1 For specimens which are either Marshall laboratory compacted or field compacted (e.g., cores), the percent air voids shall be calculated using the bulk density of the compacted bituminous mixture (Arizona Test Method 415) and maximum density of the mixture from the Rice Test (Arizona Test Method 417).

2.1.1 The percent air voids are calculated by the following equation:

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Bulk Density}}{\text{Maximum Density}}\right] \times 100$$

2.1.1.1 An example of the calculations is given in Figure 1.

2.1.1.2 A blank form for perfoming the calculations is given in Figure 3.

2.2 For specimens which are gyratory laboratory compacted, the percent air voids shall be calculated using the average relative density of the compacted bituminous mixture at N_{design} (AASHTO T 312).

2.2.1 The percent air voids are calculated by the following equation:

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{design})

2.2.1.1 An example of the calculations is given in Figure 2.

2.2.1.2 A blank form for perfoming the calculations is given in Figure 4.

3. REPORT

3.1 The percent air voids shall be reported to the nearest 0.1%.

CALCULATION OF AIR VOIDS FOR MARSHALL LABORATORY COMPACTED SPECIMENS OR FIELD COMPACTED SPECIMENS

Specimens Compacted by: Hand ☐ Mechanical ☒ 4 inch ☒ 6 inch ☐; Core ☐

Specimen I.D.	1	2	3	Average
Specimen Height	2.516	2.515	2.519	
Bulk Specific Gravity, Bulk Density, and Absorption (Arizona Test Method 415: Method A ☒, Method C ☐, or Vacuum Method ☐)				
A = Mass in grams of specimen in Air	1155.9	1155.4	1158.2	
B = Mass in grams of SSD specimen in Air	1156.9	1156.3	1159.2	
C = Mass in grams of specimen in Water	647.9	649.6	651.8	
G_{mb} = Bulk Specific Gravity = A/(B – C)	2.271	2.280	2.283	2.278
% Absorption = [(B – A)/(B – C)] x 100	0.20	0.18	0.20	
Bulk Density = (G_{mb} x 62.3 lbs./cu. ft.)	141.5	142.0	142.2	
Range of Bulk Density values (lbs./cu. ft.)	0.7			
Average Bulk Density = (Average G_{mb} x 62.3 lbs./cu. ft)				141.9
Maximum Density (lbs./cu. ft.) [from Rice Test]	149.4			

Notes:

The Individual specimen heights are reported to the nearest 0.001 inch.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The average bulk specific gravity is calculated, and reported to the nearest 0.001, using the individual bulk specific gravities which have been reported to the nearest 0.001.

The individual bulk densities are reported to the nearest 0.1 lb./cu. ft.

The average bulk density is reported to the nearest 0.1 lb./cu. ft.

The maximum density [from Rice Test] is reported to the nearest 0.1 lb./cu. ft.

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Average Bulk Density}}{\text{Maximum Density from Rice Test}}\right] \times 100 = \left[1 - \frac{141.9}{149.4}\right] \times 100 = 5.0\%$$

EXAMPLE AIR VOIDS CALCULATION FOR MARSHALL LABORATORY COMPACTED SPECIMENS

FIGURE 1

CALCULATION OF AIR VOIDS FOR GYRATORY LABORATORY COMPACTED SPECIMENS

Specimen I.D.	1	2	Average
h_{ini} = Height, in mm, of specimen at N_{ini} (8 gyrations)	128.7	129.3	
h_{des} = Height, in mm, of specimen at N_{des} (100 gyrations)	117.0	117.4	
h_{max} = Height, in mm, of specimen at N_{max} (160 gyrations)	115.6	116.0	
Bulk Specific Gravity and Absorption (Arizona Test Method 415: Method A ☐, Method C ☐, or Vacuum Method ☐)			
A = Mass, in grams, of specimen at N_{max} in Air	4747.4	4744.6	
B = Mass, in grams, of SSD specimen at N_{max} in Air	4759.4	4756.0	
C = Mass, in grams, of specimen at N_{max} in Water	2752.7	2751.2	
G_{mb} = Bulk Specific Gravity of specimen at N_{max} $= \frac{A}{B-C}$	2.366	2.367	
% Absorption = [(B – A)/(B – C)] x 100	0.60	0.57	
G_{mm} = Maximum Specific Gravity [from Rice Test]	2.449		
*Relative Density, $\%G_{mm}$, of specimen at N_{ini}	86.8	86.7	86.8
*Relative Density, $\%G_{mm}$, of specimen at N_{des}	95.5	95.5	95.5
*Relative Density, $\%G_{mm}$, of specimen at N_{max}	96.6	96.7	96.7

$$*\text{Relative Density}, \%G_{mmx} = \frac{(G_{mb}) \times (h_{max})}{(G_{mm}) \times (h_x)} \times 100$$

Where: $\%G_{mmx}$ = Relative Density, $\%G_{mm}$, of specimen at N_{ini}, N_{des}, or N_{max}
G_{mb} = Bulk Specific Gravity of specimen at N_{max}
h_{max} = Height, in mm, of specimen at N_{max}
G_{mm} = Maximum Specific Gravity [from Rice Test]
h_x = Height of specimen, in mm, at N_{ini}, N_{des}, or N_{max}

Notes:

The Individual specimen heights are reported to the nearest 0.1 mm.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The maximum specific gravity [from Rice Test] is reported to the nearest 0.001.

The individual relative densities are reported to the nearest 0.1 percent.

The average relative density for each set of specimens (at N_{ini}, N_{des}, and N_{max}) is calculated, and reported to the nearest 0.1 percent, using the corresponding individual relative densities which have been reported to the nearest 0.1 percent.

Three specimens are used when referee testing is performed.

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{des})

= (100) – (95.5) = 4.5%

EXAMPLE AIR VOIDS CALCULATION FOR GYRATORY LABORATORY COMPACTED SPECIMENS

FIGURE 2

CALCULATION OF AIR VOIDS FOR MARSHALL LABORATORY COMPACTED SPECIMENS OR FIELD COMPACTED SPECIMENS

Specimens Compacted by: Hand ☐ Mechanical ☐ 4 inch ☐ 6 inch ☐; Core ☐

Specimen I.D.				Average
Specimen Height				
Bulk Specific Gravity, Bulk Density, and Absorption (Arizona Test Method 415: Method A ☒, Method C ☐, or Vacuum Method ☐)				
A = Mass in grams of specimen in Air				
B = Mass in grams of SSD specimen in Air				
C = Mass in grams of specimen in Water				
G_{mb} = Bulk Specific Gravity = A/(B – C)				
% Absorption = [(B – A)/(B – C)] x 100				
Bulk Density = (G_{mb} x 62.3 lbs./cu. ft.)				
Range of Bulk Density values (lbs./cu. ft.)				
Average Bulk Density = (Average G_{mb} x 62.3 lbs./cu. ft)				
Maximum Density (lbs./cu. ft.) [from Rice Test]				

Notes:

The Individual specimen heights are reported to the nearest 0.001 inch.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The average bulk specific gravity is calculated, and reported to the nearest 0.001, using the individual bulk specific gravities which have been reported to the nearest 0.001.

The individual bulk densities are reported to the nearest 0.1 lb./cu. ft.

The average bulk density is reported to the nearest 0.1 lb./cu. ft.

The maximum density [from Rice Test] is reported to the nearest 0.1 lb./cu. ft.

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Average Bulk Density}}{\text{Maximum Density from Rice Test}}\right] \times 100 = \left[1 - \frac{(\quad)}{(\quad)}\right] \times 100 = \quad\%$$

FIGURE 3

CALCULATION OF AIR VOIDS FOR GYRATORY LABORATORY COMPACTED SPECIMENS

Specimen I.D.			Average
h_{ini} = Height, in mm, of specimen at N_{ini} (8 gyrations)			
h_{des} = Height, in mm, of specimen at N_{des} (100 gyrations)			
h_{max} = Height, in mm, of specimen at N_{max} (160 gyrations)			
Bulk Specific Gravity and Absorption (Arizona Test Method 415: Method A ☐, Method C ☐, or Vacuum Method ☐)			
A = Mass, in grams, of specimen at N_{max} in Air			
B = Mass, in grams, of SSD specimen at N_{max} in Air			
C = Mass, in grams, of specimen at N_{max} in Water			
G_{mb} = Bulk Specific Gravity of specimen at N_{max} $= \frac{A}{B - C}$			
% Absorption = [(B – A)/(B – C)] x 100			
G_{mm} = Maximum Specific Gravity [from Rice Test]			
*Relative Density, $\%G_{mm}$, of specimen at N_{ini}			
*Relative Density, $\%G_{mm}$, of specimen at N_{des}			
*Relative Density, $\%G_{mm}$, of specimen at N_{max}			

$$*\text{Relative Density}, \%G_{mmx} = \frac{(G_{mb}) \times (h_{max})}{(G_{mm}) \times (h_x)} \times 100$$

Where: $\%G_{mmx}$ = Relative Density, $\%G_{mm}$, of specimen at N_{ini}, N_{des}, or N_{max}
G_{mb} = Bulk Specific Gravity of specimen at N_{max}
h_{max} = Height, in mm, of specimen at N_{max}
G_{mm} = Maximum Specific Gravity [from Rice Test]
h_x = Height of specimen, in mm, at N_{ini}, N_{des}, or N_{max}

Notes:

The Individual specimen heights are reported to the nearest 0.1 mm.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The maximum specific gravity [from Rice Test] is reported to the nearest 0.001.

The individual relative densities are reported to the nearest 0.1 percent.

The average relative density for each set of specimens (at N_{ini}, N_{des}, and N_{max}) is calculated, and reported to the nearest 0.1 percent, using the corresponding individual relative densities which have been reported to the nearest 0.1 percent.

Three specimens are used when referee testing is performed.

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{des})

= (100) – (_____) = _____%

FIGURE 4