

## **SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE**

(A Modification of AASHTO Designation T 84)

### **1. SCOPE**

- 1.1 This method covers the determination of specific gravity and absorption of fine aggregate. The specific gravity may be expressed as bulk oven dry (OD) specific gravity, bulk saturated surface dry (SSD) specific gravity, or apparent specific gravity.
- 1.2 The specific gravity and absorption of fine aggregate is normally determined on Minus No. 4 Material. When the fine aggregate sample (Minus No. 4) contains a substantial amount of Minus No. 4 to Plus No. 8 Material, such as in mineral aggregate for asphaltic concrete friction course, the fine aggregate specific gravity and absorption shall be performed on Minus No. 8 Material. The fine aggregate specific gravity and absorption for mineral aggregates used in asphaltic concrete, other than asphaltic concrete friction course, shall be determined on Minus No. 4 Material. "Fine aggregate" as herein referenced will be either Minus No. 4 or Minus No. 8 Material. Corresponding coarse aggregate specific gravity and absorption testing, utilizing the appropriate Plus No. 4 or Plus No. 8 Material, shall be performed in accordance with Arizona Test Method 210.
- 1.3 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.
- 1.4 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.
- 1.5 When the specific gravity and absorption of the fine aggregate and the coarse aggregate are known, the combined aggregate specific gravity and absorption is determined, if necessary, utilizing Arizona Test Method 251.

## **2. APPARATUS**

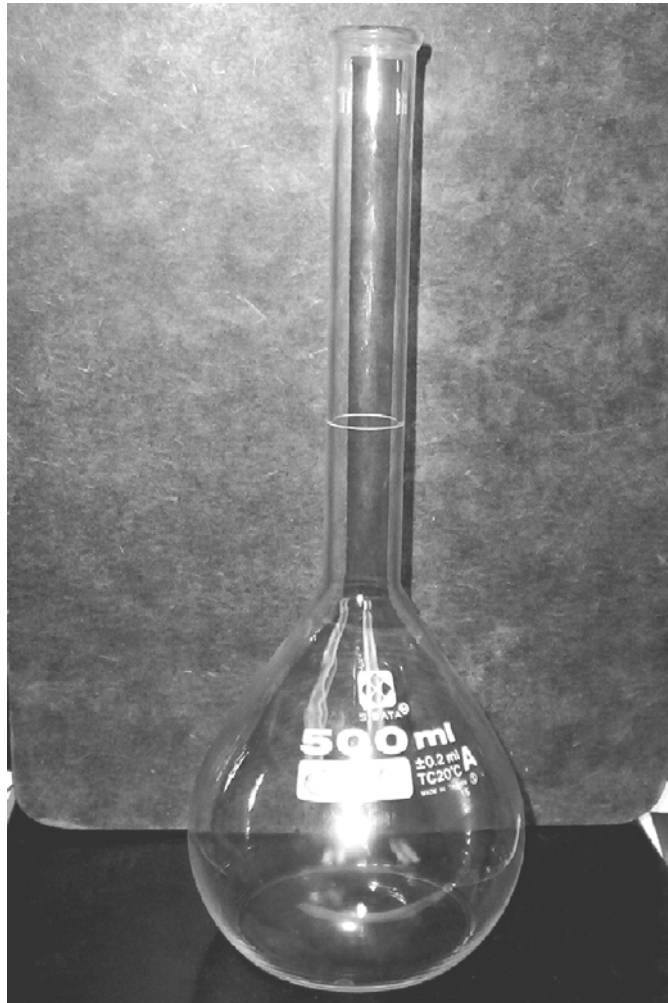
- 2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.
- 2.2 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.
- 2.3 Pycnometer - A 500 mL volumetric flask into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced within 0.2 mL. Figure 1 is an illustration of the type of flask that must be utilized. The volume of the flask filled to the mark shall be at least 50 percent greater than the space required to accommodate the test sample. If this requirement is not met for a particular aggregate, the normal sample size of  $500 \pm 10$  grams may be reduced only enough to satisfy the requirement.
- 2.4 Mold - A metal mold in the form of a frustum of a cone with dimensions as follows:  $40 \pm 3$  mm inside diameter at the top,  $90 \pm 3$  mm inside diameter at the bottom, and  $75 \pm 3$  mm in height, with the metal having a minimum thickness of 0.8 mm (See Figure 2).
- 2.5 Tamper - A metal tamper having a mass of  $340 \pm 15$  grams, and having a flat circular tamping face  $25 \pm 3$  mm in diameter (See Figure 2).
- 2.6 Oven - Capable of maintaining a temperature of  $230 \pm 9$  °F.

## **3. SAMPLING**

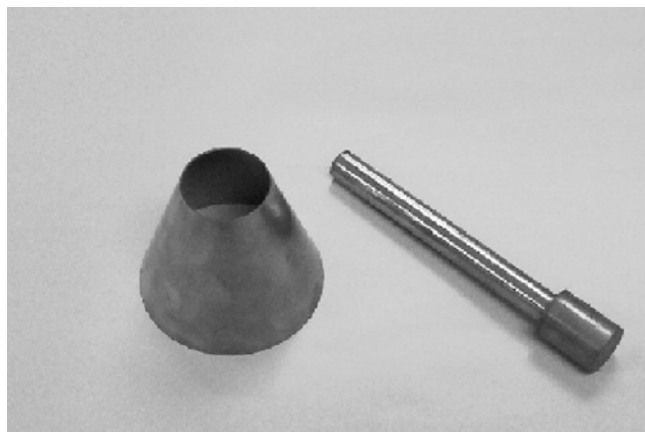
- 3.1 Sample the aggregate in accordance with Arizona Test Method 105.

## **4. PREPARATION OF TEST SAMPLE**

- 4.1 Obtain a representative approximate 1200 gram test sample of the fine aggregate.



**FIGURE 1**



**FIGURE 2**

- 4.2 Dry the test sample in a suitable pan or vessel to constant mass (see Subsection 4.3 below) at a temperature of  $230 \pm 9$  °F. (Constant mass shall be determined as follows: Dry the sample for a minimum of 1 hour at  $230 \pm 9$  °F. Record the weight of the sample to the nearest 0.1 gram. Continue drying and weighing until the weight does not change more than 0.1 gram at drying intervals of a minimum of 30 minutes.) Allow the sample to cool to comfortable handling temperature, cover with sufficient water to completely immerse it throughout the soaking period, and permit to stand for 15 to 19 hours.
- 4.3 Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant mass may be eliminated and, if the surfaces of the particles in the sample have been kept continuously wet until testing, the 15 to 19 hour soaking may also be eliminated.
- Note:** Values for absorption and bulk (SSD) specific gravity may be significantly higher for aggregate not oven dried before soaking than for the same aggregate which has been dried and soaked as specified in Subsection 4.2.
- 4.4 Decant excess water with care to avoid loss of fines, spread the sample on a flat nonabsorbent surface exposed to a gently moving current of ambient or warm air, and stir frequently to secure homogeneous drying. Continue stirring and drying until the sample approaches a free-flowing condition. As the material begins to dry sufficiently, it may be necessary to work it with the hands in a rubbing motion to break up any conglomerations, lumps, or balls of material that develop.
- 4.5 Follow the procedure (cone test for surface moisture) given in Subsection 4.6 below to determine whether or not surface moisture is present on the fine aggregate particles. It is intended that the first trial will be made with some surface water in the sample. Continue drying with constant stirring, working the material with a hand-rubbing motion as necessary, and test at frequent intervals until the test indicates that the sample has reached a surface-dry condition. If the first trial of the surface moisture test indicates that moisture is not present on the surface, it has been dried past the saturated surface-dry condition. In this case, thoroughly mix a few milliliters of water with the fine aggregate and permit the specimen to stand in a covered container for 30 minutes. Then resume the process of drying and testing at frequent intervals for the onset of the surface-dry condition.

- 4.6 With one hand, hold the mold firmly on a smooth nonabsorbent surface with the large diameter down. The mold must be held firmly in place throughout the process of filling the mold, tamping, and removal of excess material from around the base of the mold. With the other hand, place a portion of the partially dried fine aggregate loosely in the mold, filling it until overflowing occurs, and heaping additional material above the top of the mold. Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper. Each drop should start about 0.2 inch above the top surface of the fine aggregate. Permit the tamper to fall freely on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Remove loose material from around the base of the mold, and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. When the fine aggregate slumps slightly, it indicates that it has reached a surface-dry condition. Some angular fine aggregate or material with a high proportion of fines may not slump in the cone test upon reaching a surface-dry condition. This may be the case if fines become airborne upon dropping a handful of the sand from the cone test 4 to 6 inches onto a surface. For these materials, the saturated surface-dry condition should be considered as the point that one side of the fine aggregate slumps slightly upon removing the mold.

## 5. PROCEDURE

- 5.1 Only a pycnometer calibrated in accordance with the requirements of Appendix A3 of the Materials Testing Manual shall be used to perform this test. The mass of the pycnometer filled to its calibration capacity with water at  $73 \pm 3$  °F is determined and recorded to the nearest 0.1 gram. Prior to determining the mass of the pycnometer filled with water to the calibration mark, the inside of the neck of the pycnometer just above calibration level shall be dried with a rolled up paper towel.
- 5.2 Obtain a representative  $500 \pm 10$  gram sample of the saturated surface-dry fine aggregate prepared as described in Section 4. Immediately determine and record the weight of the sample to the nearest 0.1 gram.
- 5.3 Partially fill the calibrated pycnometer with water. Introduce the sample into the pycnometer and fill with additional water to approximately 90 percent of total capacity so that the water level after the elimination of all air bubbles is above the bottom of the neck but below the calibration line. Roll and agitate the pycnometer to eliminate all air bubbles.

**Note:** Adding a few drops of 99% grade isopropyl alcohol (ASTM D 770), after removal of air bubbles and just prior to bringing

the water level to its calibrated capacity, has been found useful in dispersing foam on the water surface.

- 5.4 Rinse the inside of neck of pycnometer with water and add sufficient water to bring the water level in the pycnometer to its calibrated capacity. Adjust its temperature to  $73 \pm 3$  °F, if necessary by immersion in circulating water. With a rolled up paper towel, dry the inside neck of pycnometer just above the calibration level. Determine and record the mass of the pycnometer, sample, and water to the nearest 0.1 gram.
- 5.5. Remove the fine aggregate from the pycnometer and dry to constant mass at a temperature of  $230 \pm 9$  °F. (Constant mass shall be determined as follows: Dry the sample for a minimum of 1 hour at  $230 \pm 9$  °F. Record the weight of the sample to the nearest 0.1 gram. Continue drying and weighing until the weight does not change more than 0.1 gram at drying intervals of a minimum of 30 minutes.) Cool in air at room temperature for  $1.0 \pm 0.5$  hours. Determine and record the mass to the nearest 0.1 gram.

**Note:** In lieu of drying and weighing the sample which has been removed from the pycnometer, a second portion of the saturated surface dry sample may be used to determine the oven dry weight. This sample must be obtained at the same time and shall weigh within  $\pm 0.2$  grams of the sample which is introduced into the pycnometer.

## 6. CALCULATIONS

6.1 Calculate the bulk (OD) specific gravity as shown below:

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

Where: A = mass of oven-dry test sample in air.  
B = mass of pycnometer filled with water to calibration mark.  
S = mass of saturated surface-dry test sample.  
C = mass of pycnometer with test sample and water to calibration mark.

6.2 Calculate the bulk (SSD) specific gravity as shown below:

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

6.3 Calculate the apparent specific gravity as shown below:

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

6.4 Calculate the percent absorption as shown below:

$$\text{Percent Absorption} = \frac{(S - A)}{A} \times 100$$

## 7. REPORT

7.1 Report specific gravity results to the nearest 0.001, and indicate the type of specific gravity, whether bulk (OD), bulk (SSD), or apparent.

7.2 Report the absorption result to the nearest 0.01%.

7.3 If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in Subsection 4.3, it shall be noted in the report. The source of the sample and the procedures used to prevent drying prior to testing shall also be reported.

7.4 The size of the material tested shall be noted, i.e., Minus No. 4 or Minus No. 8.

**8. PROCEDURE FOR DETERMINING COMBINED SPECIFIC GRAVITIES AND ABSORPTION FOR DIFFERENT SOURCES OF MATERIAL**

8.1 Two methods are given below for determining the combined specific gravities and absorption for different sources of material, as described in Subsections 8.2 and 8.3.

8.2 The specific gravity and absorption may be determined for fine aggregates from different sources which have been composited in the desired proportions and thoroughly blended.

8.3 The specific gravity and absorption of the fine aggregate from each individual source may be determined and the combined specific gravity and absorption calculated as described in Subsections 8.3.1 through 8.3.4 below. (Refer to the example given in Subsection 8.4 for an illustration of the procedure and calculations) The same size of material, either Minus No. 4 or pass Minus No. 8, shall be used to determine the individual specific gravities and absorption for each of the different sources.

8.3.1 For each individual material in the composite, its contribution to the total percent of fine aggregate in the composite is determined and recorded to the nearest 0.01% as "IP":

$$IP = \frac{\left( \frac{\text{Percent of Individual Material in Composite}}{\text{Material in Composite}} \right) \times \left( \frac{\text{Percent of Fine Aggregate in Individual Material}}{\text{Individual Material}} \right)}{100}$$

Where: IP = Contribution by each individual material to the total percent of fine aggregate in the composite.

8.3.2 For each individual source, the percent of fine aggregate in the composite is determined by summing the values for "IP" for that source, and recording the total as "P".



8.3.3 The combined specific gravity is calculated by the following:

$$G = \frac{P_1 + P_2 + \dots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \dots + \frac{P_n}{G_n}}$$

Where: P<sub>1</sub>, P<sub>2</sub>, ... P<sub>n</sub> = For each individual source, the percent of fine aggregate in the composite, "P".

G<sub>1</sub>, G<sub>2</sub>, ... G<sub>n</sub> = The fine specific gravity for each individual source.

8.3.4 The combined absorption is calculated by the following:

$$\text{Combined Absorption} = \frac{\left( \frac{\text{Combined Bulk (SSD)}}{\text{Specific Gravity}} \right) - \left( \frac{\text{Combined Bulk (OD)}}{\text{Specific Gravity}} \right)}{\left( \frac{\text{Combined Bulk (OD)}}{\text{Specific Gravity}} \right)}$$

8.4 The following is an example of the procedure and calculations described in Subsections 8.3.1 through 8.3.4 above. The example given is for a composite consisting of 26% coarse aggregate, 12% intermediate aggregate, and 47% fine aggregate from the primary source; with 15% aggregate from a secondary source. The coarse aggregate has 2% pass the No. 4 sieve, the intermediate aggregate has 6% pass the No. 4 sieve, the fine aggregate has 91% pass the No. 4 sieve, and the aggregate from the secondary source has 76% pass the No. 4 sieve.

Fine aggregate specific gravity and absorption for each of the different sources:

Primary Source (Coarse, Intermediate, Fine):

Bulk (OD) Specific Gravity = 2.576  
 Bulk (SSD) Specific Gravity = 2.611  
 Apparent Specific Gravity = 2.669  
 Absorption = 1.36%

Secondary Source:

Bulk (OD) Specific Gravity = 2.641  
Bulk (SSD) Specific Gravity = 2.686  
Apparent Specific Gravity = 2.764  
Absorption = 1.70%

Determination of "IP" for individual materials, and "P" for individual sources:

Primary Source (Coarse, Intermediate, Fine):

$$\text{"IP" Coarse} = \frac{(26) \times (2)}{100} = 0.52\%$$

$$\text{"IP" Intermediate} = \frac{(12) \times (6)}{100} = 0.72\%$$

$$\text{"IP" Fine} = \frac{(47) \times (91)}{100} = 42.77\%$$

$$\text{"P" for the Primary Source} = \text{IP (Coarse)} + \text{IP (Intermediate)} + \text{IP (Fine)}$$

$$= (0.52\%) + (0.72\%) + (42.77\%) = 44.01\%$$

Secondary Source:

$$\text{"IP" (Secondary Source)} = \frac{(15) \times (76)}{100} = 11.40\%$$

$$\text{"P" for Secondary Source} = \text{IP (Secondary Source)} = 11.40\%$$

Total fine aggregate in the composite = P(Primary Source) + P(Secondary Source)

$$= (44.01\%) + (11.40\%) = 55.41\%$$

$$\text{Combined Bulk (OD) Specific Gravity} = \frac{55.41}{\frac{44.01}{2.576} + \frac{11.40}{2.641}} = 2.589$$

$$\text{Combined Bulk (SSD) Specific Gravity} = \frac{55.41}{\frac{44.01}{2.611} + \frac{11.40}{2.686}} = 2.626$$

$$\text{Combined Apparent Specific Gravity} = \frac{55.41}{\frac{44.01}{2.669} + \frac{11.40}{2.764}} = 2.688$$

$$\text{Combined Absorption} = \frac{2.626 - 2.589}{2.589} \times 100 = 1.43\%$$

EXAMPLE OF CALCULATIONS FOR FINE SPECIFIC GRAVITY

FIGURE 3

|  |   |                              |   |         |                            |       |       |       |       |
|--|---|------------------------------|---|---------|----------------------------|-------|-------|-------|-------|
| Bulk Sp. Gr.<br>(O.D. basis)   | = | $\frac{A}{B + S - C}$        | $\frac{(499.9)}{(683.7) + (503.3) - (990.1)}$ | =       | $\frac{2.539}{2.538852}$   |       |       |       |       |
| Where: <b>A</b> = mass of oven-dry sample in air, g.<br><b>B</b> = mass of pycnometer filled with water, g.<br><b>C</b> = mass of pycnometer with sample and water to calibration mark, g.<br><b>S</b> = mass of saturated-surface-dry sample, g.  |   |                              |   |         |                            |       |       |       |       |
| <table border="1" style="border-collapse: collapse; width: 100px;"> <tr><td style="text-align: center;">499.9</td></tr> <tr><td style="text-align: center;">683.7</td></tr> <tr><td style="text-align: center;">990.1</td></tr> <tr><td style="text-align: center;">503.3</td></tr> </table> |   |                              |   |         |                            | 499.9 | 683.7 | 990.1 | 503.3 |
| 499.9  |   |                              |   |         |                            |       |       |       |       |
| 683.7  |   |                              |   |         |                            |       |       |       |       |
| 990.1  |   |                              |   |         |                            |       |       |       |       |
| 503.3  |   |                              |   |         |                            |       |       |       |       |
| Bulk Sp. Gr.<br>(SSD basis) =  | = | $\frac{S}{B + S - C}$        | $\frac{(503.3)}{(683.7) + (503.3) - (990.1)}$ | =       | $\frac{2.556}{2.556120}$   |       |       |       |       |
| Apparent Sp. G.  | = | $\frac{A}{B + A - C}$        | $\frac{(499.9)}{(683.7) + (499.9) - (990.1)}$ | =       | $\frac{2.583}{2.583463}$   |       |       |       |       |
| Absorption, percent  | = | $\frac{S - A}{A} \times 100$ | $\frac{(503.3) - (499.9)}{(499.9)}$           | x 100 = | $\frac{0.68}{0.680136} \%$ |       |       |       |       |