SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

(A Modification of AASHTO Designation T 85)

SCOPE

1. (a) This method covers the determination of specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk (O.D.) specific gravity, bulk (SSD) specific gravity [saturated surface dry], or apparent specific gravity. The bulk (SSD) specific gravity and absorption are based on aggregate after 15 to 19 hours soaking in water. This method is not intended to be used with lightweight aggregate.

(b) The specific gravity and absorption of coarse aggregate is normally determined on plus 4.75 mm (No. 4) material. When corresponding fine aggregate specific gravity and absorption are determined on pass 2.36 mm (No. 8) material, in accordance with Arizona Test Method 211, the coarse aggregate specific gravity and absorption shall be performed on plus 2.36 mm (No. 8) material. "Coarse aggregate" as herein referenced will be for either plus 4.75 mm (No. 4) or plus 2.36 mm (No. 8) material. Coarse aggregate specific gravity and absorption for mineral aggregates used in asphaltic concrete, other than asphaltic concrete friction course, shall be determined on plus 4.75 mm (No. 4) material."

(c) 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.

(d) 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.

(e) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with

applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

(f) Reference may be made to AASHTO T 85 for additional information, including: terminology, significance and use, precision and bias, development of equations, and interrelationships between specific gravities and absorption as defined in AASHTO T 85 and T 84.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) 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 one gram. The balance shall be equipped with suitable apparatus for suspending the sample container in water from the center of the weighing platform or pan of the balance.

(b) Sample Container - A wire basket, of adequate size for the material being tested, and so constructed to prevent trapping of air when submerged. For test samples of plus 4.75 mm (No. 4) material, the wire mesh shall be 3.35 mm (No. 6), 2.36 mm (No. 8), or 2.00 mm (No. 10). For test samples of plus 2.36 mm (No. 8) material, the wire mesh shall be 2.00 (No. 10). The wire for suspending the container from the balance shall be of the smallest practical size to minimize any possible effects of a variable immersed length.

(c) Water Tank - A watertight tank into which the sample and container are placed for complete immersion while suspended below the balance, equipped with an overflow for maintinaing a constant water level.

(d) Sieves - Conforming to AASHTO M 92, and consisting of necessary sieve sizes as described in paragraph 3(b) through 3(d).

SAMPLING

3. (a) Sample the aggregate in accordance with Arizona Test Method 105.

(b) The sample shall be sieved over the appropriate 4.75 mm (No. 4) or 2.36 mm (No. 8) sieve; or, testing may be performed on separate coarse size fractions, as described in paragraph 3(d) and the average values for specific gravity and absorption determined as given in paragraphs 5(c) and 5(e). When testing is performed on separate size fractions of the coarse aggregate, the sieve analysis of the material shall be performed in accordance with Arizona Test Method 201. If the specific gravity and absorption of the fine aggregate is to be determined, save the appropriate passing 4.75 mm (No. 4) or passing 2.36 mm (No. 8) material for testing in accordance with Arizona Test Method 211, otherwise it can be discarded.

(c) If testing is not to be performed using separate size fractions, a representative test sample of the plus 4.75 mm (No. 4) or plus 2.36 mm (No. 8) material with a minimum mass as shown below shall be obtained.

Nominal Maximum Sieve Size, millimeters (inches)	Minimum Mass of Test Sample, kilograms (pounds)
150 (6)	125 (276)
125 (5)	75 (165)
112 (4-1/2)	50 (110)
100 (4)	40 (88)
90 (3-1/2)	25 (55)
75 (3)	18 (40)
63 (2-1/2)	12 (26)
50 (2)	8 (18)
37.5 (1-1/2)	5 (11)
25.0 (1)	4 (8.8)
19.0 (3/4)	3 (6.6)
12.5 (1/2) or less	2 (4.4)

(d) It may be desirable to test the material in separate size fractions. An example is given below which illustrates the procedure to be followed. [If the sample contains more than 15 percent retained on the 37.5 mm (1-1/2") sieve, test the material larger than 37.5 mm (1-1/2") in one or more size fractions separately from the smaller size fraction(s).] When an aggregate is tested in separate size fractions, the minimum mass of test sample for each fraction shall be the difference between the masses specified above for the largest and smallest sieve sizes of the fraction. The smallest size fraction tested shall meet the minimum mass requirements listed above, corresponding to the largest sieve size (passing) of the fraction. Size fractions of more than one sieve shall be proportionate with the sieve analysis for the sizes included.

Example: [A sample with the following sieve anaylsis is tested in the selected separate size fractions shown below.]

Sieve Size	% Retained	% Passing
50 mm (2")	0	100
37.5 mm (1-1/2")	16	84
25.0 mm (1")	10	74
19.0 mm (3/4")	8	66
12.5 mm (1/2")	6	60
9.5 mm (3/8")	4	56
6.3 mm (1/4")	10	46
4.75 mm (# 4)	5	41

Size fraction of passing 50 mm to retained 37.5 mm:
8000 grams - 5000 grams = 3000 grams

Size fraction of passing 37.5 mm to retained 19.0 mm:
5000 grams - 3000 grams = 2000 grams.

For each sieve in this size fraction, the proportionate amount is determined:

Pass 37.5 mm to Retained 25.0 mm:
[10 / (10 + 8)] x 2000 = 1111 grams.

Pass 25.0 mm to Retained 19.0 mm:
[8 / (10 + 8)] x 2000 = 889 grams.

Size fraction of passing 19.0 mm to retained 4.75 mm (or 2.36 mm): 3000 grams.

For each sieve in this size fraction, the proportionate amount is determined:

Pass 19.0 mm to Retained 12.5 mm:
[6 / (6 + 4 + 10 + 5)] x 3000 = 720 grams.

Pass 12.5 mm to Retained 9.5 mm:
[4 / (6 + 4 + 10 + 5)] x 3000 = 480 grams.

Pass 9.5 mm to Retained 6.3 mm:
[10 / (6 + 4 + 10 + 5)] x 3000 = 1200 grams.

Pass 6.3 mm to Retained 4.75 mm:
[5 / (6 + 4 + 10 + 5)] x 3000 = 600 grams.

PROCEDURE

4. (a) Thoroughly wash the test sample to remove dust or other coatings from the surface.

(b) Dry the test sample to constant mass [see paragraph (c) below] at a temperature of 110 ± 5 °C (230 ± 9 °F). Cool in air at room temperature for 1 to 3

hours for test samples of 37.5 mm (1-1/2") nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle [approximately 50 °C (122 °F)]. Subsequently immerse the aggregate in water at room temperature for a period of 15 to 19 hours.

(c) 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 test, 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 paragraph 4(b). This is especially true of particles larger than 75 mm (3 inch) since the water may not be able to penetrate the pores to the center of the particle in the prescribed soaking period.

(d) Remove the test sample from the water and roll it in a large absorbent cloth or towel until all visible films of water are removed from the surface of the aggregate, wiping the larger particles individually as necessary. Take care to avoid loss of water from aggregate pores during surface-drying by completing the operation as quickly as possible. Immediately determine the mass of the test sample in the saturated surface-dry condition. Record this and all subsequent masses to at least the nearest gram.

(e) After determining the saturated-surface-dry mass place the test sample in the sample container and determine its mass in water at 23.0 ± 1.7 °C (73.4 ± 3.1 °F). Take care to remove all entrapped air before determining the mass, by shaking the container while immersed. The container shall be immersed to a depth sufficient to cover it and the test sample during mass determination.

(f) Dry the test sample to constant mass at a temperature of 110 ± 5 °C (230 ± 9 °F). Cool in air at room temperature 1 to 3 hours, or until the aggregate has cooled to a temperature that is comfortable to handle [approximately 50 °C (122 °F)] and determine the mass.

CALCULATIONS

5. (a) Calculate the bulk (O.D.) specific gravity as shown below:

$$\text{Bulk (O.D.) Specific Gravity} = \frac{A}{(B - C)}$$

Where: A = mass of oven-dry test sample in air, grams.
B = mass of saturated-surface-dry test sample in air, grams.
C = mass of saturated test sample in water, grams.

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

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

(c) Calculate the apparent specific gravity as shown below:

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

(d) When the sample is tested in separate size fractions, the average value for bulk (O.D.) specific gravity, bulk (SSD) specific gravity, or apparent specific gravity can be computed as the average of the respective specific gravities for the individual size fractions, weighted in proportion to the mass percentage of the size fractions in the original sample.

$$G = \frac{1}{\frac{P1}{100\,(G1)} + \frac{P2}{100\,(G2)} + \ldots + \frac{Pn}{100\,(Gn)}}$$

Where: G = Average specific gravity. All forms of expression of specific gravity can be averaged in this manner.
P1, P2, ... Pn = mass percentage for each size fraction in original sample (total equals 100).
G1, G2, ... Gn = Respective specific gravity values for each size fraction for the type of specific gravity being averaged.

(e) Calculate the percent absorption as shown below:

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

(f) When the sample is tested in separate size fractions, the average value for percent absorption can be computed as the average of the individual percent absorption values for the respective size fractions, weighted in proportion to the mass percentage of the size fractions in the original sample.

$$A = \left[\frac{(P1)(A1)}{100}\right] + \left[\frac{(P2)(A2)}{100}\right] + \ldots + \left[\frac{(Pn)(An)}{100}\right]$$

Where: A = Average percent absorption.
P1, P2, ... Pn = mass percentages for each size fraction in original sample (total equals 100).
A1, A2, ... An = Individual percent absorption values for the respective size fractions.

REPORT

6. (a) Report specific gravity results to the nearest 0.001, and indicate the type of specific gravity, whether bulk (O.D.), bulk (SSD), or apparent.

(b) Report the absorption result to the nearest 0.01%.

(c) If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in paragraph 4(c), it shall be noted in the report.

(d) The size of the material tested shall be noted, i.e., plus 4.75 mm (No. 4) or plus 2.36 mm (No. 8.)

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

7. Two methods are given below for determining the combined specific gravities and absorption for different sources of material, as described in paragraphs (a) and (b).

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

(b) The specific gravity and absorption of the coarse aggregate from each individual source may be determined and the combined specific gravity and absorption calculated as described in paragraphs (c) through (g) below. [Refer to the example given in paragraph (g) for an illustration of the procedure and calculations.] The same size of material, either plus 4.75 mm (No. 4) or plus 2.36 mm (No. 8), shall be used to determine the individual specific gravities and absorption for each of the different sources.

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

$$IP = \frac{\begin{bmatrix}\text{Percent of}\\ \text{Individual Material}\\ \text{in Composite}\end{bmatrix} \times \begin{bmatrix}\text{Percent of Coarse}\\ \text{Aggregate in}\\ \text{Individual Material}\end{bmatrix}}{100}$$

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

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

(e) The combined specific gravity is calculated by the following:

$$G = \frac{P1 + P2 + \ldots + Pn}{\frac{P1}{G1} + \frac{P2}{G2} + \ldots + \frac{Pn}{Gn}}$$

Where: P1, P2, ... Pn = For each individual source, the percent of coarse aggregate in the composite, "P".
G1, G2, ... Gn = The coarse specific gravity for each individual source.

(f) The combined absorption is calculated by the following:

$$\text{Combined Absorption} = \frac{\begin{bmatrix}\text{Combined Bulk}\\ \text{(SSD) Specific}\\ \text{Gravity}\end{bmatrix} - \begin{bmatrix}\text{Combined}\\ \text{Bulk (O.D.) Specific}\\ \text{Gravity}\end{bmatrix}}{\begin{bmatrix}\text{Combined Bulk (O.D.)}\\ \text{Specific Gravity}\end{bmatrix}}$$

(g) The following is an example of the procedure and calculations described in paragraphs (b) through (f) above. The example given is for a composite consisting of 26% coarse aggregate, 12% intermediate, and 47% fines from the primary source; with 15% blend from a secondary source. The coarse aggregate has 98% plus 4.75 mm (No. 4), the intermediate has 94% plus 4.75 mm (No. 4), the fines have 9% plus 4.75 mm (No. 4), and the blend has 24% plus 4.75 mm (No. 4).

Specific gravity and absorption for each of the different sources:

Primary Source (Coarse, Intermediate, Fine):

Bulk (O.D.) Specific Gravity = 2.549
Bulk (SSD) Specific Gravity = 2.586
Apparent Specific Gravity = 2.651
Absorption = 1.45%

Secondary Source (Blend):

Bulk (O.D.) Specific Gravity = 2.665
Bulk (SSD) Specific Gravity = 2.724
Apparent Specific Gravity = 2.781
Absorption = 2.21%

Determination of "IP" for individual materials, and "P" for individual sources, for the Primary Source (Coarse, Intermediate, Fine) and the Secondary Source (Blend):

Primary Source:

$$\text{"IP" Coarse} = \frac{(26) \times (98)}{100} = 25.48\%$$

$$\text{"IP" Intermediate} = \frac{(12) \times (94)}{100} = 11.28\%$$

$$\text{"IP" Fine} = \frac{(47) \times (9)}{100} = 4.23\%$$

$$\text{"P" for Primary Source} = 40.99\%$$

Secondary Source:

$$\text{"IP" Blend} = \frac{(15) \times (24)}{100} = 3.60\%$$

$$\text{"P" for Secondary Source} = 3.60\%$$

$$[\text{P (Primary)}] + [\text{P (Secondary)}] = 44.59\%$$

$$\begin{bmatrix}\text{Combined}\\ \text{Bulk (O.D.)}\\ \text{Specific}\\ \text{Gravity}\end{bmatrix} = \frac{44.59}{\frac{40.99}{2.549} + \frac{3.60}{2.665}} = 2.558$$

$$\begin{bmatrix}\text{Combined}\\ \text{Bulk (SSD)}\\ \text{Specific}\\ \text{Gravity}\end{bmatrix} = \frac{44.59}{\frac{40.99}{2.586} + \frac{3.60}{2.724}} = 2.597$$

$$\begin{bmatrix}\text{Combined}\\ \text{Apparent}\\ \text{Specific}\\ \text{Gravity}\end{bmatrix} = \frac{44.59}{\frac{40.99}{2.651} + \frac{3.60}{2.781}} = 2.661$$

$$\begin{bmatrix}\text{Combined}\\ \text{Absorption}\end{bmatrix} = \frac{2.597 - 2.558}{2.558} \times 100 = 1.52\%$$