Test Procedure for

BULK SPECIFIC GRAVITY AND WATER ABSORPTION OF AGGREGATE

TxDOT Designation: Tex-201-F

Effective Date: January 2020

1. SCOPE

1.1 Use this method to determine the bulk specific gravity and water absorption of aggregate retained on the No. 200 (75 µm) sieve. The bulk specific gravity may be used in calculating the maximum theoretical specific gravity (G_t) or the voids in the mineral aggregate (VMA) of a bituminous mixture. Water absorption may be used to determine the amount of free moisture within the aggregate. Figures 1 and 2 illustrate the theory of the bulk specific gravity determination.

$$Gsb = \frac{DryWeight}{BulkVolume}$$

Bulk Volume = solid volume + water permeable pore volume

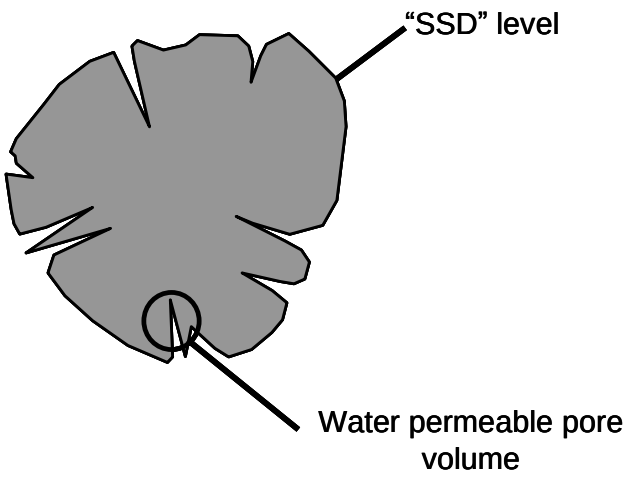

Figure 1—Aggregate Specific Gravity

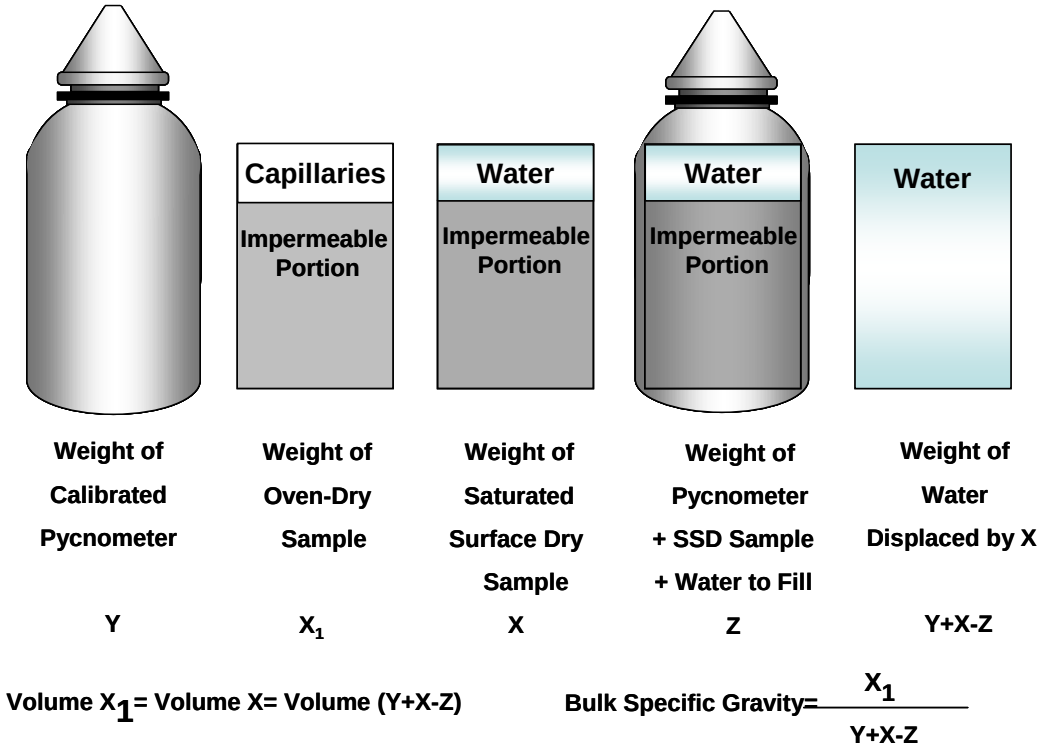

Figure 2—Bulk Specific Gravity

1.2 The values given in parentheses (when provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. DEFINITIONS

2.1 *Absorption moisture content*—the moisture content at saturated surface-dry condition in contrast to its oven-dry condition.

2.2 *Apparent relative density (specific density)*—the solid material making up the constituent particles not including the pore space within the particles that is accessible to water.

2.3 *Bulk Specific Gravity*—the ratio of the oven-dry weight of the aggregate to the bulk volume of the aggregate particles.

2.4 *Bulk Volume of an Aggregate*—the volume of water displaced by aggregate in a SSD condition, including both the volume of the impermeable portion of the aggregate particles and the volume of the permeable voids in the particles.

2.5 *Saturated surface-dry (SSD)*—the condition of the aggregate when all permeable pores of each particle are completely saturated with water and its surface has no free moisture.

2.6 *Saturated surface-dry specific gravity*—the ratio of the mass of SSD aggregate to the mass of an equal volume of water.

3. APPARATUS

3.1 *Balance*, Class G2 in accordance with Tex-901-K, with a minimum capacity of 10,000 g.

3.2 *Glass jar*, 2 L (0.5 gal.), and pycnometer cap.

3.3 *Drying oven*, capable of attaining a temperature of at least 225°F (107°C).

3.4 *Set of standard U.S. sieves*, meeting the requirements of Tex-907-K.

3.5 *Round pans*, 12 in. (305 mm) diameter.

3.6 *Small trowel*, with a rectangular blade.

3.7 *Syringe.*

3.8 *Sample-splitter, quartering machine, quartering cloth, or shovel and a smooth surface.*

3.9 *Heavy gauge metal wire*, short length (optional).

3.10 *Electric fan.*

3.11 *Mercury thermometer*, marked in 1°F (0.5°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure

3.12 *Funnel*, wide-mouthed.

3.13 *Lint-free cloth or towel*.

3.14 *Metal Cone*, with:

- inside top diameter of 40 ± 3 mm (1.5 ± 0.125 in.)
- inside bottom diameter of 90 ± 3 mm (3.5 ± 0.125 in.)
- height of 75 ± 3 mm (3 ± 0.125 in.), and
- minimum thickness of 0.8 mm (0.0313 in.)

3.15 *Sample container*, wire basket of No.8 (2.36 mm) or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4–7 L (1–1-3/4 gal.) for 38 mm (1-1/2 in.) nominal maximum size or smaller, and a larger container as needed for testing larger maximum size aggregate. The container should be constructed to prevent trapping air when the container is submerged.

3.16 *Suspended apparatus*, wire suspending the container should be the smallest practical size to minimize any possible effects of a variable immersed length

3.17 *Tamper*, face diameter of 25 ± 3 mm (1 ± 0.125 in.) and mass of 340 ± 15 g.

3.18 *Water tank*, into which the sample and container are placed for complete immersion while suspended below the balance, equipped with an overflow outlet for maintaining a constant water level.

4. MATERIALS

4.1 *Carborundum cloth or paper*, finer than No. 200 (75 µm).

4.2 *Clean tap water*.

5. PROCEDURES

5.1 *Calibrating Pycnometer:*

5.1.1 Calibrate the pycnometer to assure it is of definite and constant volume. Select a jar with good threads and free of cracks or chips on the rim.

5.1.2 When the rim is rough or the pycnometer leaks water, place a piece of fine grain Carborundum cloth on a smooth, solid plane surface. Hold the empty jar upside down with the rim against the Carborundum cloth and smooth the rim by rotating the jar over the cloth. Apply force and continue the grinding action until the rim is perfectly smooth.

5.1.3 Clean the jar and fill with water at a temperature of 73 ± 2°F (23 ± 1°C).

Note 1—Use other water temperature when accurate control of the water temperature at 73 ± 2°F (23 ± 1°C) is not practical. However, the water temperatures used during the pycnometer calibration and the final weighing of the pycnometer containing the test sample must be within 3°F (2°C) of each other.

5.1.4 With the gasket seated smoothly in place to prevent leaking, screw the metal pycnometer cap snug on the jar.

5.1.5 Add water until the lid is full and bubbles stop coming out of the top.

5.1.6 Place a finger over the hole in the cap and roll the pycnometer to free all entrapped air.

5.1.7 Dry the outside of the pycnometer cap and jar thoroughly.

5.1.8 Use the syringe to completely fill the pycnometer with water and leave a rounded bead of water on top of the cap.

5.1.9 Determine the mass of the pycnometer, filled with water, to the nearest 0.5 g, and record the record as Y in Section 6.

5.2 *Determining SSD Specific Gravity of Coarse Aggregate:*

5.2.1 Secure a representative field sample in accordance with Tex-221-F and reduce to the minimum mass of the test sample as seen in Table 1 using a sample splitter or quartering cloth.

5.2.2 Dry sieve the sample and discard all material passing the No. 4 (4.75 mm) sieve and thoroughly wash to remove dust or other coatings from the surface of the aggregate.

Table 1—Minimum Size of Test Sample

Nominal Maximum Size,	Minimum Mass of Test Sample, g (lb.)
1/2 in. (12.5 mm) or less	2000 (4.4)
3/4 in. (19.0 mm)	3000 (6.6)
1 in. (25.0 mm)	4000 (8.8)
1-1/2 in. (37.5 mm)	5000 (11)
2 in. (50.0 mm)	8000 (18)

5.2.3 Dry the sample in the oven to constant mass and cool in air at room temperature.

5.2.4 Place the sample in a pan and cover with water. Allow to soak for a minimum of 24 hours. Avoid using metal pans that react with aggregates.

5.2.5 Drain or siphon the water from the sample and transfer the sample to a large lint-free cloth or towel.

5.2.6 Roll the sample in the large lint-free cloth or towel until all visible films of water are removed from the surface of the aggregate. Take care to avoid evaporation of water from aggregate pores. Continue until the entire sample is at SSD.

5.2.7 Transfer the SSD test sample to the balance. Determine the mass of the test sample to the nearest 0.5g and record as X in Section 6.

5.2.8 Immediately place the SSD test sample in the sample container and completely immerse the container in the water tank containing water at 73 ± 3 °F (23 ± 2°C).

5.2.9 Remove all entrapped air by shaking and twisting the container while immersed in the water tank .

5.2.10 Determine the mass of the test sample in water to the nearest 0.5g and record as S in Section 6. The difference between the mass in air and the mass in water equals the mass of water displaced by the sample

5.2.11 Remove the container from the water tank and transfer the aggregate sample into a tared pan.

5.2.12 Dry the aggregate in an oven to constant mass and cool in air to room temperature.

5.2.13 Determine the mass of the test sample to the nearest 0.5g and record as X_1 in Section 6.

5.3 *Determining SSD Specific Gravity of Fine Aggregate:*

5.3.1 Secure a representative field sample of the fine aggregate passing a 4.75 (No. 4) sieve in accordance with Tex-221-F. Use a sample splitter or quartering cloth to reduce the sample to a laboratory test size of approximately 3000 g.

5.3.2 Place the test sample into a pan and cover with water. Allow to soak for a minimum of 24 hours. Avoid using metal pans, which react with aggregates.

5.3.3 Decant the water with care to avoid the loss of fines and spread the test sample on a flat, clean, nonabsorbent, smooth surface such as a metal-topped workbench

5.3.4 Expose the sample to a gently moving current of air without applying artificial heat such as using a fan.

5.3.5 Stir frequently with a small trowel to ensure uniform drying and continue until the test sample approaches the saturated surface-dry condition.

5.3.6 Periodically test the surface moisture using the metal cone and tamper

5.3.6.1 Hold the cone firmly on a smooth nonabsorbent surface with the larger diameter down.

5.3.6.2 Using a small scoop, place a portion of the partially dried fine aggregate loosely into the cone by filling it to overflowing additional material above the top of the cone while holding it with the cupped fingers of the hand holding the cone.

5.3.6.3 Lightly tamp the fine aggregate into the cone with 25 drops of the tamper. Start each drop approximately 0.2 in. (5 mm) above the top surface of the fine aggregate. Allow the tamper to fall freely and adjust the starting height to the new surface elevation after each drop. Distribute the drops over the entire surface of the fine aggregate.

5.3.6.4 Remove loose sand from the base and lift the cone vertically.

5.3.6.5 When surface moisture is still present, the fine aggregate will retain the molded shape.

5.3.6.6 Slight slumping on one or more sides of the molded fine aggregate indicates it has reached a surface-dry condition.

Note 2—Some angular fine aggregate or material with high proportion of fines may not slump in the cone test upon reaching a surface-dry condition. This may be the case when fines become airborne upon dropping a handful of sand from the cone test from a height of 4–6 in. (100–150 mm) onto a surface. For these materials, consider the SSD condition as the point that one side of the fine aggregate slumps slightly upon removing the mold.

5.3.6.7 When slumping of the molded fine aggregate produces a spire with a top flat surface less than the diameter of the tamper, the fine aggregate is too dry and has passed the surface-dry condition. In this case, thoroughly mix a few millimeters of water with the fine aggregate sample and let it stand in a covered container for 30 minutes. Then repeat Section 5.3.6 through 5.3.6.6, until the surface-dry condition is achieved.

5.3.7 When the SSD condition is reached, immediately weigh 1200 ± 10 g of saturated surface-dry aggregate to prevent the loss of moisture and record as X to the nearest 0.1g.

5.3.8 When absorption is to be determined, immediately weigh out a separate 1200 ± 10 g of saturated surface-dry aggregate and record as X to the nearest 0.1g in Section 6.5. Dry the sample to a constant mass in an oven and cool to room temperature. Determine the mass of the oven dry sample and record as X_1 to the nearest 0.1g in Section 6.5

5.3.9 Partially fill the pycnometer about one quarter full of water.

5.3.10 Place the SSD sample from Section 5.3.7 into the pycnometer using a wide-mouthed funnel while taking care not to lose any of the material.

5.3.11 Rinse the funnel over the pycnometer with water so that any clinging particles will wash into the pycnometer.

5.3.12 Fill the pycnometer with water to within about 0.5 in. (12.5 mm) of the rim, screw the cap on the jar and fill completely with water.

5.3.13 Stop the hole in the cap with a finger and manually roll, invert or agitate the pycnometer to free all entrapped air. Raise and lower the jar in such a manner that the material will flow from one end of the jar to the other while rolling.

5.3.14 When a quantity of air bubbles has accumulated, refill the pycnometer, washing out the air and roll again.

5.3.15 Repeat the manual rolling, inverting and agitation of the pycnometer until all air is removed.

5.3.16 Dry the outside of the pycnometer and cap thoroughly.

5.3.17 Place pycnometer on the scale. Use a syringe or rubber bulb to fill the pycnometer carefully with water, leaving a rounded bead of water on top of the cap.

5.3.18 Determine the mass of the pycnometer and contents to the nearest 0.1 g and record as Z in Section 6.

5.3.19 Set the pycnometer in a clean, tared pan. Remove the pycnometer cap and pour the sample into the pan.

5.3.20 Rinse the cap, pycnometer, and hands thoroughly over the pan to collect the remainder of the test sample.

5.3.21 Allow the material to settle and the water to become clear. Decant or siphon the water from the sample.

5.3.22 Dry the aggregate sample in an oven to constant mass and cool in air to room temperature.

5.3.23 Determine the mass of the test sample to the nearest 0.1g and record as X_1 in Section 6.

6. CALCULATIONS

6.1 Calculate the SSD specific gravity (G_{SSD}) of the aggregate:

For Coarse Aggregate $G_{SSD} = \frac{X}{(X - S)}$

For Fine Aggregate: $G_{SSD} = \frac{X}{(X + Y - Z)}$

Where:
G_{SSD} = Saturated surface-dry specific gravity of aggregate
S = Submerged sample weight, in basket, g
X = Weight of saturated, surface-dry sample, g
Y = Weight of calibrated pycnometer filled with water, g
Z = Weight of pycnometer, saturated surface-dry sample, and water, g

6.2 Calculate the bulk specific gravity (G_{BULK}) of the aggregate:

For Coarse Aggregate: $G_{BULK} = \frac{X_1}{(X - S)}$

For Fine Aggregate: $G_{BULK} = \frac{X_1}{(X + Y - Z)}$

Where:
G_{BULK} = Bulk (oven-dry) specific gravity of aggregate
S = Submerged sample weight, in basket, g
X_1 = Weight of oven-dry sample, g
X = Weight of saturated, surface-dry sample, g
Y = Weight of calibrated pycnometer filled with water, g
Z = Weight of pycnometer, saturated surface-dry sample, and water, g

6.3 Calculate the apparent specific gravity (G_A) of the aggregate:

For Coarse Aggregate: $G_A = \frac{X_1}{(X_1 - S)}$

For Fine Aggregate: $G_A = \frac{X_1}{(X_1 + Y - Z)}$

Where:
G_A = Bulk (oven-dry) specific gravity of aggregate

S = Submerged sample weight, in basket, g

X_1 = Weight of oven-dry sample, g

Y = Weight of calibrated pycnometer filled with water, g

Z = Weight of pycnometer, saturated surface-dry sample, and water, g.

6.4 Calculate the average bulk specific gravity of combined sizes of aggregate or combination of materials:

$$G_b = \frac{100}{\left[\frac{W_1}{G_1} + \frac{W_2}{G_2} + \ldots + \frac{W_n}{G_n}\right]}$$

Where:

G_b = Average bulk specific gravity of combined aggregate

G_1 = Bulk specific gravity of material No. 1

G_2 = Bulk specific gravity of material No. 2

G_n = Bulk specific gravity of material No. n

W_1 = Percentage of material No. 1 from screen analysis or based on total weight of combination

W_2 = Percentage of material No. 2 from screen analysis or based on total weight of combination

W_n = Percentage of material No. n from screen analysis of based on total weight of combination: $W_1 + W_2 + \ldots + W_n$, must total 100%

6.5 Using the test data secured in determining the bulk specific gravity, calculate the water absorption of the aggregate:

$$A = \frac{(X - X_1)}{X_1} \times 100$$

Where:

A = Percent water absorption (24 hours) of aggregate based on the oven-dry weight of sample

X = Weight of saturated, surface-dry sample, g

X_1 = Weight of oven-dry aggregate, g.

6.6 Calculate the average percent water absorption of combined materials:

$$A = \frac{A_1W_1 + A_2W_2 + \ldots + A_nW_n}{100}$$

Where:

A = Average percent water absorption (24 hours) of combined materials based on the total weight of oven-dry combination

A_1 = Percent water absorption of material No. 1
A_2 = Percent water absorption of material No. 2
A_n = Percent water absorption of material No. n
W_1, W_2, and W_n are the same as defined earlier in Section 6.4.

7. REPORT FORMS

7.1 Bulk Specific Gravity and Water Absorption of Aggregate

7.2 Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1%.

8. ARCHIVED VERSIONS

8.1 Archived versions are available.