Test Procedure for

BULK SPECIFIC GRAVITY AND WATER ABSORPTION OF AGGREGATE

Texas Department of Transportation

TxDOT Designation: Tex-201-F

Effective Dates: November 2004–December 2010.

1. SCOPE

1.1 This method is used to determine the bulk specific gravity and water absorption of aggregate retained on the 180 µm (No. 80) 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 in the aggregate. Figures 1 and 2 demonstrate the theory of the bulk specific gravity determination.

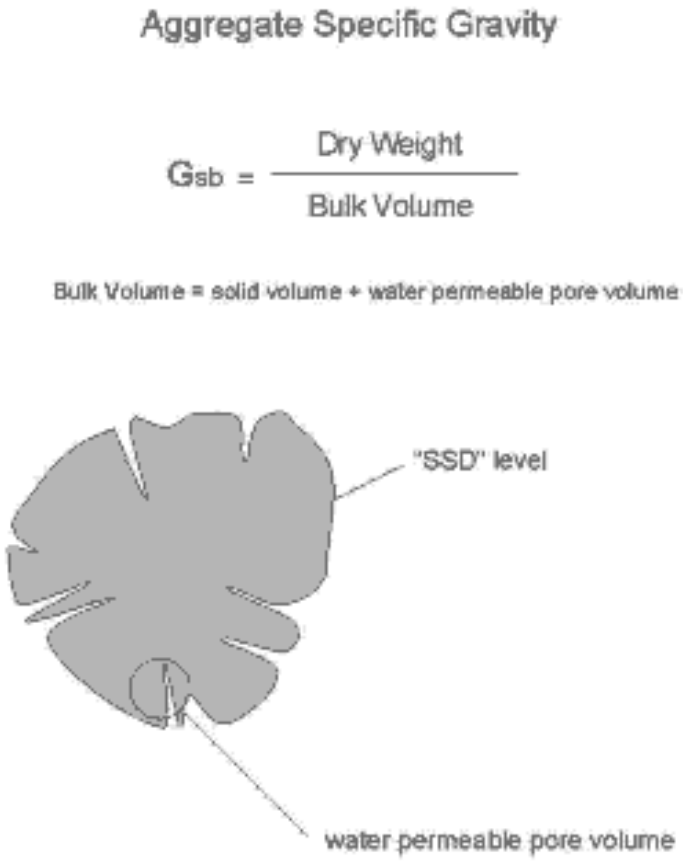

Figure 1—Aggregate Specific Gravity

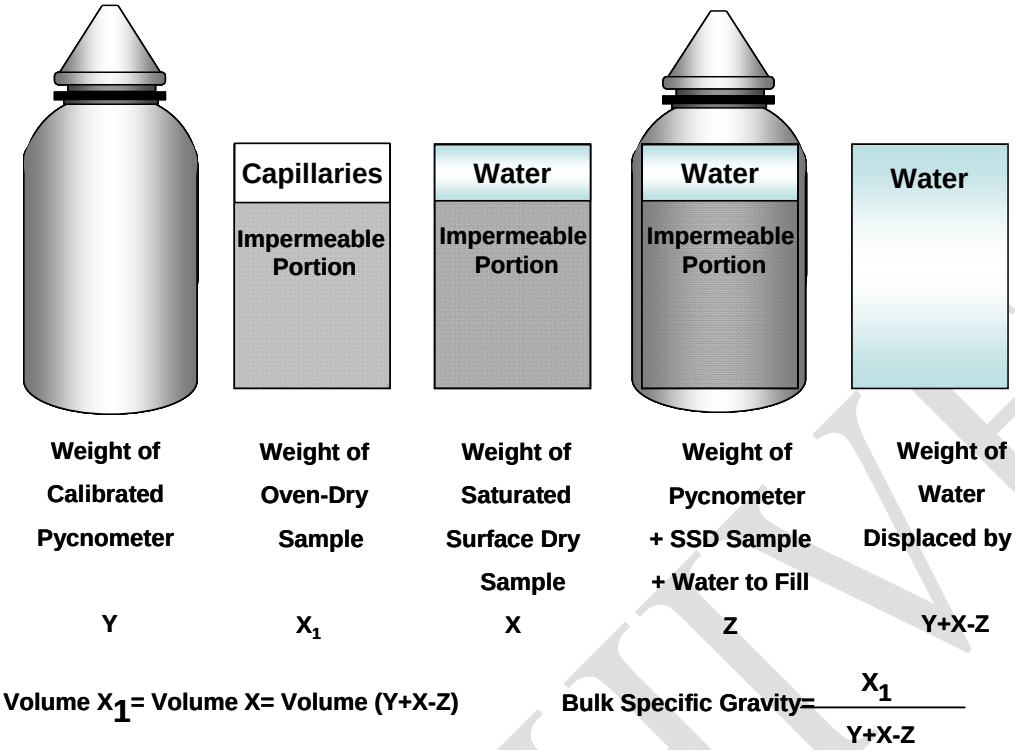

Figure 2—Bulk Specific Gravity

1.2 The values given in parentheses (if 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 *Bulk Volume of an Aggregate*—Bulk volume of an aggregate includes both the volume of the impermeable portion of the aggregate particles and the volume of the permeable voids in the particles. The bulk volume of the aggregate is equal to the volume of water displaced by the aggregate in a saturated, surface-dry condition.

2.2 *Bulk Specific Gravity*—Bulk specific gravity is the ratio of the oven-dry weight of the aggregate to the bulk volume of the aggregate particles.

3. APPARATUS

3.1 *Balance,* readable to 0.1 g and accurate to 0.5 g.

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

3.3 *Drying oven*, capable of attaining a temperature of 93°C (200°F) or more, hot plate, gas burner, or suitable microwave oven.

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

3.5 *Round pans*, approximately 7.6 L (8 qt.).

3.6 *Small masonry pointed trowel,* or equivalent.

3.7 *Syringe.*

3.8 *Sample-splitter, quartering machine or quartering cloth,* (unless shoveling method on clean surface is used).

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

3.10 *Electric fan.*

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

4. MATERIALS

4.1 *Absorbent towels.*

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

4.3 *Clean tap water.*

4.4 *Heavy gummed paper tape*, 51 mm (2 in.) wide (optional).

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 with no cracks or broken places on the rim.

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

Note 1—Other water temperature may be used when accurate control of the water temperature at 23 ± 1°C (73 ± 2°F) 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 2°C (4°F) of each other.

5.1.3 With the gasket seated smoothly, screw the metal pycnometer cap snugly on the jar.

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

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

5.1.6 Use the syringe to completely fill the pycnometer with water, leaving a rounded bead of water on top of the cap.

5.1.7 Dry the outside of the pycnometer thoroughly, including underneath the cap lip. If the pycnometer leaks water, place a piece of fine grain Carborundum cloth on a smooth, solid plane surface. Hold the jar upside down, and smooth and true the rim by rotating the jar. Apply force and continue the grinding action until the rim is perfectly smooth.

5.1.8 Weigh the pycnometer, filled with water, to the nearest 0.1 g, and record the weight as Y under Section 6 each time the pycnometer is used. Calibrate the pycnometer each day testing is performed.

5.2 *Preparing Sample*—this is the standard procedure for preparing a saturated surface dry (SSD) sample:

5.2.1 Quarter a test sample out of well-mixed representative material.

5.2.2 Dry the sample to constant weight and use the procedure outlined in Tex-200-F for sieve analysis.

5.2.3 Divide the coarse aggregate into sizes that conform to the requirements of the specification.

5.2.4 Divide the fine aggregate into two sizes, the 2.00 mm (No. 10) to 180 µm (No. 80) material and the material passing the 180 µm (No. 80) sieve. Further break material down into 2.00 mm (No. 10) to 425 µm (No. 40), and 425µm (No. 40) to 180 µm (No. 80), when there is a substantial amount of both size fractions present. This will assist in evacuation of air from the pycnometer and improve test accuracy.

5.2.5 After the aggregates have been separated into the proper sizes, rinse with clean water to remove lumps and coatings on particles.

5.2.6 Wash the coarse aggregates over a 2.00 mm (No. 10) sieve.

5.2.7 Place approximately 1500 to 2000 g of each size aggregate in separate pans and cover with water for 24 ± 2 hours.

5.2.8 Rewash the coarse aggregates over the 2.00 mm (No. 10) sieve to remove slaked material.

5.2.9 Prepare comparison samples by washing approximately 500 g of each aggregate portion to remove clinging dust then oven dry each sample to constant weight.

5.3 *Saturated Surface Drying (SSD) of Aggregate Method*—this procedure is the standard method to reach SSD condition for aggregates:

- For coarse aggregate size fractions, use Sections 5.3.1–5.3.7.
- For fine aggregate size fractions, use Sections 5.3.8–5.3.10.

5.3.1 Transfer the test sample to a clean, dry towel and roll gently to remove most of the surface moisture. Minimize the towel rolling of easily abraded aggregates to reduce dust production.

5.3.2 Surface-dry each coarse aggregate portion using another clean, dry towel.

Note 2—A dust-free towel is important to minimize dusting of the drying particles, which would mask their true color.

5.3.3 Spread the test sample on a clean, dry towel.

5.3.4 Use a fan to complete the drying process. Gently stir sample by hand, as necessary, to insure uniform removal of surface moisture to achieve the saturated surface-dry condition.

5.3.5 As a test sample approaches the surface dry condition, place the entire dry comparison sample on the towel slightly apart from the test sample.

5.3.6 Compare the color of the two samples, while continuing the drying process. The surface dry condition is met when the test sample has the same color as the dry comparison sample. It is sometimes necessary to stand back several meters (feet) when comparing the samples to see slight differences in color.

5.3.7 When the SSD condition is reached, proceed immediately to Sections 5.3.11-5.3.31 before further evaporation occurs.

5.3.8 Carefully drain the water from the aggregate passing the 2.00 mm (No. 10) sieve and retain on the 180 µm (No. 80) sieve.

5.3.9 Air-dry the wet material on a smooth, nonabsorbent surface. Use a fan to reduce drying time. Do not apply artificial heat or sunlight.

5.3.10 Stir and mix the sample frequently so the particles on top do not become drier than the surface-dry condition. The SSD condition is met when the test sample meets at least two of the four criteria outlined in Section 5.4.

5.3.11 Transfer the saturated surface-dry material to the balance and weigh immediately to prevent further evaporation of moisture.

5.3.12 Weigh the sample to the nearest 0.1 g and record weight as X under Section 6. Sample size must be 1500-2000 g for that retained on 2.00 mm (No. 10) sieve and 1200-1500 g for that passing 2.00 mm (No. 10) and retained on the 180 µm (No.80) sieve.

5.3.13 Using a funnel, fill the pycnometer jar approximately one-fourth full with water.

5.3.14 Place the saturated, surface-dry sample into the pycnometer jar. The water must be within 2°C (4°F) of the calibration temperature.

5.3.15 Rinse the funnel thoroughly so that all clinging particles wash into the jar.

5.3.16 Add water, filling the jar to the top.

5.3.17 Wet the inside of the pycnometer top and screw it on the jar.

5.3.18 Add water until the lid is full and bubbles stop coming out of the top. Ensure that the water temperature is 23 ± 1°C (73 ± 2°F) or within 2°C (4°F) of the selected calibration water temperature.

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

5.3.20 When the sample contains the large pieces of coarse aggregate (retained on 9.5 mm [3/8 in.] sieve) tilt the jar and roll at the same time, causing the material to gently slide from top to bottom.

5.3.21 When a quantity of air bubbles accumulate, refill the pycnometer, washing out the air, and roll again. A piece of heavy gauge wire, bent to conform to the shape of the upper portion of the pycnometer jar, may be inserted and rotated to free small bubbles clinging to the jar shoulders.

5.3.22 Repeat this process until as much entrapped air as possible is removed.

5.3.23 Thoroughly dry both the outside of the pycnometer and the underside of the rim of the pycnometer cap.

5.3.24 Use the syringe to carefully fill with water, leaving a rounded bead of water on top of the pycnometer cap.

5.3.25 Weigh to the nearest 0.1 g and record.

5.3.26 Roll the pycnometer as before for another two minutes. Redry and refill the pycnometer with water.

5.3.26.1 If the pycnometer weight has increased by 0.2 g or less, this weight is recorded as Z under Section 6.

5.3.26.2 If the weight change is more than 0.2 g, continue the process until a change of 0.2 g or less is achieved.

5.3.27 Remove the cap from the pycnometer and pour the sample into a clean, tared pan.

5.3.28 Use as much water as necessary to rinse jar, cap, and hands thoroughly.

5.3.29 Allow the material to remain undisturbed until the water becomes perfectly clear, then decant or siphon the water from the sample. Be especially careful to lose none of the material while removing the water from the sample.

5.3.30 Dry the aggregate to constant weight at a temperature of 104 to 204°C (220 to 400°F) and cool to room temperature before weighing.

5.3.31 Weigh and record the net oven-dry weight of sample to the nearest 0.1 g. Represent as X_1 under Section 6.

5.4 *Drying Methods for Fine Aggregates*—Use these four drying-process methods. Compare two to meet SSD test condition (continue the SSD drying process until at least two methods indicate that the SSD condition has been reached):

5.4.1 *Method 1:*

5.4.1.1 Place some of the oven dry comparison sample into a dry pan with a smooth bottom.

5.4.1.2 Tilt the pan to a 45° angle with the table and tap lightly on the bottom, observing the manner in which the dry material slides down the bottom of the tilted pan.

5.4.1.3 Place a portion of the test sample in another dry pan, tilt, and tap while observing how the material flows or slides. When the aggregate being tested ceases to adhere to the bottom of the pan and flows freely, as the dry sample did, it is surface dry.

5.4.2 *Method 2:*

5.4.2.1 Scoop some of the oven-dry comparison sample on a small masonry trowel (or similar instrument, completely cleaned and dried before each check).

5.4.2.2 Tilt the trowel slowly to one side, observing how the individual particles flow freely from the trowel.

5.4.2.3 Scoop the same amount of the nearly surface dry test sample and tilt the trowel in the same manner, watching it flow from the trowel. When the material being tested flows off the trowel freely as individual particles in the same manner as the dry sample, it is surface-dry.

5.4.3 *Method 3:*

5.4.3.1 Attach approximately 10 cm^2 (4 $in.^2$) of paper tape to a small block of wood, with the adhesive side outward.

5.4.3.2 Stir and level the test sample and immediately place the taped face of the wood block on the test sample for 5 seconds. Check the paper tape just prior to use. If the adhesive side feels sticky because of humidity, rub it rapidly against a dry cloth just prior to placing it on the test sample.

5.4.3.3 Gently lift the wood block and tape upward, taking care not to slide the tape along the top of the test sample.

5.4.3.4 Observe the number of test sample particles that are adhering to the water-soluble glue of the paper tape. When the test sample is dry enough so that no more than one particle adheres to the tape on two consecutive checks, the sample is surface-dry.

5.4.4 *Method 4:*

5.4.4.1 As the test sample approaches the surface-dry condition, periodically compare it to the dry comparison sample. Put the dry sample in a scoop and lay it on top of the test sample.

5.4.4.2 When the test sample has the same color as the dry comparison sample, it is surface-dry.

6. CALCULATIONS

6.1 Bulk specific gravity of the aggregate:

$$G = \frac{X_1}{(X + Y - Z)}$$

Where:

G = Bulk (oven-dry) specific gravity of aggregate

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.

6.2 Using the data from above, calculate the apparent specific gravity (G_A) of the aggregate:

$$G_A = \frac{X_1}{(X_1 + Y - Z)}$$

6.3 Average bulk specific gravity of combined sizes of aggregate or combination of materials:

$$G_b = \frac{100}{(\frac{W_1}{G_1} + \frac{W_2}{G_2} + etc)}$$

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

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: W1 + W2 + W3, etc., must total 100%.

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

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

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.

6.5 Calculate the average percent water absorption of combined materials:

$$A = \frac{A_1W_1 + A_2W_2 + etc}{100}$$

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

W_1 and W_2 are the same as defined earlier.

7. NOTES

7.1 Use the apparent specific gravities of aggregate sizes finer than the 180 µm (No. 80) sieve, determined in accordance with Tex-202-F when calculating the bulk specific gravity of combined aggregate containing those sizes.

7.2 Use the dry bulk specific gravity of lightweight material, determined in accordance with Tex-433-A when calculating the bulk specific gravity of combined aggregate containing lightweight materials.

7.3 Repeated bulk specific gravity results must be within ± 0.02 on material from the same sample.

8. REPORT FORMS

8.1 'Bulk Specific Gravity and Water Absorption of Aggregate'.

9. ARCHIVED VERSIONS

9.1 Archived versions are available.