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Test Procedure for

**SATURATED SURFACE-DRY SPECIFIC GRAVITY  
AND ABSORPTION OF AGGREGATES**



TxDOT Designation: Tex-403-A

*Effective Date: August 1999*

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**1. SCOPE**

- 1.1 This method determines the saturated surface-dry (SSD) specific gravity and water absorption of natural mineral aggregates used in Portland cement concrete.
  - 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.
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**2. DEFINITIONS**

- 2.1 *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.
  - 2.2 *Saturated surface-dry*—the condition of the aggregate when all permeable pores of each particle are completely saturated with water and its surface has no free moisture.
  - 2.3 *Saturated surface-dry specific gravity*—the ratio of the mass of SSD aggregate to the mass of an equal volume of water.
  - 2.4 *Absorption moisture content*—the moisture content at saturated surface-dry condition in contrast to its oven-dry condition.
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**3. REPORT FORMS**

- 3.1 [Moisture Properties and Unit Weight of Concrete Aggregates](#)
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**4. APPARATUS**

- 4.1 *Glass jar*, 2 L (0.5 gal.), and pycnometer cap.
  - 4.2 *Balance*, Class G2 in accordance with Tex-901-K, minimum capacity of 4000 g (8.75 lb.), with the capability to weigh by hanging the sample under the balance (optional).
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- 4.3 *Sample container*, wire basket of 3.35 mm (No. 6) 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 (optional).
- 4.4 *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 (optional).
- 4.5 *Suspended apparatus*, wire suspending the container should be the smallest practical size to minimize any possible effects of a variable immersed length (optional).
- 4.6 *Drying oven*, maintained at  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ).
- 4.7 *Funnel*, wide-mouthed.
- 4.8 *Set of standard U.S. sieves*, meeting requirements of Tex-907-K, in the following sizes:
- 4.75 mm (No. 4)
  - 600  $\mu\text{m}$  (No. 30).
- 4.9 *Pans*, 305 mm (12 in.) in diameter.
- 4.10 *Small trowel*, with a rectangular blade.
- 4.11 *Syringe or rubber bulb*.
- 4.12 *Quartering machine, sample splitter, or quartering cloth*.
- 4.13 *Lint-free cloth or towel*.
- 4.14 *Metal Cone*, with:
- inside top diameter of  $40 \pm 3$  mm ( $1.5 \pm 0.125$  in.)
  - inside bottom diameter of  $90 \pm 3$  mm ( $3.5 \pm 0.125$  in.)
  - height of  $75 \pm 3$  mm ( $3 \pm 0.125$  in.), and
  - minimum thickness of 0.8 mm (0.0313 in.)
- 4.15 *Tamper*, face diameter of  $25 \pm 3$  mm ( $1 \pm 0.125$  in.) and mass of  $340 \pm 15$  g.

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## 5. MATERIALS

- 5.1 *Clear, potable water*.
- 5.2 *Fine Carborundum cloth*.

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## 6. PROCEDURES

### 6.1 *Calibrating Pycnometer:*

- 6.1.1 Select a 2 L (0.5 gal.) mason jar with good threads on the neck.
- 6.1.2 Be sure the rim is free of cracks or chips.
- 6.1.3 If the rim is rough, place a piece of fine grain Carborundum cloth on a smooth, solid, level surface; hold the jar in a vertical position with the top against the Carborundum cloth; and smooth and true the rim by rotating the jar over the cloth.
- 6.1.4 Apply force and continue the grinding action until the rim of the jar appears to be perfectly smooth.
- 6.1.5 Clean the jar and fill with clean tap water at  $23 \pm 2^{\circ}\text{C}$  ( $73 \pm 3^{\circ}\text{F}$ ).
- 6.1.6 With the gasket seated smoothly in place to prevent leaking, screw the metal pycnometer cap snugly on the jar.
- 6.1.7 Use the rubber siphon bulb to fill with water, leaving a rounded bead of water on top of the cap.
- 6.1.8 Dry the outside of the cap and jar with a towel.
- 6.1.9 Determine the mass of the pycnometer filled with water to the nearest 0.5 g and record the mass as *Y* under Section 7.
- 6.1.10 Obtain and record the temperature of the water.

**Note 1**—This test procedure calls for a specific temperature range for the water used during both the calibration of the pycnometer and during the actual performance of the test. If for any reason this range cannot be met, take special care to ensure that the temperature of the water used to calibrate the pycnometer is within  $\pm 2^{\circ}\text{C}$  ( $\pm 3^{\circ}\text{F}$ ) of the temperature of the water used to perform the test.

**Note 2**—Use identification marks and match marks on the cap and jar to produce constant volume measurements.

### 6.2 *Determining SSD Specific Gravity of Fine Aggregate:*

- 6.2.1 Secure a representative field sample of the fine aggregate passing a 4.75 (No. 4) sieve in accordance with Tex-400-A. Use a sample splitter or quartering cloth to reduce the sample to a laboratory test size of approximately 3000 g.
- 6.2.2 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.

**Note 3**—For field determination of absorption only, use Tex-409-A, Part II.
- 6.2.3 Decant the water and spread the material in a thin layer on a clean, smooth surface such as a metal-topped workbench.

- 6.2.4 Allow the sample to air dry without applying artificial heat.
- 6.2.5 Use a small trowel to stir and mix the sample frequently so that the particles on top will not become drier than SSD.
- 6.2.6 Hold the cone firmly on a smooth nonabsorbent surface with the larger diameter down.
- 6.2.7 Place the partially dried fine aggregate loosely in the cone.
- 6.2.8 Fill it to slightly overflowing by holding the mold with a cupped hand.
- 6.2.9 Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper. Start each drop at about 5 mm (0.2 in.) above the top surface of the fine aggregate.
- 6.2.10 Allow the tamper to fall freely and distribute the drops over the entire surface.
- 6.2.11 Remove loose sand from around the base and lift the cone vertically.
  - 6.2.11.1 If surface moisture is still present, the fine aggregates will retain the molded shape.
  - 6.2.11.2 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 if fines become airborne upon dropping a handful of sand from the cone test 100–150 mm (4–6 in.) 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.
- 6.2.12 Transfer the SSD test sample to the balance and weigh out approximately 1200 g immediately to prevent loss of moisture.
- 6.2.13 Record the mass to the nearest 0.5 g as *X* under Section 7.
- 6.2.14 Place the SSD sample into the pycnometer jar about one quarter full of water by means of the wide-mouthed funnel, taking care not to lose any of the material.
- 6.2.15 Rinse the funnel over the jar with water so that any clinging particles will wash into the jar.
- 6.2.16 Fill the jar with water to within about 12.5 mm (0.5 in.) of the rim, screw the cap on the jar, and then fill completely with water.
- 6.2.17 Stop the hole in the cap with a finger and roll the pycnometer to free all entrapped air. When the sample contains large pieces of coarse aggregate, roll the pycnometer gently to prevent breaking the glass jar. Raise and lower the jar in such a manner that the material will flow from one end of the jar to the other while it is being rolled.
- 6.2.18 When a quantity of air bubbles has accumulated, refill the pycnometer, washing out the air, and roll again.
- 6.2.19 Repeat the rolling and shaking of the jar until all of the air has been removed. To facilitate the removal of the air, use a water aspirator, but take care to prevent siphoning out any of the finer particles.

- 6.2.20 Dry the outside of the pycnometer thoroughly.
- 6.2.21 Use a syringe or rubber bulb to fill the jar carefully with water, leaving a rounded bead of water on top of the cap.
- 6.2.22 Determine the mass of the pycnometer and contents to the nearest 0.5 g.
- 6.2.23 Record the mass,  $Z$ , and the temperature of the water as shown under Section 7.
- 6.2.24 Remove the pycnometer cap and pour the sample into a clean, tared pan.
- 6.2.25 Rinse the cap, jar, and hands thoroughly over the pan to collect all of the material.
- 6.2.26 Allow the material to settle and the water to become clear, then decant or siphon the water from the sample.
- 6.2.27 Dry the aggregate to constant mass in an oven, then cool to room temperature and weigh.
- 6.2.28 Record the net oven-dry mass of the sample to the nearest 0.5 g as  $X_1$  under Section 7.
- 6.2.29 Keep the excess saturated surface-dry material sealed in the airtight container for check tests. When making check determinations, use an odd number of grams, approximately the same mass as for the first test, for mass of surface-dry aggregate.
- 6.3 *Coarse Aggregate:*
  - 6.3.1 Secure a representative field sample in accordance with Tex-400-A and reduce to laboratory test size of approximately 1500 g with a sample splitter or quartering cloth.
  - 6.3.2 Place the sample in a pan and cover with water. Allow to soak for a minimum of 24 hours. Avoid using metal pans, which react with aggregates.  
**Note 4**—For field determination of absorption only, use Tex-409-A, Part II.
  - 6.3.3 Drain the water from the sample and transfer a portion of the material to a lint-free cloth or towel.
  - 6.3.4 Roll the material in the cloth and rub with dry ends until all surface moisture has been removed. The material may also air dry at room temperature to SSD. Do not dry past the SSD condition.
  - 6.3.5 When SSD is reached, place the surface-dried material into a small container and cover with a lid.
  - 6.3.6 Continue this operation until entire sample is at SSD.
  - 6.3.7 Transfer the SSD test sample to the balance and weigh immediately to prevent loss of moisture.
  - 6.3.8 Place sample into pycnometer jar about one quarter full of water using the wide-mouthed funnel, taking care not to lose any of the material.

- 6.3.9 Rinse the funnel so that any clinging particles wash into the jar.
- 6.3.10 Fill the jar with water to within about 12.5 mm (0.5 in.) of the rim, screw the cap on the jar, and then fill completely with water.
- 6.3.11 Stop the hole in the cap with finger and roll the pycnometer to free all entrapped air. If the sample contains large pieces of coarse aggregate, roll the pycnometer gently to prevent breaking the glass jar. Raise and lower the jar so the material will flow from one end of the jar to the other while being rolled.
- 6.3.12 When a quantity of air bubbles has accumulated, refill the pycnometer, washing out the air, and roll again. Repeat the rolling and shaking of the jar until all of the air has been removed. To facilitate the removal of the air, a water aspirator may be used, but take care to prevent siphoning out any of the finer particles.
- 6.3.13 Dry the outside of the pycnometer thoroughly.
- 6.3.14 Carefully fill the jar with water using a syringe or rubber bulb, leaving a rounded bead of water on the top of the cap.
- 6.3.15 Determine the mass of the pycnometer and contents to the nearest 0.5 g.
- 6.3.16 Record the mass,  $Z$ , and the temperature of the water as shown in Section 7.
- 6.3.17 Remove pycnometer cap and pour sample into a clean, tared pan.
- 6.3.18 Rinse cap, jar, and hands thoroughly over the pan to collect all of the material.
- 6.3.19 Allow material to settle and water to become clear, then decant or siphon the water from the sample.
- 6.3.20 Dry the aggregate to constant mass in an oven, then cool to room temperature and weigh.
- 6.3.21 Record net oven-dry mass of sample to the nearest 0.5 g as  $X_l$  under Section 7.
- 6.3.22 Keep the excess saturated surface-dry material sealed in the airtight container for check tests. When making check determinations, use an odd number of grams, approximately the same mass as for the first test, for mass of surface-dry aggregate.
- 6.4 *Mineral Filler:*
- 6.4.1 Determine the specific gravity of the mineral filler in accordance with Tex-202-F, using material that passes the 600  $\mu\text{m}$  (No. 30) sieve.
- 6.5 *Aggregate Coarser than 25 mm (1 in.) Nominal Maximum Size (Optional):*
- Note 5**—Nominal Maximum Size is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.
- 6.5.1 Secure a representative field sample in accordance with Tex-400-A. Reduce to laboratory test size with a sample splitter or quartering cloth according to Table 1.

- 6.5.2 Reject all material passing a 4.75 mm (No. 4) sieve by dry sieving and thoroughly washing to remove dust or other coatings from the surface.
- 6.5.3 Place the sample in a pan and cover with water. Allow to soak for a minimum of 24 hours. Avoid using metal pans, which react with aggregates.  
**Note 6**—For field determination of absorption only, use Tex-409-A, Part II.
- 6.5.4 Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed.
- 6.5.4.1 Wipe the larger particles individually. Use a moving stream of air to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the operation of surface drying.
- 6.5.4.2 Determine the mass of the test sample in the saturated surface-dry condition.
- 6.5.4.3 Record this and all subsequent masses to the nearest 1 g or 0.1 percent of the sample mass, whichever is greater.
- 6.5.5 After determining the mass, immediately place the saturated-surface-dry test sample in the sample container and determine the mass in water at  $23.0 \pm 1.7^{\circ}\text{C}$  ( $73.4 \pm 3^{\circ}\text{F}$ ), having a density of  $997 \pm 2 \text{ kg/m}^3$ . Take care to remove all entrapped air before determining the mass by shaking the container while immersed.
- 6.5.6 Record the weight of submerged sample as *S* under Section 7.
- 6.5.7 Dry the test sample to constant mass at a temperature of  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ). Cool in air at room temperature 1–3 hours, or until the aggregate has cooled to a temperature that is comfortable to handle (approximately  $50^{\circ}\text{C}$ ). Determine the mass and record as *X*<sub>7</sub> under Section 7.

**Table 1—Test Sample Size**

Nominal Maximum Size, mm (in.)	Minimum Mass of Test Sample, kg (lb.)
25.0 (1)	4 (8.8)
37.5 (1-1/2)	5 (11)
50 (2)	8 (18)
63 (2-1/2)	12 (26)
75 (3)	18 (40)

## 7. CALCULATIONS

- 7.1 Calculate SSD specific gravity (*G*):

$$G = X / (X + Y - Z) \quad \text{or} \quad X / (X - S)$$

-OR-

Bulk specific gravity ( $G_{\text{BULK}}$ )

$$G_{\text{BULK}} = X_1 / (X + Y - Z) \quad \text{or} \quad X_1 / (X - S)$$

Where:

$S$  = submerged sample weight, in basket

$X$  = mass of SSD sample, kg (lb.)

$X_1$  = the net oven-dry mass of the sample, kg (lb.)

$Y$  = mass of calibrated pycnometer filled with water, kg (lb.)

$Z$  = mass of pycnometer containing SSD sample and water at  $23 \pm 2^\circ\text{C}$  ( $73 \pm 3^\circ\text{F}$ ) to fill,  
kg (lb.)

- 7.2 For a combination of aggregates, calculate  $G$  for each ( $G_1$ ,  $G_2$ ,  $G_i$ , etc.) and then calculate the average SSD specific gravity of the combination:

$$G = 100 / [(W_1 / G_1) + (W_2 / G_2) + (W_i / G_i) + \text{etc.}]$$

Where:

$W_i$  = percentage of  $i^{\text{th}}$  material based on the total mass of the combination.

- 7.3 Calculate absorption of the aggregate:

$$A = (X - X_1) / X_1$$

- 7.4 Calculate average percent absorption of combined materials:

$$A = [(A_1 \bullet W_1) + (A_2 \bullet W_2) + \text{etc.}] / 100$$

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## 8. REPORT

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