

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

**AASHTO 4. SIGNIFICANCE AND USE**

4.1 Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in T 19M/T 19. Bulk specific gravity determined on the saturated surface-dry basis is used if the aggregate is wet; that is, if its absorption has been satisfied. Conversely, the bulk specific gravity determined on the oven-dry basis is used for computations when the aggregate is dry or assumed to be dry.

4.2 Apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water. This value is not widely used in construction aggregate technology.

4.3 Absorption values are used to calculate the change in the mass of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after soaking dry aggregate in water. Aggregates mined from below the water table may have a higher absorption when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than that achieved by the required amount of soaking time: For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined by T 255 by drying.

**LS 4. SIGNIFICANCE AND USE**

4.1 In addition to the Significance and Use given in the AASHTO procedure, further clarification is provided below in 4.2.

4.2 Bulk relative density is used in calculations of the VMA in asphalt mixtures. Slight biases in determining relative density may lead to inaccuracies in assessing the correct VMA. In order to minimize these inaccuracies, MTO has required the removal of fines from the fine aggregate for hot mix asphalt design purposes for over 40 years (Procedure 6.1). Procedure 6.2 has been developed for Superpave mixture design. The procedure is intended to be used on the proposed blend of fine aggregates. In developing the actual blend of materials to be used in the mixture, the designer should use whatever technique of AASHTO T 84 they deem most accurate in determining the relative densities of the individual components, and then blend proportionately to create a test sample.

**AASHTO 5. APPARATUS**

5.1. *Balance*, conforming to the requirements of M 231, Class G2..... \_\_\_\_\_

5.2 *Pycnometer*- A flask or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced with  $\pm 100 \text{ mm}^3$ ..... \_\_\_\_\_

The volume of the container filled to the mark shall be at least 50 percent greater than the space required to accommodate the test sample..... \_\_\_\_\_

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

A volumetric flask of 500 ml capacity or a fruit jar fitted with a pycnometer top is satisfactory for a 500 g test sample of most fine aggregates..... \_\_\_\_\_

A Le Chatelier flask as described in T 133 is satisfactory for an approximately 55 g test sample..... \_\_\_\_\_

5.3 *Mold*- A metal mold in the form of a frustum of a cone with dimensions as follows: 40 ± 3 mm inside diameter at the top, 90 ± 3 mm inside diameter at the bottom, and 75 ± 3 mm in height, with the metal having a minimum thickness of 0.8 mm..... \_\_\_\_\_

5.4 *Tamper*- A metal tamper having a mass of 340 ± 15 g and having a flat circular tamping face 25 ± 3 mm in diameter..... \_\_\_\_\_

**6. SAMPLING**

6.1 Sampling shall be accomplished in general accordance with T 2..... \_\_\_\_\_

**LS 5. PROCEDURE**

5.1 Procedures of AASHTO T 84 shall be followed, except as noted below, for the determination of relative density, apparent relative density, and absorption of fine aggregate..... \_\_\_\_\_

The period of soaking in water shall be 15-19 h as specified by AASHTO (Note 1) except as noted below..... \_\_\_\_\_

*Note 1: The ASTM procedure specifies 24 ± 4 h of soaking.*

5.2 If the aggregate contains material coarser than the 4.75 mm sieve, remove this material from the test sample..... \_\_\_\_\_

If the amount of material coarser than the 4.75 mm sieve is greater than 5% by mass of the sample, this material should be tested in LS-604..... \_\_\_\_\_

If the amount is less than 5% by mass, discard the material but assume that this material has the same density as the parent fine aggregate material in any calculations of density of the combined coarse and fine aggregates..... \_\_\_\_\_

**6. EXCEPTIONS TO AASHTO T 84**

**6.1 Individual fine aggregates for hydraulic cement concrete and for hot mix asphalt mixture design process**

6.1.1 Obtain 2 representative sub-samples of approximately 1200 g of oven-dried fine aggregate by use of a sample splitter or by quartering..... \_\_\_\_\_

6.1.2 Wash the samples over a 75 µm sieve in accordance with MTO LS-601, Method of Test for Material Finer Than 75 µm Sieve in Mineral Aggregates by Washing, until all material passing the 75 µm sieve is removed..... \_\_\_\_\_

6.1.3 Saturate the samples in water by immersion for 24 ± 4 h for concrete fine aggregate and 15-19 h for asphalt fine aggregate..... \_\_\_\_\_

6.1.4 Test the 2 sub-samples. For the purpose of determining the saturated surface dry condition, where possible, use the normal cone test..... \_\_\_\_\_

6.1.5 If duplicate tests of relative density differ by more than 0.027, the materials shall be retested..... \_\_\_\_\_

6.1.6 If duplicate tests of absorption differ by more than 0.31%, the materials shall be retested.... \_\_\_\_\_

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

**6.2 Blended fine aggregates for hot mix asphalt mixture design process (see Note 2)**

6.2.1 Prepare a sample of approximately 2400 g of oven-dried fine aggregate according to LS-600 Part B. \_\_\_\_\_

Reclaimed asphalt pavement materials (RAP) shall not be blended into the virgin fine aggregate sample for this test. \_\_\_\_\_

RAP materials shall be tested separately according to 6.3. \_\_\_\_\_

6.2.2 Thoroughly mix the blended sample and split this combined sample into two sub-samples of approximately 1200 g and perform the test on each sub-sample. \_\_\_\_\_

*Note 2: Testing of blended fine aggregate is carried out only when specified by the owner.* \_\_\_\_\_

6.2.3 Wash each sub-sample over a 75 µm sieve in accordance with MTO LS-601, Method Of Test for Material Finer Than 75 µm Sieve in Mineral Aggregates by Washing, until all material passing the 75 µm sieve is removed. \_\_\_\_\_

6.2.4 Saturate the sub-samples in water by immersion for 15-19 h. \_\_\_\_\_

6.2.5 Test the 2 sub-samples. For the purpose of determining the saturated surface dry condition, where possible, use the normal cone test. \_\_\_\_\_

6.2.6 In cases where the fine aggregate slumps before the saturated surface dry condition is reached (normally fine aggregates with large amounts of material retained on the 2.36 and 1.18 mm sieves), remove the material coarser than the 2.36 mm sieve by dry sieving. \_\_\_\_\_

Test the material pass 2.36 mm using the cone test. \_\_\_\_\_

Test the material retained on the 2.36 mm sieve using procedure 4 of the test method using hard-finish paper towels (Note 3) \_\_\_\_\_

*Note 3: Whatman No 541 filter paper may be suitable, is re-usable, and is available in approximately 500 x 500 mm sheets.* \_\_\_\_\_

6.2.7 If duplicate tests of relative density differ by more than 0.027, the materials shall be retested \_\_\_\_\_

6.2.8 If duplicate tests of absorption differ by more than 0.31%, the materials shall be retested.... \_\_\_\_\_

**6.3 Fine aggregates extracted from RAP for both Marshall and Superpave mix design**

6.3.1 Remove the asphalt from the RAP, wash and oven-dry the extracted aggregate according to LS-282. \_\_\_\_\_

6.3.2 Separate the extracted aggregates on a 4.75 mm sieve into coarse and fine aggregate fractions. Do not sieve so thoroughly as to significantly change the shape of the aggregate particles. \_\_\_\_\_

6.3.3 Follow the procedures of 6.1. \_\_\_\_\_

**6.4 Combinations of virgin fine aggregate and RAP for both Marshall and Superpave processes.**

6.4.1 Calculate the density of the fine aggregate in the asphalt mixture by using a calculation based on the density of the fine aggregate determined following 6.1 or 6.2 and the density of the RAP fine aggregate determined in 6.3. The calculation shall be based on the mass proportions of virgin fine aggregate to the mass proportion of fine aggregate contributed to the mixture by the RAP.. \_\_\_\_\_

**AASHTO 7. PREPARATION OF TEST SPECIMEN**

7.1. Obtain approximately one kilogram of the fine aggregate from the sample using the applicable procedures described in T 248. \_\_\_\_\_

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

7.1.1. Dry it in a suitable pan or vessel to constant mass at a temperature of  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ) \_\_\_\_\_  
 Allow it to cool to comfortable handling temperature, cover with water, either by immersion or by the  
 addition of at least 6 percent moisture to the fine aggregate and permit to stand for 15 to 19 h.. \_\_\_\_\_

7.1.2. As an alternative to Section 7.1.1, where the absorption and specific gravity values are to be used  
 in proportioning concrete mixtures with aggregates used in their naturally moist condition, the  
 requirement for initial drying to constant mass may be eliminated and, if the surfaces of the particles  
 have been kept wet, the required soaking may also be eliminated..... \_\_\_\_\_

**Note 1-** Values for absorption and specific gravity in the saturated surface-dry condition may be  
 significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in  
 accordance with Section 7.1.1..... \_\_\_\_\_

7.2. Decant excess water with care to avoid loss of fines, spread the sample on a flat, non-absorbent  
 surface exposed to a gently moving current of warm air, and stir frequently to secure homogenous  
 drying..... \_\_\_\_\_

If desired, mechanical aids such as tumbling or stirring may be employed to assist in achieving the  
 saturated surface-dry 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. Continue this operation until the test specimen approaches a free-flowing condition.... \_\_\_\_\_

Follow the procedure in Section 7.2.1 to determine whether or not surface moisture is present on the  
 constituent fine aggregate particles. It is intended that the first trial of the cone test will be made with  
 some surface water in the specimen..... \_\_\_\_\_

Continue drying with constant stirring and if necessary, work the material with a hand-rubbing motion,  
 and test at frequent intervals until the test indicates that the specimen 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 min. Then  
 resume the process of drying and testing at frequent intervals for the onset of the surface-dry  
 condition..... \_\_\_\_\_

7.2.1. *Cone Test for Surface Moisture* – Hold the mold firmly on a smooth non-absorbent surface with  
 the large diameter down. Place a portion of the partially dried fine aggregate loosely in the mold by filling  
 until overflow occurs and heaping additional material above the top of the mold by holding it with the  
 cupped fingers of the hand holding the mold..... \_\_\_\_\_

Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper..... \_\_\_\_\_

Each drop should start about 5 mm (0.2 in.) above the top surface of the fine aggregate..... \_\_\_\_\_

Permit the tamper to fall freely under gravitational attraction on each drop..... \_\_\_\_\_

Adjust the starting height to the new surface elevation after each drop and distribute the drops over the  
 surface..... \_\_\_\_\_

Remove loose sand from the base 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..... \_\_\_\_\_

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

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 100 to 150 mm 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..... \_\_\_\_\_

**Note 2** – The following criteria have also been used on materials that do not readily slump:

1. *Provisional Cone Test* – Fill the cone mold as described in Section 7.2.1. except only use 10 drops of the tamper. Add more fine aggregate and use 10 drops of the tamper again. Then add material two more times using three and two drops of the tamper, respectively. Level off the material even with the top of the mold; remove loose material from the base; and lift the mold vertically.
2. *Provisional Surface Test* – If airborne fines are noted when the fine aggregate is such that it will not slump when it is at a moisture condition, add more moisture to the sand, and at the onset of the surface-dry condition, with the hand lightly pat approximately 100 g of the material on a flat, dry clean, dark, or dull non-absorbent surface such as a sheet of rubber, a worn oxidized, galvanized, or steel surface, or a black-painted metal surface. After 1 to 3 s, remove the fine aggregate. If noticeable moisture shows on the test surface for more than 1 to 2 s, then surface moisture is considered to be present on the fine aggregate.
3. Colorimetric procedures described by Kandhal and Lee, Highway Research No.307, p.44
4. For reaching the saturated surface-dry condition on a single-size material that slumps when wet, hard-finish paper towels can be used to surface dry the material until the point is just reached where the paper towel does not appear to be picking up moisture from the surface of the fine aggregate particles.

**8. PROCEDURE**

8.1. Make and record all mass determinations to 0.1 g..... \_\_\_\_\_

8.2. Partially fill the pycnometer with water..... \_\_\_\_\_

Immediately introduce into the pycnometer 500 ± 10 g of saturated surface-dry fine aggregate prepared as described in Section 7, and fill with additional water to approximately 90 percent of capacity. \_\_\_\_\_

Manually roll, invert, and agitate or use a combination of these actions to eliminate all air bubbles in the pycnometer (Note 3) ..... \_\_\_\_\_

Accomplish mechanical agitation by external vibration of the pycnometer in a manner that will not degrade the sample. A level of agitation adjusted to just set individual particles in motion is sufficient to promote de-airing without degradation. A mechanical agitator shall be considered acceptable for use if comparison tests for each six-month period of use show variations less than the acceptable range of two results (d2s) indicated in Table 1 of the AASHTO procedure from results of manual agitation on the same material..... \_\_\_\_\_

Adjust its temperature to 23.0 ± 1.7°C (73.4 ± 3°F), if necessary by immersion in circulating water, and bring the water level in the pycnometer to its calibrated capacity..... \_\_\_\_\_

Determine total mass of the pycnometer, specimen, and water..... \_\_\_\_\_

**Note 3** – It normally takes about 15 to 20 min to eliminate air bubbles by manual methods. Dipping the tip of a paper towel into the pycnometer has been found to be useful in dispersing the foam that sometimes builds up when eliminating the air bubbles, or adding a few drops of isopropyl alcohol, after

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

removal of air bubbles and just prior to bringing the water level to its calibrated capacity, has also been found useful in dispersing foam on the water surface. Do not use isopropyl alcohol when using the alternative method described in Section 8.2.1..... \_\_\_\_\_

8.2.1 *Alternative to Determining the Mass in Section 8.2.* – The quantity of added water necessary to fill the pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Compute the total mass of the pycnometer, specimen, and water as follows: ..... \_\_\_\_\_

$$C = 0.9975V_a + S + W \tag{1}$$

where:

C = mass of pycnometer with specimen and water to calibration mark, g

V<sub>a</sub> = volume of water added to pycnometer, mL

S = mass of saturated surface-dry specimen, g

W = mass of the pycnometer empty, g

8.2.2. *Alternative to the Procedure in Section 8.2.* – Use a Le Chatelier flask initially filled with water to a point on the stem between the 0 and the 1 mL mark. Record this initial reading with the flask and contents within the temperature range of 23.0 ± 1.7°C (73.4 ± 3°F). Add 55 ± g of fine aggregate in the saturated surface-dry condition (or other mass as necessary to result in raising the water level to some point on the upper series of graduation). After all fine aggregate has been introduced, place the stopper in the flask and roll the flask in an inclined position, or gently whirl it in a horizontal circle so as to dislodge all entrapped air, continuing until no further bubbles rise to the surface (Note 4). Take a final reading with the flask and contents within 1°C (1.8°F) of the original temperature..... \_\_\_\_\_

**Note 4** – When using the Le Chatelier flask method, slowly adding a small measured amount (not to exceed 1 mL of isopropyl alcohol, after removal of air bubbles, has been found useful in dispersing foam appearing on the water surface. The volume of alcohol used must be subtracted from the final reading (R<sub>2</sub>) ..... \_\_\_\_\_

8.3. Remove the fine aggregate from the pycnometer, dry to constant mass at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature for 1.0 ± 0.5 h and determine the mass..... \_\_\_\_\_

**Note 5** – In lieu of drying and determining the mass of a sample that has been removed from the pycnometer, a second portion of the saturated surface-dry sample may be used to determine the oven-dry mass. This sample must be obtained at the same time and be within 0.2 grams of the mass of the sample that is introduced into the pycnometer..... \_\_\_\_\_

8.3.1. If the Le Chatelier flask method is used, a separate sample portion is needed for the determination of absorption. Weigh a separate 500 ± 10 g portion of the saturated surface-dry fine aggregate, dry to constant mass, and reweigh. This sample must be obtained at the same time as the sample that is introduced into the Le Chatelier flask..... \_\_\_\_\_

8.4. Determine the mass of the pycnometer filled to its calibration capacity with water at 23.0 ± 1.7°C (73.4 ± 3°F) ..... \_\_\_\_\_

8.4.1. *Alternative to Determining the Mass in Section 8.4.* – The quantity of water necessary to fill the empty pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Calculate the mass of the pycnometer filled with water as follows: ..... \_\_\_\_\_

$$B = 0.9975V + W \tag{2}$$

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

where:

B = mass of flask filled with water, g

V = volume of flask, mL

W = mass of the flask empty, g

**9. BULK SPECIFIC GRAVITY**

9.1. Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), as follows: ..... \_\_\_\_\_

$$\text{bulk sp gr} = A/(B + S - C) \tag{3}$$

where:

A = mass of oven-dry specimen in air, g

B = mass of pycnometer filled with water, g

S = mass of saturated surface-dry specimen, g

C = mass of pycnometer with specimen and water to calibration mark, g

9.1.1. If the Le Chatelier flask method was used, calculate the bulk specific gravity, 23/23°C, as follows:

..... \_\_\_\_\_

$$\text{bulk sp gr} = \frac{S1(A/S)}{0.9975 (R2 - R1)} \tag{4}$$

where:

S1 = mass of saturated surface-dry specimen used in Le Chatelier flask, g

R2 = final reading of water level in Le Chatelier flask

R1 = initial reading of water level in Le Chatelier flask

**10. BULK SPECIFIC GRAVITY (SATURATED SURFACE-DRY BASIS)**

10.1. Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), on the basis of mass of saturated surface-dry aggregate as follows: ..... \_\_\_\_\_

$$\text{bulk sp gr (saturated surface-dry basis)} = S/(B + S - C) \tag{5}$$

10.1.1. If the Le Chatelier flask method was used, calculate the bulk specific gravity, 23/23°C, on the basis of saturated surface-dry aggregate as follows: ..... \_\_\_\_\_

$$\text{bulk sp gr (saturated surface-dry basis)} = \frac{S1}{0.9975 (R2 - R1)} \tag{6}$$

**11. APPARENT SPECIFIC GRAVITY**

11.1. Calculate the apparent specific gravity, 23/23°C (73.4/73.4°F), as follows: ..... \_\_\_\_\_

$$\text{apparent sp gr} = A/(B + A - C) \tag{7}$$

**12. ABSORPTION**

12.1. Calculate the percentage of absorption as follows: ..... \_\_\_\_\_

$$\text{Absorption, percent} = [(S - A)/A] \times 100 \tag{8}$$

**RELATIVE DENSITY AND ABSORPTION OF FINE AGGREGATE** LS-605 R33/T84-13(2017)

**LS 7. USE OF LABORATORY CONTROL AGGREGATE**

- 7.1 At least every week in which a sample is tested, a sample of the standard reference aggregate shall also be tested. Material shall be taken from a stock supply maintained by the Soils and Aggregates Section, of the Materials Engineering and Research Office at the Ministry of Transportation (soils-aggregates@ontario.ca) .....
- 7.2 Control Chart Use: The per cent loss of the last twenty samples of reference material shall be plotted on a control chart in order to monitor the performance of the laboratory.....
- 7.3 The mean values of the control material are provided on the label.....

**8. REPORT**

The report shall include the following:

- 8.1 Relative density values shall be reported to the nearest 0.001 and indicate the basis for relative density as either oven-dry (OD), saturated-surface dry (SSD) or apparent.....
- 8.2 Report the absorption result to the nearest 0.01%.....
- 8.3 When two determinations are made on a fine aggregate, the mean of the results shall be reported as the final "test result".....
- 8.4 When a sample has been separated on the 2.36 mm sieve and the density and absorption of the retained 2.36 mm material determined separately from the pass 2.36 mm material, this shall be noted and the individual and weighted mean densities and absorptions reported together with the calculation.....
- 8.5 When fine aggregate extracted from RAP has been tested and the density combined with that of the virgin fine aggregate, the individual densities and absorptions of the extracted RAP aggregate and virgin fine aggregate shall be reported. The weighted mean density and absorption shall also be reported together with the calculation.....
- 8.6 The per cent absorption and relative density of the last twenty samples of reference material on control charts.....

**AASHTO 13. REPORT**

- 13.1 Report specific gravity results to the nearest 0.001 (Fine Aggregate meeting M 6 requirements may be reported to the nearest 0.01) and absorption to the nearest 0.1 percent.....
- The Appendix of this AASHTO Standard gives mathematical interrelationships among the three types of specific gravities and absorption. These may be useful in checking the consistency of reported data or calculating a value that was not reported by using other reported data.....
- 13.2. If the fine aggregate was tested in a naturally moist condition other than the oven dried and 15-h soaked condition, report the source of the sample and the procedures used to prevent drying prior to testing.....

**COMMENTS**