~~Designation:D7370–08~~ Designation: D 7370 – 09

Standard Test Method for
Determination of Relative Density and Absorption of Fine, Coarse and Blended Aggregate Using Combined Vacuum Saturation and Rapid Submersion[1]

1. Scope

1.1 This ~~standard~~test method covers the determination of relative density and absorption of fine aggregates by Method A and coarse and blended aggregates by Method B.

1.2 The values are stated in SI units and are regarded as the standard units.

1.3 A multi-laboratory precision and bias statement for coarse and combined aggregate tests in this standard has not been developed at this time. Therefore, this standard should not be used for acceptance or rejection of coarse and combined aggregate materials for purchasing purposes.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:[2]*

C 29/C 29M Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
C 127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
C 128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C 702 Practice for Reducing Samples of Aggregate to Testing Size
D 75 Practice for Sampling Aggregates
D 4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
D 3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Summary of Test Method

3.1 Sufficient aggregate sample is dried to constant mass. For each test two representative dry aggregate samples of the same material are selected for testing. One sample is evacuated in a vacuum chamber inside a plastic bag and opened under water for rapid saturation of the aggregate. The dry mass and submerged mass of the sample is used for calculation of apparent relative density. The second sample of the same aggregate is tested in a known volume metal pycnometer. The known mass of the pycnometer with water, mass of the dry aggregate and mass of the aggregate and pycnometer filled with water is used for calculation of unsaturated density. The results from the two samples tested are then used to calculate absorption, and relative density (OD).

3.2 This test can be completed in less than 30 minutes and can be used for rapid determination of aggregate properties in construction testing laboratories.

3.3 This test can be performed on fine, coarse and blended (combined) aggregates by using appropriate plastic bag and pycnometer sizes.

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[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.51 on Aggregate Tests.

~~Current edition approved July 15, 2008. Published August 2008.~~

Current edition approved June 1, 2009. Published July 2009. Originally approved in 2008. Last previous edition approved in 2008 as D 7370 – 08.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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4. Significance and Use

4.1 Relative density (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. Relative density (specific gravity) is also used in the computation of voids in aggregate in Test Method C 29/C 29M. Relative density (specific gravity) saturated surface dry (SSD) is used if the aggregate is at SSD, that is, if its absorption has been satisfied. Conversely, the relative density (specific gravity) oven-dry (OD) is used for computations when the aggregate is dry or assumed to be dry.

4.2 Apparent density and apparent relative density (apparent specific gravity) pertain to the solid material making up the constituent particles not including the pore space within the particles which is accessible to water.

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, when it is deemed that the aggregate has been in contact with water long enough to satisfy the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for a prescribed period of time.

Note 1—There are other test methods that have been used and continue to be used to determine these aggregate properties: C 127 and C 128. This test method may result in values for these properties that are close to or divergent from values from other test methods.

Note 2—The quality of the results produced by this standard are dependant upon the competence of the personnel performing the procedure and the capability, calibration, and the maintenance of the equipment used. Agencies that meet the criteria of Practice D 3666 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D 3666 alone does not completely assure reliable results. Reliable results depend on many factors: following the suggestions of Practice D 3666 or similar acceptable guideline provides a means of evaluating and controlling some of those factors.

5. Apparatus

5.1 *Balance*, a balance that conforms to Guide D 4753. The balance shall be sensitive, readable and accurate to 0.1 g. The balance shall be equipped with suitable apparatus for suspending the sample in water.

5.2 *Water Bath*, with minimum dimensions (Length(length by Widthwidth by Depth)depth) of 610 by 460 by 460 mm (24 by 18 by 18 in.) or a large cylindrical container with a minimum diameter of 460 mm and depth of 460 mm (18 by 18 in.), for completely submerging the sample in water while suspended, equipped with an overflow outlet for maintaining a constant water level and means to maintain the water temperature at 25 ± 1°C (77 ± 2°F).

Note 3—It is preferable to keep the water temperature constant by using a temperature controlled heater. Also, to reduce the chance for the bag to touch the sides of the water tank, it is preferable to elevate the water tank to a level at which the sample can be placed on the weighing mechanism while the operator is standing up (waist height), and the placement of the sample and the bag in the water tank can easily be inspected.

5.3 *Sample Holder*, for water displacement of the sample, having no sharp edges.

5.4 *Vacuum Chamber*, with a pump capable of evacuating a sealed and enclosed chamber to a pressure of 6 mm Hg, when at sea level. The device shall automatically seal the plastic bag and exhaust air back into the chamber in a controlled manner to ensure proper conformance of the plastic to the specimen. The air exhaust and vacuum operation time shall be set at the factory so that the chamber is brought to atmospheric pressure in 80 to 125 seconds, after the completion of the vacuum operations.

5.5 *Vacuum Measurement Gauge*, independent of the vacuum sealing device that could be placed directly inside the chamber to verify vacuum performance and the chamber door sealing condition of the unit. The gauge shall be capable of reading down to 3 mm Hg and readable to ±1 mm Hg.

5.6 *Plastic Bags*, used with the vacuum device shall be one of the two following sizes. The smaller bags shall have a minimum opening of 235 mm (9.25 in.) and maximum opening of 260 mm (10.25 in.) and the larger bags shall have a minimum opening of 375 mm (14.75 in.) and a maximum opening of 394 mm (15.5 in.). The bags shall be of plastic material, shall be puncture resistant, and shall be impermeable to water. The bags shall have a minimum thickness of 0.127 mm (0.005 in.). The apparent specific gravity for the bags shall be provided by the manufacturer.

5.7 *Small Metal Pycnometer*, with 137 ± 0.2 mm (5.375 ± 0.008 in.) ID and 89 ± 0.40 mm (3.5 ± 0.016 in.) height, for testing fine aggregates. The pycnometer shall be machined to be smooth on all surfaces. The inside of the lid shall be machined at a 5° angle to create an inverted conical surface. The pycnometer shall be equipped with a graduated temperature strip to allow the user to visually monitor temperature during testing.

5.8 *Large Metal Pycnometer*, with 198 ± 0.2 mm (7.776 ± 0.008 in.) ID and 114 ± 0.8 mm (4.5 ± 0.03 in.) height, for testing coarse and blended aggregate. The pycnometer shall be machined to be smooth on all surfaces. The inside of the lid shall be machined at a 5° angle to create an inverted conical surface. The pycnometer shall be equipped with a graduated temperature strip to allow the user to visually monitor temperature during testing.

5.9 *Fine Aggregate Fixture*, for holding and securing the lid on the small metal pycnometer from lifting during fine aggregate tests. The fixture shall be provided with a level indicator.

5.10 *Accessories*—Bag cutting knife or scissors, spray bottle filled with isopropyl alcohol, a bucket large enough to allow the pycnometer to be fully submerged in water, water containers to dispense water into pycnometer during testing, syringe with a needle no larger in diameter than 3 mm (0.125 in.), small paint brush and 25 ± 5 mm (1 ± 0.2 in.) wide metal spatula.

5.11 *Rubber Sheets*, for protecting the plastic bags against punctures caused by sharp edges on coarse and blended aggregate samples. The apparent specific gravity for the rubber sheets shall be provided by the manufacturer.

5.12 *PC computer*, with appropriate software for calculation of the results.

5.12 Thermometric device for monitoring the temperature to within ±1ºC (±1.8º F).

6. Verification

6.1 *System Verification*:

6.1.1 The vacuum settings of the vacuum chamber shall be verified once every 12 months and after major repairs and after each shipment or relocation.

6.1.2 Place the gauge inside the vacuum chamber and record the setting, while the vacuum unit is operating. The gauge should indicate a pressure of 6 mm Hg (6 TORR) or less. The unit shall not be used if the gauge reading is above 6 mm Hg (6 TORR).

6.1.3 ~~Vacuum gauge used for verification shall be verified for accuracy once every three years.~~

6.1.3 Vacuum gauge used for verification shall be standardized for accuracy on annual basis.

NOTE 4—In line vacuum gauges, while capable of indicating vacuum performance of the pump, are not suitable for use in enclosed vacuum chambers and cannot accurately measure vacuum levels.

NOTE 5—The worksheet in the appendix is provided as an optional tool to the user for recording of masses obtained during this test method. Users may develop their own worksheet or a computer program for this purpose.

6.2 *Calibration of the Small Pycnometer* :

6.2.1 Prior to testing, condition the pycnometer at 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F). Use a level indicator or the provided level to level the fixture.

6.2.2 Remove the pycnometer from the water bucket and dry it with a towel. Place the pycnometer in the fixture and push it back until it makes contact with the stops.

6.2.3 Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) from the top. Using the alcohol spray bottle, spray the surface of the water to remove bubbles.

6.2.4 Gently place the lid on the pycnometer and close the clamps on the fixture.

6.2.5 Using a syringe filled with 25 ± 1°C (77 ± 2°F) water, slowly fill the pycnometer through the large fill hole on the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step prevents formation of air bubbles inside the pycnometer. Fill the pycnometer until water comes out the 3 mm (⅛ in.) hole on the surface of the lid.

6.2.6 Wipe any remaining water from the top of the lid with a towel.

6.2.7 ~~Place the entire fixture with the pycnometer on the scale and record the mass.~~ Place the entire fixture with the pycnometer on the scale and record the mass to the nearest 0.1 g.

6.2.8 Clean the pycnometer and repeat steps 6.2.1 to 6.2.7 two more times and average the calibration masses obtained in 6.2.7.

6.2.9 If the range for the 3 calibration masses is larger than 0.5 g, then the test is not being run correctly. Check to see if the fixture is level. Make certain the water injection with the syringe is done below the pycnometer water surface and is applied gently. Check the water temperature. Check the pycnometer temperature. Repeat the above procedure until you have three masses that are within 0.5 g range.

6.2.10 Re-calibrate the pycnometer for each day of use.

6.3 *Calibration of the Large Pycnometer* :

6.3.1 Prior to testing, condition the pycnometer at 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F).

6.3.2 Remove the pycnometer from the water bucket and dry it with a towel. Set the pycnometer on a level surface.

6.3.3 Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) from the top. Using the alcohol spray bottle, spray the surface of the water to remove any air bubbles.

6.3.4 Gently place the lid on the pycnometer. Using a syringe filled with 25 ± 1°C (77 ± 2°F) water, slowly fill the pycnometer through the large fill hole on the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step prevents formation of air bubbles inside the pycnometer. Fill the pycnometer until water comes out the 3 mm (⅛ in.) hole on the surface of the lid.

6.3.5 Wipe any remaining water from the top of the lid and sides with a towel. Place the pycnometer on the scale and record the mass to the nearest 0.1 g.

6.3.6 Clean the pycnometer and repeat steps 6.3.2 to 6.3.5 two more times and average the calibration masses obtained in 6.3.5.

6.3.7 If the range for the 3 calibration masses is larger than 1 g, then the test is not being run correctly. Check to see if the fixture is level. Make certain the water injection with the syringe is done below the pycnometer water surface and is applied gently. Check the water temperature. Check the pycnometer temperature. Repeat the above procedure until you have three masses that are within 1 g range.

6.3.8 Re-calibrate the pycnometer for each day of use.

7. Sampling

7.1 *Fine Aggregate Samples (Method A)*:

7.1.1 Sampling shall be done in accordance with Practice D 75. For fine aggregate testing thoroughly mix the sample and reduce it to obtain one 1000 ± 5 g sample for apparent density and two 500 ± 3 g samples for determination of apparent bulk density.

For aggregate reduction use the appropriate procedures described in Practice C 702.

7.2 *Coarse Aggregate Samples (Method B)*:

7.2.1 Sample the aggregate in accordance with Practice D 75.

7.2.2 Dry the fine, coarse and combined aggregate to constant mass at 110 ± 5ºC (230 ± 9ºF) and thoroughly mix the sample of aggregate and reduce it to one 2000 ± 10 g sample for determination of apparent density and two 1000 ± 10 g samples for determination of apparent bulk density. For reduction of the aggregate samples, use the appropriate procedures in Practice C 702.

7.2.3 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with Test Method C 136, including the sieves used for separating the size fractions for the determinations in this method.

NOTE 6—When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more sub samples, and the values obtained combined for the computations.

8. Procedures

8.1 *Method A, Fine Aggregate Test* :

8.1.1 Make certain water temperature used for this test remains at 25 ± 1°C (77 ± 2°F).

8.1.2 Prior to testing, condition the pycnometer at 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F).

8.1.3 *Determine Apparent Bulk Density* :

8.1.3.1 Make certain the samples are dried to constant mass.

8.1.3.2 For a single test select and separate two 500 ± 3 g samples (samples A and B) for the test in the pycnometer and one 1000 ± 5 g sample for vacuum saturation test.

8.1.3.3 Allow the sample to cool to room temperature.

8.1.3.4 Place the empty pycnometer in the fixture and push it back until it makes contact with the stops.

8.1.3.5 Weigh a 500 ± 3 g dry sample that is at 25 ± 1°C (77 ± 2°F) and record its mass to the nearest 0.1 g (column A in appendix).

8.1.3.6 Steps 8.1.3.7 to 8.1.3.14 shall be completed in less than 2 minutes.

8.1.3.7 Place approximately 500 mL (halfway full) of 25 ± 1°C (77 ± 2°F) water in the pycnometer.

8.1.3.8 Slowly and evenly pour the sample into the pycnometer. Make certain aggregate is not lost in the process of filling the pycnometer. Use a brush if necessary to sweep any remaining fines into the pycnometer. If any aggregate is lost during the process of filling the pycnometer, start the test over.

8.1.3.9 Use a metal spatula and push it to the bottom of the pycnometer against the inside circumference. Slowly and gently drag the spatula to the center of the pycnometer, removing the spatula after reaching the center. Repeat this procedure 7 more times so that the entire circumference is covered in 8 equal angles, that is, every 45 degrees until the starting point is reached. If necessary, use a squeeze water bottle to rinse any sample residue off the spatula into the pycnometer.

8.1.3.10 Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) of the pycnometer rim. It is important that the water level is kept at or below the 10 mm line to avoid spills during lid placement

8.1.3.11 Use the spray bottle filled with isopropyl alcohol and spray the top of the water to remove air bubbles.

8.1.3.12 Gently place the lid on the pycnometer and lock the clamps. Using the syringe, slowly fill the pycnometer through the center hole on top of the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step will prevent formation of air bubbles inside the pycnometer.

8.1.3.13 Fill the pycnometer until water just comes out the 3 mm (⅛ in.) hole on the surface of the lid.

8.1.3.14 Wipe any remaining water from around the 3 mm (⅛ in.) hole with a towel.

8.1.3.15 Weigh the pycnometer and the fixture. Record the mass to the nearest 0.1 g (column B in appendix).

8.1.3.16 Repeat steps 8.1.3.1 to 8.1.3.15 for the second 500 ± 3 g sample, Sample B.

8.1.3.17 Record the mass of the sample B to the nearest 0.1 g (column B of the appendix).

8.1.3.18 Average the mass for sample A and sample B.

8.1.4 *Determine Apparent Density* :

8.1.4.1 Set the pressure level on the vacuum device according to manufacturer's recommendation.

8.1.4.2 Use a small plastic bag and inspect the bag to make sure there are no holes, stress points or side seal discontinuities in the bag. If any of the above conditions are noticed, use another bag.

8.1.4.3 Weigh the bag and record in column C of the worksheet.

NOTE 7—Handle the bag with care to avoid creating weak points and punctures.

8.1.4.4 Weigh 1000 ± 5 g of oven dry aggregate and record the mass to the nearest 0.1 g in column E.

8.1.4.5 Place the sample in the bag. Support the bottom of the bag on a smooth tabletop when pouring the aggregate to protect against punctures and impact points.

8.1.4.6 Place the bag containing the sample inside the vacuum chamber.

8.1.4.7 Grab the two sides of the bag and spread the sample flat by gently shaking the bag side to side. Do not press down or spread the sample from outside the bag. Pressing down on the sample from outside the bag will cause the bag to puncture and will