7.4 Fine Aggregate: Density and Absorption Tests

7.4.1 Introduction

7.4.1.1 Bulk specific gravity: Bulk specific gravity of the aggregate is a characteristic generally used for the 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 analysed on an absolute volume basis. It is also used in the computation of voids in aggregate and the determination of moisture in aggregate by displacement in water. 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. Bulk specific gravity determined on the oven-dry basis is used for computations when the aggregate is dry or assumed to be dry.

7.4.1.2 Apparent specific gravity: 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.

7.4.1.3 Absorption: 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 absorption is obtained after the aggregate has been submerged in water for approximately 24 hours.

7.4.2 Scope. This test provides methods for determining the bulk and apparent densities (after submersion in water for 24h) of fine aggregate, the bulk specific gravity on the basis of mass saturated surface-dry aggregate and water absorption of fine aggregate.

7.4.3 Equipment

a) Balance, of capacity not less than 3 kg, accurate to 0.5g and of such type and size as to permit the basket containing the sample to be suspended from the beam and weight in water.
b) Ventilated oven, thermostatically controlled to maintain the temperature at 105 °C plus or minus 5 °C.
c) Pycnometer, capable of holding 0.5 kg to 1.0 kg of material up to 10mm nominal size and capable of being filled with water to a constant volume with an accuracy of plus or minus 0.5 ml. The volume of the pycnometer shall be least 50% greater than the volume required to accommodate the sample.
d) Metal mould, in the form of a frustum of a cone 40 mm plus or minus 3mm diameter at the top, 90 mm plus or minus 3mm diameter at the bottom and 75 mm plus or minus 3 mm high. The metal shall be at least 900 micron thick.
e) Container, of sufficient size to contain the sample covered in water and to permit vigorous agitation without any loss of material or water.
f) 75 micron test sieve and a nesting sieve to protect the 75 micron sieve, e.g. a 1.18mm sieve.
g) A metal tamper, of 340 g plus or minus 15 g and having a flat circular tamping face 25 mm plus or minus in 3mm diameter.
h) A plain glass funnel (optional)
i) A wide-mouthed glass vessel, Figure 7.4.1.

7.4.4 Preparation of test specimen

a) A sample of about 1 kg for material having a nominal size 10mm to 5mm inclusive, or about 500 g if finer than 5mm, shall be used. A duplicate sample is also required.
Figure 7.4.1  Section of a pycnometer made from a preserving jar
b) The sample shall be thoroughly washed to remove material passing the 75 micron sieve as follows:

i) Place the sample in the container and add enough water to it to cover it. Agitate vigorously the contents of the container and immediately pour the wash water over the test sieves, which have previously been wetted on both sides and arranged with the coarser test sieve to top.

ii) The agitation shall be sufficiently vigorous to result in the complete separation from the coarse particles of all particles finer than the 75 micron sieve, and to bring the fine material into suspension in order that it will be removed by decantation of the wash water. Avoid, as far as possible, decantation of coarse material. Repeat the operation until the wash water appears to be clean. Return all material retained in the sieves to the washed sample.

7.4.5 Fine Aggregate Density and Absorption Test

7.4.5.1 Procedure using the pycnometer

a) Transfer the washed aggregate to the tray and add further water to ensure that the sample is completely immersed. Soon after immersion, remove bubbles of entrapped air by gentle agitation with a rod.

b) Keep the sample immersed for 24h plus or minus 2h, the water temperature being 20°C plus or minus 5°C for at least the last 20h of immersion. Then carefully drain the water from the sample through the 75 micron sieve, covered by the protective coarser sieve, any material retained being returned to the sample.

c) Expose the aggregate to a gentle current of warm air to evaporate surface moisture and stir it at frequent intervals to ensure case of material finer than 5mm, it just attains a “free-running” condition. Refer Note 1 and to Figure 7.4.2 Weigh the saturated and surface-dried sample, Mass (A). If the apparent density only is required, the draining and drying operations described above may be omitted, although for material finer than 5mm some surface drying is desirable to facilitate handling.

d) Place the aggregate in the pycnometer and fill the pycnometer with water. Screw the cone into place and eliminate any entrapped air by rotating the pycnometer on its side. Top up the pycnometer with water to remove any forth form the surface and so that the surface of the water in the hole is flat. Dry the pycnometer on the outside and weight it. Mass (B)

e) Empty the contents of the pycnometer into a tray ensuring that all the aggregate is transferred. Refill the pycnometer with water to the same level as before, dry the outside of it and weight it. Mass (C).

f) Carefully drain the water from the sample by decantation through the 75 micron test sieve and return any material retained to the sample. Place the sample in the tray, in the oven at a temperature of 105 C plus or minus 5 C for 24h plus or minus 0.5h, during which period it shall be stirred occasionally to facilitate drying. Cool to room temperature and weigh it, Mass (D).

Note 1. The “free-running” or “saturated surface-dry” condition of the fine aggregate is sometimes difficult to identify and in order to help in identification, two alternative methods are suggested for possible aids.

Method 1

After drying the sample with a stream of warm air allow it to cool to room temperature whilst thoroughly stirring it. Hold the mould with its larger diameter face downwards on a smooth non-absorbent level surface. Fill the mould loosely with part of the sample and lightly tamp 25 times through the hole at the top of the mould with the prescribed tamper. Do not refill the space left after tamping. Gently
Figure 7.4.2 Estimation of free-running condition of fine aggregate

a) Aggregate moist; almost retains complete shape of metal mould

b) Aggregate slightly moist; appreciable slump observed

c) Aggregate saturated surface-dry; almost complete collapse but definite peak still visible and slopes are angular

d) Aggregate nearly oven dry; no distinct peak, surface outline close to being curvilinear

NOTE: These sketches are not to scale and are for reference purposes only.
lift the mould clear of the aggregate and compare the moulded shape with the figure in 7.4.2. If the shape resembles figure a) or b), there is still surface moisture present. Dry the sample further and repeat the test. If the shape resembles figure c), a condition close to the saturated surface-dry has been achieved. If the shape resembles figure d), the aggregate has dried beyond the saturated surface-dry and is approaching the oven-dry condition. In this case, reject the sample and repeat the test on a fresh sample.

**Method 2**

As an alternative to method 1, a dry glass funnel may be used to help determine the “free-running” condition of aggregate finer than 5mm. With the funnel inverted over the sample tray pour some of the sample over the sloping sides by means of a small scoop. If still damp, particles of the aggregate will adhere to the sides of the funnel. Continue drying until subsequent pouring shows no sign of particles sticking to the glass.

**7.4.5.2 Procedure using the wide-mouthed glass vessel.** The procedure shall be the same as with the procedure using the pycnometer except that in filling the jar with water it shall be filled just to overflowing and the glass plate slid over it to exclude any air bubbles.

**7.4.5.3 Calculations**

**a) Particle density**

(i) The particle density on an oven-dried basis in (Mg/m$^3$) is calculated from the following expression.

\[ \frac{D}{A - (B - C)} \]

(ii) The particle density on a saturated and surface-dry condition in (Mg/m$^3$) is calculated from the following expression.

\[ \frac{A}{A - (B - C)} \]

(iii) The Apparent particle density in (Mg/m$^3$) is calculated from the following expression.

\[ \frac{D}{D - (B - C)} \]

**b) Water absorption**

The water absorption (as percentage of dry mass) is calculated from the following expression.

\[ 100 \frac{(A - D)}{D} \]

Where,

- **A** is the mass of saturated surface-dry sample in air, g.
- **B** is the mass of pycnometers or wide-mouthed glass vessel containing sample filled with water, g.
- **C** is the mass of pycnometers or wide-mouthed glass vessel filled with water only, g.
- **D** is the mass of oven-dried sample in air, g.

A data sheet is given as Form 7.4.1.
## Chapter 7 Standard Test Procedures

### Tests For Aggregates And Bricks

#### Form 7.4.1

**ABSORPTION AND DENSITY OF FINE AGGREGATE**

<table>
<thead>
<tr>
<th>Name of testing agent</th>
<th>Client</th>
<th>Contractor's name</th>
<th>Contract</th>
<th>Description of material</th>
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<tr>
<td>BRRL, Mirpur</td>
<td>The Engineers Ltd., Dhaka</td>
<td>The Engineers Ltd., Dhaka</td>
<td>Feni-Chaka Highway Ch. 0+000 - 18+300</td>
<td>Natural Sand</td>
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<table>
<thead>
<tr>
<th>Sample number</th>
<th>Weight of oven dry sample</th>
<th>Weight of sample on SSD basis</th>
<th>Weight of pycnometer + sample + water</th>
<th>Weight of pycnometer + water</th>
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<td>BRRL - D/F - 5-0023</td>
<td>400.89</td>
<td>410.99</td>
<td>2410.39</td>
<td>2151.29</td>
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</tbody>
</table>

1. DENSITY (OVEN-DRY BASIS) = D / (A - (B - C))

   \[ \text{Density (Oven-Dry Basis)} = \frac{D}{A - (B - C)} \]

   \[ \text{Density (Oven-Dry Basis)} = 2.64 \]

2. DENSITY SATURATED SURFACE - DRY = A / (A - (B - C))

   \[ \text{Density (Saturated Surface - Dry)} = \frac{A}{A - (B - C)} \]

   \[ \text{Density (Saturated Surface - Dry)} = 2.7 \]

3. APPARENT DENSITY = D / (D - (B - C))

   \[ \text{Apparent Density} = \frac{D}{D - (B - C)} \]

   \[ \text{Apparent Density} = 2.83 \]

4. WATER ABSORPTION = 100 x (A - D) / D

   \[ \text{Water Absorption} = 100 \times \frac{A - D}{D} \]

   \[ \text{Water Absorption} = 3\% \]

<table>
<thead>
<tr>
<th>Date sampled</th>
<th>Date tested</th>
<th>Name and designation of tester</th>
<th>Signature</th>
</tr>
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<td>29/6/96</td>
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