7.7 Aggregate Crushing Value and 10% Fines Value

7.7.1 Aggregate Crushing Value (ACV)

7.7.1.1 Introduction. One of the requirements, for the suitability of aggregates for construction, is the ability of the aggregate to resist crushing. The Aggregate Crushing Value gives a relative measure of the resistance of the aggregate to crushing under a gradually applied compressive load.

7.7.1.2 Scope. The particular purpose which an aggregate is meant to serve requires the aggregate to have a particular strength. This strength is usually stated in the specification. This test provides a method for measuring this strength. This method is not suitable for testing aggregates with a crushing value higher than 30, and in this case the ten percent fines value is recommended.

7.7.1.3 Method outline. A test specimen, of chosen fractions, is compacted in a standardised manner, into a steel cylinder fitted with a freely moving plunger. The specimen is then subjected to a standard loading regime applied through the plunger. This action crushes the aggregate to a degree which is dependent on the aggregate's crushing resistance. This degree is assessed by a sieving test on the crushed specimen and is taken as the Aggregate Crushing Value.

7.7.1.4 Sampling. The sample used for this test shall be taken in accordance with Chapter 2.

7.7.1.5 Equipment

   a) Steel cylinder, open-ended, of nominal 150mm internal diameter with plunger and base-plate of the general form and dimensions shown in Figure 7.7.1 and given in Table 7.7.1. The surface in contact with the aggregate shall be machined and case hardened, and shall be maintained in a smooth condition.

Table 7.7.1 Principal dimensions of cylinder and plunger apparatus

<table>
<thead>
<tr>
<th>Component</th>
<th>Dimensions</th>
<th>Nominal 150 mm internal diameter of cylinder, mm</th>
<th>Nominal 75 mm internal diameter of cylinder, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder</td>
<td>Internal diameter, A</td>
<td>154±0.5 mm</td>
<td>78±0.5 mm</td>
</tr>
<tr>
<td></td>
<td>Internal diameter, B</td>
<td>125 to 140 mm</td>
<td>70.0 to 85.0 mm</td>
</tr>
<tr>
<td></td>
<td>Minimum wall thickness, C</td>
<td>16.0 mm</td>
<td>8.0 mm</td>
</tr>
<tr>
<td>Plunger</td>
<td>Diameter of piston, D</td>
<td>152±0.5 mm</td>
<td>76.0±0.5 mm</td>
</tr>
<tr>
<td></td>
<td>Diameter of stem, E</td>
<td>&gt;95 to = or &lt;D</td>
<td>&gt;45.0 to = or &lt;D</td>
</tr>
<tr>
<td></td>
<td>Overall length of piston plus stem, F</td>
<td>100 to 115 mm</td>
<td>60.0 to 80.0 mm</td>
</tr>
<tr>
<td></td>
<td>Minimum depth of piston, G</td>
<td>Not less than 25.0</td>
<td>Not less than 19.0</td>
</tr>
<tr>
<td></td>
<td>Diameter of hole, H</td>
<td>20.0±0.1 mm</td>
<td>10.0±0.1 mm</td>
</tr>
<tr>
<td>Base-plate</td>
<td>Minimum thickness, I</td>
<td>10 mm</td>
<td>10 mm</td>
</tr>
<tr>
<td></td>
<td>Length of each side of square, J</td>
<td>200 to 230 mm</td>
<td>110 to 115 mm</td>
</tr>
</tbody>
</table>

b) A cylindrical metal measure, of sufficient rigidity to retain its form under rough usage and with an internal diameter of 115 mm plus or minus 1 mm and an internal depth of 180 mm plus or minus 1 mm.

c) A tamping rod, made out of straight iron or steel bar of circular cross section. 16 mm plus or minus 1 mm diameter and 600 mm plus or minus 5 mm long, with both ends hemispherical.

d) A balance, of capacity not less than 3 kg and accurate to 1 g.
Figure 7.7.1 Outline form of cylinder and plunger apparatus for the aggregate crushing value and ten percent fines test

e) A ventilated oven, thermostatically controlled at a temperature of 105°C plus or minus 5°C.
f) A rubber mallet, a metal tray of known mass and large enough to contain 3 kg of aggregate and a brush with stiff bristles.
g) Square-hole perforated plate test sieves, of sizes 14.0 mm and 10.0 mm and an ovenware 2.36 mm test sieve.
h) A compression testing machine, capable of applying any force up to 400 kN at a uniform rate of loading so that the force is reached in 10 min.

7.7.1.6 Preparation of test portions and specimens

a) Test portions. Reduce laboratory samples to test portions of sufficient mass to produce 3 specimens of 14 mm to 10 mm size fractions.
b) Sieve the entire dried test portion on the 14 mm and the 10 mm test sieve to remove the oversize and undersize fraction. Divide the resulting 14 mm to 10 mm size
fractions to produce 3 test specimens each of sufficient mass that the depth of the material in the cylinder is approximately 100 mm after tamping.

c)  Dry the test specimens by heating at a temperature of $105^\circ C$ plus or minus $5^\circ C$ for a period of not more than 4 h. Cool to room temperature and record the mass of the material comprising the test specimen.

Table 7.7.2  Guide to minimum mass of test portions required to obtain a suitable mass of material to determine the Aggregate Crushing Value.

<table>
<thead>
<tr>
<th>Grade of the aggregate</th>
<th>Minimum mass of test portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-in aggregate 40 mm max. size</td>
<td>60 kg</td>
</tr>
<tr>
<td>All-in aggregate 20 mm max. size</td>
<td>45 kg</td>
</tr>
<tr>
<td>Graded aggregate 40 to 5 mm</td>
<td>40 kg</td>
</tr>
<tr>
<td>Graded aggregate 20 to 5 mm</td>
<td>25 kg</td>
</tr>
<tr>
<td>Graded aggregate 14 to 5 mm</td>
<td>15 kg</td>
</tr>
</tbody>
</table>

7.7.1.7  Procedure

a)  Place the cylinder of the test apparatus in position on the base-plate and add the test specimen in three layers of approximately equal depth, each layer being compacted to 25 strokes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface. Ensure that the plunger is free to move.

b)  Place the apparatus, with the test specimen prepared as described in 7.7.1.6(c) and plunger in position, between the platens of the testing machine and load it as uniform a rate as possible so that the required force of 400 kN is reached in 10 min plus or minus 30 s.

c)  Release the load and remove the crushed aggregate by holding the cylinder over a clean tray of known mass and hammering on the outside with the rubber mallet until the crushed aggregate falls freely on to the tray. Transfer fine particle adhering to the inside of the cylinder and to the surface of the hammer to the tray by means of the stiff bristle brush. Weight the tray and the aggregate and record the mass of the aggregate to the nearest 1g ($M_1$).

d)  Sieve the whole of the specimen on the 2.36mm test sieve until no further significant amount passes during a further period of 1 min. Weight and record the mass of the fractions passing and retained on the sieve to the nearest 1g ($M_2$ and $M_3$) respectively and if the total mass ($M_2 + M_3$) differs from the initial mass ($M_1$) by more than 10g, discard the result and test a further specimen.

e)  Repeat the procedure from (a) to (b) above inclusive using a second specimen of the same mass as the first specimen.

7.7.1.8  Calculation and expression of result. Calculate the Aggregate Crushing Value (ACV) expressed as a percentage to the first decimal place, of the mass of fines formed to the total mass of the test specimen from the following expression.

$$ (ACV) = 100 \times \frac{M_2}{M_1} $$

Where,

$M_1$ is the mass of the test specimen in grammes.

$M_2$ is the mass of the material passing the 2.36mm test sieve in grammes.
7.7.1.9 **Results.** Calculate the mean of the two values determined to the nearest whole number. Report the mean as the Aggregate Crushing Value, unless the individual results differ by more than 0.07 times the mean value. In this case repeat the test on two further specimens, calculate the median of the four results to the nearest whole number and report the median as the Aggregate Crushing Value.

A data sheet is given as Form 7.7.1.

7.7.2 **10% Fines Value Test**

7.7.2.1 **Scope.** The particular purpose which an aggregate is meant to serve requires the aggregate to have a particular strength. This strength is usually stated in the specification. This test provides a method for measuring this strength. This method is suitable for testing both strong and weak aggregate passing a 14.0 mm test sieve and retained on a 10.0 mm test sieve.

7.7.2.2 **Method outline.** A test specimen, of chosen fractions, is compacted in a standardised manner, into a steel cylinder fitted with a freely moving plunger. The specimen is then subjected to a standard loading regime applied through the plunger. The action crushes the aggregate to a degree which is dependent on the aggregate’s crushing resistance. This degree is assessed by a sieving test on the crushed specimen. The procedure is repeated with various loads to determine the maximum force which generates a given sieve analysis. This force is taken as the ten percent fines value (TFV).

7.7.2.3 **Sampling.** The sample used for this test shall be taken in accordance with Chapter 2.

7.7.2.4 **Equipment.** The equipment required for this test is identical to the equipment required for the ACV test as described in 7.7.1.5.

a) Additional equipment for testing aggregate in a soaked condition.

b) Drying cloths or absorbent paper, for the surface drying of the aggregate.

c) One or more wire-mesh baskets, with apertures greater than 6.5 mm.

d) A stout watertight container in which the basket may be immersed.

7.7.2.5 **Preparation of test portions and specimens**

a) **Test portions**

Reduce laboratory samples to test portions of sufficient mass to produce 3 specimens of 14 mm to 10mm size fraction.

Use Table 7.7.1 for a guide to the minimum mass of test portion required to obtain a mass of material to determine the aggregate 10% fines value.

b) **Test specimen in a dry condition**

(i) Sieve the entire dried test portion on the 14 mm and the 10 mm test sieve to remove the oversize and undersize fraction. Divide the resulting 14 mm to 10 mm size fractions to produce 3 test specimens each of sufficient mass such that the depth of the material in the cylinder is approximately 100 mm after tamping.

(ii) Dry the test specimens by heating at a temperature of 105°C plus or minus 5°C for a period of not more than 4 h. Cool to room temperature before testing. Record the mass of the material comprising the test specimen.
c) Test specimens in a soaked condition

(i) Prepare the test portion as in 7.7.1.6(b) except that the test portion is tested in the as-received condition and not oven-dried. Place test specimen in a wire basket and immerse it in the water in the container with a cover at least 50 mm of water above the top of the basket. Remove entrapped air by lifting the basket 25 mm above the base of the container and allowing it to drop 25 times at a rate of approximately once per second. Keep the aggregate completely immersed in water at all times and for the next 24 h plus or minus 2 h and maintain the water temperature at 20°C plus or minus 5°C.

(ii) After soaking, remove from the water and blot the free water from the surface using the absorbent cloths. Carry out the test procedure immediately after this operation.

7.7.2.6 Procedure: Aggregates in dry condition

a) Place the cylinder of the test apparatus in position on the base-plate and add the test specimen in three layers of approximately equal depth, each layer being compacted to 25 strokes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface. Ensure that the plunger is free to move.

b) Place the apparatus, with the test specimen and plunger in position, between the platens of the testing machine and load it as uniform a rate as possible so as to cause a total penetration of the plunger in 10 min plus or minus 30 s of approximately:

(i) 15 mm for rounded or partially rounded aggregates (uncrushed gravels).
(ii) 20 mm for normal crushed aggregate.
(iii) 24 mm for vesicular (honeycombed) aggregates.

c) Record the force (f) applied to produce the required penetration. Release the load and remove the crushed aggregate by holding the cylinder over a clean tray of known mass and hammering on the outside with the rubber mallet until the crushed aggregate falls freely on to the tray. Transfer fine particle adhering to the inside of the cylinder and to the surface of the hammer to the tray by means of the stiff bristle brush. Weigh the tray and the aggregate and record the mass of the aggregate used to the nearest 1 g ($M_1$).

d) Sieve the whole of the specimen on the 2.36 mm test sieve until no further significant amount passes during a further period of 1 min. Weigh and record the mass of the fractions passing and retained on the sieve to the nearest 1 g ($M_2$ and $M_3$) respectively and if the total mass ($M_2 + M_3$) differs from the initial mass ($M_1$) by more than 10 g, discard the result and test a further specimen.

If the percentage of the material (m) passing the sieve, calculated from the expression: $M = 100 \times \frac{M_2}{M_1}$ does not fall within the range 7.5% and 12.5%, test a further specimen, using an adjusted maximum test loading to bring the percentage of fines within the range and record the value of (m) obtained.

e) Repeat the complete test procedure with the same mass of aggregate at the same force that gives percentage fines value within the range 7.5% and 12.5%.

7.7.2.7 Procedure; aggregates in a soaked condition

a) Follow the procedure described in 7.7.2.6(a) except that after the crushed specimen has been removed from the cylinder, dry it in the oven at a temperature
of 105°C plus or minus 5°C either to constant weight or for a minimum of 12 h. Allow the dried material to cool and weigh to the nearest 1 g \( (M_1) \). Complete the procedure 7.7.2.6(d) and 7.7.2.6(e).

### 7.7.2.8 Calculation and expression of result

a) Calculate the force \( F \) (in kN), to the nearest whole number, required to produce 10% fines for each test specimen, with the percentage of material passing in the range of 7.5% to 12.5%, from the following expression:

\[
F = \frac{14 \ f}{m + 4}
\]

Where,
- \( f \) is the maximum force in kN.
- \( m \) is the percentage of material passing the 2.36 mm test sieve at the maximum force.

b) Calculate the mean of the two results to the nearest 10 kN or more or to the nearest 5 kN for forces of less than 100 kN. Report the mean as the aggregate 10% fines value, unless the individual results differ by more than 10 kN or by more than 0.1 times the mean value. In this case repeat the test on two further specimens, calculate the median of the four results to the nearest whole number and report the median as the aggregate 10% fines value.

A data sheet is given as Form 7.7.1.
### AGGREGATE CRUSHING VALUE

**10% FINES VALUE**

<table>
<thead>
<tr>
<th>Name of testing agent</th>
<th>Client</th>
<th>Contractor's name</th>
<th>Contract</th>
<th>Date of sample</th>
</tr>
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<tbody>
<tr>
<td>BRRL</td>
<td>RRMP-II</td>
<td>Unknown</td>
<td>Traning</td>
<td>01/05/2000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Load kN.</th>
<th>Weight of test specimen M₁ g</th>
<th>Weight passing 2.36mm test sieve M₂ g</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>400</td>
<td>2834</td>
<td>546</td>
</tr>
</tbody>
</table>

\[
\text{ACV} = \frac{M₂}{M₁} \times 100 = 18.3\%
\]

### 10% FINES VALUE

<table>
<thead>
<tr>
<th>Wt. Of Sample in gms</th>
<th>Wt. Of Passing 2.36mm Sieve</th>
<th>Crushing % (A)</th>
<th>Force f kN</th>
<th>( F = \frac{14f}{(m+4)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2783</td>
<td>223</td>
<td>8.01</td>
<td>160</td>
<td>( \frac{14 \times 160}{8.01 + 4} = 187 \text{ kN} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name and designation of tester</th>
<th>Date tested</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Md. Jahangir Alam, ARO</td>
<td>02/05/2000</td>
<td></td>
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</tbody>
</table>