1. Scope
This method is used in conjunction with the relevant field density and laboratory compaction test methods to determine, for 6 tests per lot, as appropriate to test lots of materials and soils for earthworks and pavements (including asphalt and concrete in pavements):

- the mean and standard deviation of the density ratio, moisture variation and moisture ratio, and in-situ air voids ratio; and
- the characteristic density ratio (CDR) and characteristic moisture ratio (CMR), and characteristic percentage in-situ air voids (CAV).

The method is also used for 3 tests per lot, to determine mean values for density ratio and moisture ratio, and for in-situ air voids if appropriate.

The method also provides actions when some test sites exceed the permitted amount of 40 mm nominal size material, or when the core thickness is less than the minimum.

2. Procedure

2.1. Material Record
Record material source, placed location and nominal size.

2.2. Test Lot Bounds
The test lot must contain only areas which are essentially homogeneous. This occurs when material type, general appearance, test rolling response, moisture condition during compaction, compaction technique and nature of underlying materials are substantially alike. Areas which fail to meet these conditions must be excluded from the lot but may be tested independently, as a separate lot.

Areas within 200 mm of the edges of construction or within 5 metres of lateral construction joints shall be excluded from the lot.

In the case of trenches, areas within 200 mm of the long edge and within 2 metres of the end of the trench shall be excluded from the lot.

Soils and pavement materials which do not appear essentially homogeneous and are not uniform in terms of maximum particle size and particle size distribution may be included provided that materials are of similar origin and type; and laboratory compaction tests are performed on material from each field density site.

2.3. Selection of a Lot
The boundaries of the lot must be defined. Any areas to be excluded from the lot on the basis of appearance or test-rolling response are to be designated prior to the selection of sites.

2.4. Selection of Test Sites within a Lot
Select the required number (n = 3 or 6, as appropriate to lot size) of randomly located test sites within the test lot in accordance with RC 316.10, or AS 1289.1.4.2.

Normal lots, with 6 tests per lot, have a maximum allowed area defined in the appropriate standard specification section. Acceptance of the lot shall be based on the characteristic density ratio and characteristic moisture ratio, and characteristic percentage in-situ air voids, as appropriate, determined from 6 individual tests per lot.

Any lot which has a surface area less than 500 m² may be treated as a small area. Acceptance of the lot shall be based on the mean values of density ratio and moisture ratio, or percentage air voids for 3 individual tests (Refer VicRoads Standard Specification Section 173, Clause 173.04(d)).

For earthworks and pavement construction, 3 tests per lot shall be used for Compaction Scale C.

2.5. At each test site for:
(a) Earthworks and pavement materials: (except materials covered by (b) and (c))

Either:
(i) Determine the dry density ratio ($R_D$), moisture variation ($w$) and moisture ratio ($R_m$) in accordance with AS 1289.5.4.1, or
(ii) Determine the Hilf wet density ratio ($R_{HD}$), and moisture variation ($w_V$) in accordance with AS 1289.5.7.1.

Record the appropriate values to the nearest 0.1 %.
(b) Pavement materials stabilised with cementitious binders in-situ:
In addition to steps (a) (i) and (ii) above, undertake the following:
(i) Record the type, date and time of addition of cementitious binder used in the field;
(ii) Record the time and date of completion of Laboratory Compaction;
(iii) Calculate the elapsed time between step (i) and step (ii);
(iv) Determine the density decay factor (DDCF) corresponding to the elapsed time (t), either in accordance with RC 330.03, or from the table provided in VicRoads Standard Specification Section 307;
(v) Multiply the density ratio (RD) by the density decay correction factor determined in step (iv);
(vi) Record the value calculated to the nearest 0.1 %
(vii) Use the calculated value determined in step (vi) as the density ratio for the site.

(c) Asphalt:
Determine the density ratio (DR) and the percentage in-situ air voids in accordance with AS 2891.14.5. Record these values to the nearest 0.1 %.
The reference density to be used for asphalt testing shall be the assigned maximum density of the asphalt calculated as the 6 point rolling average maximum density of the production mix, in accordance with AS 2891.14.5, Appendix A, Item (e), except that 6 samples shall be used.

3. Calculations
Calculate the following values as required, as detailed in Table 1 and as appropriate either for 6 tests per lot (all steps, and n=6), or for 3 tests per lot (steps (a), (d), (f), (i) only, and n = 3). Note that specific symbols for density ratio (see Table 2) and that specific steps are relevant either to test results from AS 1289.5.4.1, AS 1289.5.7.1, or both, or to AS 2891.14.5, as appropriate.

All calculated values are in percent. Rounding of values to the nominated precision shall occur at reporting.

3.1. From density tests for the lot, calculate as appropriate:

<table>
<thead>
<tr>
<th>Table 1 - Calculation and reporting test values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tests (n) within oversize material requirements</td>
</tr>
<tr>
<td>For 6 test-site lot</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>5, or 4</td>
</tr>
<tr>
<td>Note (a) applies</td>
</tr>
<tr>
<td>3 or less, Note (b) applies</td>
</tr>
<tr>
<td>For 3 test-site lot</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>2 or less, Note (b) applies</td>
</tr>
</tbody>
</table>

The test report shall include one of the following statements, if appropriate:

Note (a) Insufficient test results are available to calculate characteristic values
Note (b) Insufficient test results are available to calculate mean values

Note 1: For small areas and Compaction Scale C, only mean density ratio is required; and when applicable, only mean moisture ratio or mean moisture variation is required.

Note 2: On occasions, some test lots deliver insufficient test results, either due to the presence of excessive material of nominal size greater than 40 mm (VicRoads Section 173.04), or core thickness less than the minimum (VicRoads Section 407.22).

Where this occurs, the modifications detailed in Table 1 to the calculation of lot characteristics shall apply, as appropriate, and the relevant statement (Note (a) or Note (b) of Table 1) shall be included on the test report.

<table>
<thead>
<tr>
<th>Table 2 - Equations and symbols for density ratio calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>From tests to AS 1289.5.4.1</td>
</tr>
<tr>
<td>(a) The mean density ratio of the test lot (n sites), for:</td>
</tr>
<tr>
<td>$R_D = \frac{\sum R_D}{n}$ or</td>
</tr>
<tr>
<td>(b) The standard deviation of the density ratio ($S_{DR}$) of the test lot (n = 6 sites):</td>
</tr>
<tr>
<td>$S_{DR} = \sqrt{\frac{\left(\bar{R}<em>{D} - R</em>{D}\right)^2}{5}}$</td>
</tr>
<tr>
<td>(c) The characteristic density ratio (CDR) of the test lot (n = 6 sites) below which a nominated percentage (20%) of the lot falls:</td>
</tr>
<tr>
<td>$CDR = \frac{\bar{R}<em>{D} - 0.92 \cdot S</em>{DR}}{R_{D}}$</td>
</tr>
<tr>
<td>where:</td>
</tr>
<tr>
<td>$S_{DR} = \text{the standard deviation for density ratio (n = 6)}$</td>
</tr>
<tr>
<td>$\bar{R}<em>{D}$, $\bar{R}</em>{HD}$, $MDR$ = the mean density ratio of the test lot, in percent, as appropriate to material tested</td>
</tr>
<tr>
<td>$\sum R_D$, $\sum R_{HD}$, $\sum DR$ = the sum of the dry density ratio values ($R_D$), or Hilf wet density ratio values ($R_{HD}$), or density ratio values for asphalt (DR), for n test sites.</td>
</tr>
</tbody>
</table>
3.2. From moisture variation tests

Calculate as appropriate for the lot:

(d) The mean value of the moisture variation ($w_V$) of the test lot ($n$ sites):

$$w_V = \frac{\sum w}{n}, \text{ or } w_V = \frac{\sum w_V}{n}$$

where $\sum w = \text{the sum of the moisture variation values, } (w) \text{ obtained using AS 1289.5.4.1, for } n \text{ test sites.}$

$\sum w_V = \text{the sum of the moisture variation values, } (w_V) \text{ obtained using AS 1289.5.7.1, for } n \text{ test sites.}$

(e) When applicable, the standard deviation of the moisture variation ($S_{wV}$) of the test lot ($n = 6$ sites):

$$S_{wV} = \sqrt{\frac{\sum (w_V - w)^2}{n}}$$

3.3. From tests to AS 1289.5.4.1

Calculate as appropriate for the lot:

(f) The mean moisture ratio ($R_m$) of the test lot ($n$ sites):

$$R_m = \frac{\sum R_m}{n}$$

where $\sum R_m = \text{the sum of the moisture ratio values, } (R_m) \text{ for } n \text{ test sites.}$

(g) The standard deviation of the moisture ratio ($S_{MR}$) of the test lot ($n = 6$ sites):

$$S_{MR} = \sqrt{\frac{\sum (R_m - R_m)^2}{n}}$$

(h) The characteristic moisture ratio ($CMR$) of the test lot ($n = 6$ sites), below which a nominated percentage (20%) of the lot falls:

$$CMR = R_m - 0.92 \cdot S_{MR}$$

3.4. From tests to AS 2891.14.5

Calculate as appropriate for the lot:

(i) The mean percentage in-situ air voids ($AV$) of the test lot ($n$ sites):

$$AV = \frac{\sum AV}{n}$$

where $\sum AV = \text{the sum of the percentage in-situ air voids, } (AV) \text{ for } n \text{ test sites.}$

(j) The standard deviation of the percentage in-situ air voids ($S_{AV}$) of the test lot ($n = 6$ sites):

$$S_{AV} = \sqrt{\frac{\sum (AV - AV)^2}{n}}$$

(k) The characteristic percentage in-situ air voids ($CAV$) of the test lot ($n = 6$ sites), below which a nominated percentage (20%) of the lot falls:

$$CAV = \frac{AV}{AV} - 0.92 \cdot S_{AV}$$

4. Reporting

4.1. Report, for all testing, as appropriate:

(a) The type, source, placed location and nominal size of the material.

(b) The location of the test sites in relation to site chainages and offsets from the centreline(s).

(c) Compactive effort, appropriate to the test method, used to obtain laboratory reference values for soils.

(d) As applicable, the report number for the reference values, the assigned values, or the asphalt mix design bulk density.

(e) The test methods used to determine laboratory reference values and field density and moisture content values.

(f) Those parameters and values required by either AS 1289.5.4.1, AS 1289.5.7.1 or AS 2891.14.5 and referred methods, including reference values and test site values.

(g) If applicable, the method of preparation of the sample for laboratory determination of reference values if the soil is stabilised.

(h) The mean density ratio of the test lot, in percent, to the nearest 0.1.

(i) For normal lots, the standard deviation of the density ratio, and the characteristic density ratio, of the test lot, in percent, to the nearest 0.1.

(j) Reference to this Test Method (RC 316.00).

4.2. Report, when applicable:

(a) The mean moisture variation, mean moisture ratio, and mean percentage in-situ air voids of the test lot, in percent, to the nearest 0.1.

(b) For normal lots, the standard deviation of the moisture ratio, the standard deviation of the percentage in-situ air voids the characteristic moisture ratio, and the characteristic percentage in-situ air voids, in percent, to the nearest 0.1.

(c) If and when applicable, a statement that characteristic values, or mean values when appropriate, cannot be determined (Refer Table 1, Note (a) or Note (b) for text).
### VicRoads Test Method - Revision Summary

**RC 316.00 – Density Ratio and Moisture Ratio - Lot Characteristics**

<table>
<thead>
<tr>
<th>Date</th>
<th>Clause</th>
<th>Description of Revision</th>
<th>Authorised by</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2016</td>
<td>1</td>
<td>Scope aligned with Sections 173, 204, 304, 407 and to also include asphalt and concrete pavement lots. Aligned to Section 173 for samples containing oversize material or cores below minimum thickness</td>
<td>Manager - Construction Materials</td>
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<tr>
<td></td>
<td>2.4</td>
<td>Re-titled, paras re-ordered &amp; revised and air voids included</td>
<td></td>
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<tr>
<td></td>
<td>2.5 (b)</td>
<td>Completion of compaction made clear</td>
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<tr>
<td></td>
<td>2.5 (c)</td>
<td>Defined reference density for asphalt</td>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td>Rounding of values moved to 4. Reporting Added Note 2 and Table 1, re insufficient tests Introduced sub-clauses for each test process Equations for HIlf and asphalt density ratio, and variants for moisture variation introduced, symbols consistent with Australian Standards.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>New clause added for air voids</td>
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<tr>
<td></td>
<td>4</td>
<td>Revised and re-ordered</td>
<td></td>
</tr>
<tr>
<td>June 2013</td>
<td>2.5(a) &amp; 4.2(d)</td>
<td>Re-worded to provide clear options Added text to include 3 test site lots (small areas)</td>
<td>Manager - Construction Materials</td>
</tr>
<tr>
<td></td>
<td>1,2,4,3, 4(note)</td>
<td></td>
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</tr>
<tr>
<td>Dec 2012</td>
<td>Full document</td>
<td>Re-styled with minor corrections made</td>
<td>Principal Advisor – Pavements &amp; Materials</td>
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