Density Ratio and Moisture Ratio – Lot Characteristics

Test Method
RC 316.00
February 2022

Abstract

The test calculates the lot characteristics for Density Ratio and Moisture Ratio result values for test lots of materials and soils for earthworks and pavements.

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 in the road bed and nominal size.

2.2 Test Lot Bounds

A test lot consists of a single layer, batch or area of like work which has been constructed or produced under essentially uniform conditions and is essentially homogeneous with respect to material type, general appearance, test rolling response, moisture condition during compaction, compaction technique and nature of underlying materials. Discrete portions of a lot which are non-homogeneous with respect to material and appearance shall be excluded from the lot and shall be either treated as separate lots, or reworked. The extent of each lot shall not exceed one day's production.

Areas within 200 mm of the edges of construction or within 2 metres of either lateral construction joints or ends of trenches, 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 m^2 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:

Report individual values as required by the referenced test method.

Un-rounded values shall be used in further calculation.

2.5.1 for earthworks and pavement materials:

(except materials covered by clauses 2.5.2 and 2.5.3)

Either:

(a) Determine the dry density ratio (R_D), moisture variation (w) and moisture ratio (R_m) in accordance with AS 1289.5.4.1 and clause 3.2, or

(b) Determine the Hilf wet density ratio (R_{HD}), and moisture variation (w_v) in accordance with AS 1289.5.7.1, and also:

  (i) determine the field moisture content in accordance with AS 1289.5.7.1, clause 4.1(h); and

  (ii) calculate optimum moisture content in accordance with the Note to AS 1289.5.7.1 clause 4.2(h); and

  (iii) calculate moisture ratio and characteristic moisture ratio in accordance with the formulae in clause 3.3.

2.5.2 for earthworks or pavement materials stabilised with cementitious binders in-situ:

The following procedure shall be used to determine the Density Ratio (DR or R_D) for each test site for earthworks or pavement materials stabilised with cementitious binders in-situ:

Note 1: VicRoads Sections 290 and 307 use DR for Density Ratio, the relevant Australian Standards for the tests use R_D for Density Ratio.

Note 2: The density decay correction factor will need to be determined through one of the options described in RC 330.04 prior to testing commencing.

Determine DR or R_D for each test site in accordance with the procedure of RC 330.04. For some situations, use of RC 330.03 is also required.

2.5.3 for asphalt:

Determine the density ratio (*DR*) and the percentage in-situ air voids in accordance with AS 2891.14.5.

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 apply for density ratio (see Table 2) and that specific steps are relevant to test results either from AS 1289.5.4.1, AS 1289.5.7.1, or both, or from AS 2891.14.5, as appropriate.

All calculated values are in percent. Un-rounded calculated values shall be used in further calculations. Rounding of values to the nominated precision shall occur at reporting.

Table 1 - Calculation and reporting test values	
Number of tests (n) within oversize material requirements	Calculate and Report (as appropriate to material)
For 6 test-site lot	
6	CDR, CMR, CAV; and mean values and standard deviations
5, or 4 Note (a) applies	Mean density ratio, Mean moisture ratio, Mean moisture variation, Mean air voids ratio
3 or less, Note (b) applies	All individual values only
For 3 test-site lot	
3	Mean density ratio, Mean moisture ratio, Mean moisture variation, Mean air voids ratio
2 or less, Note (b) applies	All individual values only
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.*

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

Table 2 - Equations and symbols for density ratio calculations

From tests to AS 1289.5.4.1	From tests to AS 1289.5.7.1	From tests to AS 2891.14.5

(a) The mean density ratio of the test lot (n sites), using as applicable:

$$\overline{R_D} = \sum R_D \big/ n \qquad \text{or} \qquad \overline{R_{HD}} = \sum R_{HD} \big/ n \qquad \text{or} \qquad MDR = \sum DR \big/ n$$

(b) The standard deviation of the density ratio (S_{DR}) of the test lot ($n = 6$ sites), using as applicable:

$$S_{DR} = \sqrt{\frac{\sum (\overline{R_D} - R_D)^2}{5}} \quad \text{or} \quad S_{DR} = \sqrt{\frac{\sum (\overline{R_{HD}} - R_{HD})^2}{5}} \quad \text{or} \quad S_{DR} = \sqrt{\frac{\sum (MDR - DR)^2}{5}}$$

(c) The characteristic density ratio (CDR) of the test lot ($n = 6$ sites), below which a nominated percentage (20%) of the lot falls, using as applicable:

$$CDR = \overline{R_D} - 0.92 \times S_{DR} \quad \text{or} \quad CDR = \overline{R_{HD}} - 0.92 \times S_{DR} \quad \text{or} \quad CDR = MDR - 0.92 \times S_{DR}$$

where:

S_{DR}	=	the standard deviation for density ratio ($n = 6$)
$\overline{R_D}, \overline{R_{HD}}, MDR$	=	the mean density ratio of the test lot, in percent, as appropriate to material tested
$\sum R_D, \sum R_{HD}, \sum DR$	=	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.

3.2 From tests to AS 1289.5.4.1

Calculate as appropriate for the lot:

(d) The mean value of the moisture variation ($\overline{w_v}$) of the test lot (n sites):

$$\overline{w_v} = \sum w \big/ n$$

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

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

$$S_{WV} = \sqrt{\frac{\sum (\overline{w_v} - w_v)^2}{5}}$$

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

$$\overline{R_m} = \sum R_m \big/ n$$

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

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

$$S_{MR} = \sqrt{\frac{\sum (\overline{R_m} - R_m)^2}{5}}$$

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

$$CMR = \overline{R_m} - 0.92 \times S_{MR}$$

3.3 From tests to AS 1289.5.7.1

Calculate as appropriate for the lot:

(i) The mean value of the moisture variation ($\overline{w_v}$) of the test lot (n sites):

$$\overline{w_v} = \sum w_v \big/ n$$

where $\sum w_v$ = the sum of the moisture variation values, (w_v) obtained using AS 1289.5.7.1, for n test sites.

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

$$S_{WV} = \sqrt{\frac{\sum (\overline{w_v} - w_v)^2}{5}}$$

(k) The field moisture content (w_f) for each test site in accordance with AS 1289.5.7.1 clause 4.1(h).

(l) The optimum moisture content (w_O) for each test site in accordance with the Note to AS 1289.5.7.1 clause 4.2 (h). When applicable, (w_O) may be adjusted for oversize, becoming (w_r).

(m) The moisture ratio (R_m) for each test site:

$$R_m = \frac{100\, w_f}{w_O} \quad \text{or} \quad R_m = \frac{100\, w_f}{w_r}$$

(n) The mean moisture ratio $(\overline{R_m})$ of the test lot (n sites):

$$\overline{R_m} = \frac{\Sigma R_m}{n}$$

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

$$S_{MR} = \sqrt{\frac{\Sigma(\overline{R_m} - R_m)^2}{5}}$$

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

$$CMR = \overline{R_m} - 0.92 \times S_{MR}$$

3.4 From tests to AS 2891.14.5

Calculate as appropriate for the lot:

(q) The mean percentage in-situ air voids ($\overline{AV}$) of the test lot (n sites):

$$\overline{AV} = \frac{\Sigma AV}{n}$$

where ΣAV = the sum of the percentage in-situ air voids, (AV), for n test sites.

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

$$S_{AV} = \sqrt{\frac{\Sigma(\overline{AV} - AV)^2}{5}}$$

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

$$CAV = \overline{AV} + (0.92 \times S_{AV})$$

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) Reporting requirements of 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:

(k) For normal lots for earthwork and pavement materials: the moisture variation and moisture ratio for each test site, the mean moisture ratio, the standard deviation of the moisture ratio, and the characteristic moisture ratio, in percent, to the nearest 0.1 %.

(l) For earthwork and pavement materials that have been stabilised with cementitious binders in-situ, the value of Density Decay Correction Factor used to determine Density Ratio as detailed in RC 330.04 and the source of this value (either Table A or B from RC 330.04 or report number for testing to RC 330.03).

(m) For normal lots for asphalt: mean percentage in-situ air voids of the test lot, the standard deviation of the percentage in-situ air voids, and the characteristic percentage in-situ air voids, in percent, to the nearest 0.1 %.

(n) Where less than 6 test sites are available, report the test values as detailed in Table 1.

(o) 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).

Department of Transport Test Method - Revision Summary

RC 316.00 – Density Ratio and Moisture Ratio - Lot Characteristics

Version	Date	Clause	Description of Revision	Authorised by
2.0	February 2022	2.5.1 (b) 2.5.2 3 3.1, Table 2 3.2 3.3 3.4(s) 4.2 4.2(l)	Set requirements for moisture ratio determination Reference to and text moved to RC 330.04 for use of DDCF Confirmed un-rounded values to be used in further calculations. Changed to "using as applicable:" Set calculations for moisture ratio for earthworks testing Adjusted moisture ratio calculations for pavement material Corrected CAV formula Re-numbered as continuation of 4.1 Adjusted to reference RC 330.04 and source of DDCF	Principal Engineer – Pavements, Geotech. & Materials
	October 2019	2.5 2.5.2 4.2 (b)	Re-numbered Re-worded to include earthworks material stabilized with cement Follows Section 290 and 307 format New text to report validating information	Manager - Construction Materials
	March 2018	2.2 2.5 2.5(a)(ii) 4.1(f) 4.2	Lot definition aligned to Section 173.02 Now 2 m from joints, trench para deleted Added: Report individual values as required by the referenced test method. Un-rounded values shall be used in further calculation. Revised to clarify moisture ratio Text revised to make clear Separated for product and new sub-clause (c)	Manager - Construction Materials
	April 2016	1 2.4 2.5 (b) 2.5 (c) 3	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 Re-titled, paras re-ordered & revised and air voids included Completion of compaction made clear Defined reference density for asphalt 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.	Manager - Construction Materials

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