Test method T162

Compaction control test (rapid method)

OCTOBER 2012

Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added appendix 2(c) altered	D. Dash	May 1999
Ed 1/Rev 0	All	Revised and reformatted. Only one method used (Compaction of independent portions). Standard or Modified compaction. Changed 'M' subscripts. Notes added and renumbered. Appendix revised.	G Donald	Nov 2007
Ed 1/Rev 1	3(a)	Mould tolerances consistent with T111.	David Hazell	Sep 2008
Ed 1/Rev 2	2(b), (g), 3(l), 5.2(c), (d), 5.3(c), 5.4(c)	Max moisture adj (Z), list of tests. Revised apparatus to dry back. Check Z, thorough mixing. Steps adjusted.	David Hazell	May 2011
Ed 2/ Rev 0	All	Reformatted RMS template	J Friedrich	October 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T162 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T162

Compaction control test (rapid method)

1. Scope

This Test Method sets out the procedure to determine the Maximum Converted Wet Density and the approximate difference between the field moisture content and the apparent Optimum Moisture Content of a road construction material.

The method uses Standard or Modified compaction on independent sub-samples having different moisture contents.

NOTE: *The method is adapted from AS 1289.5.7.1.*

2. General

(a) This method is applicable to materials passing the 37.5 mm AS sieve

(b) As this test is a rapid method curing is omitted. Therefore, the maximum moisture adjustment expressed as a percentage of wet mass (*Z*) must be within the tolerance –4%/+6% for the sample otherwise T111 must be used instead of T162

NOTE: *Larger moisture adjustments may not be uniformly distributed through the sample with this test method.*

(c) The test relates "converted" wet density and "added" moisture without the immediate need to determine the moisture content

(d) Standard compaction is to be used unless otherwise specified

(e) For material stabilised in the field, time limits may be imposed in specifications for sampling and testing

(f) This test method relies on minimal loss of moisture of the material from the time of sampling. Excessive moisture loss will result in a higher relative compaction when determined using T166

(g) The following documents are referred to in this Test Method:

(i) T105 Preparation of Samples for Testing (Soils)

(ii) T111 Dry Density/Moisture Relationship of Road Construction Materials

(iii) T120 Moisture Content of Road Construction Materials (Standard Method)

(iv) T121 Moisture Content of Road Construction Materials (Sand Bath or Hot Plate Method)

(v) T166 Relative Compaction of Road Construction Materials

(vi) T180 Moisture Content of Road Construction Materials (Microwave Oven Method)

(vii) AS 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort

(viii) AS 1289.5.2.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using modified compactive effort

3. Apparatus

(a) A cylindrical metal mould with an internal diameter and volume as specified below. A detachable base plate and a collar assembly, approximately 60 mm high, both of which can be firmly attached to, or removed from, the mould

(i) An internal diameter of 105 ± 0.5 mm and a volume of 1000 ± 15 mL (i.e. one litre mould)

NOTE: *A suitable design is shown in Figure 1 of AS 1289.5.1.1.*

OR

(ii) An internal diameter of 148.5 ± 1.0 mm and a volume of 2000 ± 30 mL (i.e. two litre mould)

(b) A metal rammer with a 50 ± 0.4 mm face diameter and the requirements as specified below

(i) For Standard compaction, a drop mass of 2.7 ± 0.01 kg and equipped with a suitable device to control the height of drop to a free fall of 300 ± 2.0 mm

OR

(ii) For Modified compaction, a drop mass of 4.9 ± 0.01 kg and equipped with a suitable device to control the height of drop to a free fall of 450 ± 2.0 mm

NOTE: *A suitable form of hand apparatus is shown in Figure 2 of AS 1289.5.1.1 or AS 1289.5.2.1. Provided the essential dimensions are adhered to, mechanical forms of the apparatus may be used.*

(c) A rigid foundation on which to compact the specimen (e.g. a concrete floor or a concrete block of at least 100 kg) with suitable attachments for firmly holding the mould base plate assembly during compaction

(d) A balance of suitable capacity with a limit of performance not greater than ± 5 g

(e) A jack, lever and frame or other device suitable for extruding compacted specimens from the mould

(f) A bowl and trowel, or mixing machine suitable for thoroughly mixing increments of water with the sub-sample

(g) A suitable measuring cylinder

(h) A steel straightedge, about 300 mm long, about 25 mm wide and about 3 mm thick, preferably with a bevelled edge

(i) A 300 mm ruler marked in mm or a suitable depth gauge

(j) Dishes of suitable size

(k) Suitable brush ware

(l) Apparatus suitable to evenly dry back samples (e.g. hot plate, oven, heat lamps, fan heater, hair drier, etc). Do not use apparatus that unevenly heats a sample (e.g. microwave ovens)

4. Preparation

Samples are to be prepared in accordance with T105.

5. Procedure

5.1 General

(a) If required, determine the field moisture content (w_f) of the material passing 37.5 mm AS sieve in accordance with T120, T121 or T180

(b) Use the mould as determined in T105

(c) Determine the mass of the mould and record the mass (M_1)

NOTE: *In some cases, the mass of the mould (M_1) is to include the mass of the base plate and liner. The base plate may be retained to prevent some materials (e.g. fine crushed rock) slipping from the mould. Thin plastic wrap or petroleum jelly may be used as a liner to retain moisture.*

(d) Assemble the mould collar and base plate, and place the assembly on the rigid foundation

(e) Carry out testing of the sub-samples as described in Steps 5.2, 5.3 and 5.4 until at least three test results "straddle" the Optimum Moisture Content (*OMC*). Straddling has been achieved when:

(i) Three moisture contents lie between OMC -2.5% and OMC +2% with one result below OMC and one result exceeding OMC

(ii) The increments between the moisture contents in ascending order lie between 1% and 2.5%

NOTE: *.Preferably results should be approximately 2% below, at OMC and 2% above OMC.*

5.2 Sub-sample 1

(a) Remove the sub-sample from the sealed container and determine the mass (*M*)

(b) Adjust the moisture content, if required, to approximate OMC. Record the mass of water added to or removed from the sub-sample (M_W). Determine the amount of water added to the sub-sample as a percentage of wet mass (Z)

(c) Check that percentage of wet mass (Z) meets the requirements in Step 2(b) otherwise abandon this test, cure the sample and test according to T111

(d) Thoroughly mix the sub-sample to create uniform moisture while minimising moisture loss

(e) Compact the sample in the mould using the appropriate compaction as specified in the following table (i.e. number of equal layers and each layer subject to a uniformly distributed number of blows from the required rammer falling freely from the height). Do not vary the compacted thickness of each layer by more than 5 mm

Item	Standard Compaction	Modified Compaction
No. of layers	3	5
Rammer drop mass (kg)	2.7 ± 0.01 kg	4.9 ± 0.01 kg
Height of drop (mm)	300 ± 2.0	450 ± 2.0
No. of uniformly distributed blows per layer	25 for the one litre mould, or, 50 for the two litre mould	25 for the one litre mould, or, 50 for the two litre mould

NOTE: *Use only sufficient material to slightly overfill the mould leaving not more than 5 mm to be struck off after removing the collar. If overfilled by more than 5 mm or under filled, the sample is to be replaced by a new sub-sample.*

(f) Free the material from around the collar and then carefully remove the collar

(g) Level the specimen to the top of the mould by means of the straightedge. Patch any holes developed in the surface by the removal of coarse material with smaller size material

(h) Remove the mould plus specimen from the base plate and determine the mass (M_3)

NOTE: *Where the base plate is retained, M_3 is to include the mass of the base plate and liner.*

(i) Eject the specimen from the mould and discard

(j) Calculate the wet density (ρ) as set out in Calculations (a). If the compaction was not carried out at field moisture content, then adjust the wet density to the converted wet density (CWD) by the method set out in Calculations (b)

5.3 Sub-sample 2

(a) Remove sub-sample 2 from the sealed container and determine the mass (M)

(b) Adjust the sub-sample to appropriate moisture content. Record the mass of water added to or removed from the sub-sample (M_W). Determine the amount of water added to or removed from the sub-sample as a percentage of wet mass (Z)

NOTE: *If the first sub-sample was obviously above OMC, compact the remaining sub-samples at lower moisture contents. Suitable increments of moisture content range from 1% for gravels up to 3% for clays.*

Where the sample needs to be dried back, determine the loss in mass of the sub-sample (M_W) as the drier mass less the original mass (M). In this case M_W is a negative value.

(c) Repeat Steps 5.2(c) to (j)

5.4 Sub-sample 3 and additional sub-samples

(a) Remove the next sub-sample from the sealed container and determine the mass (M)

(b) Adjust the sub-sample to appropriate moisture content. Record the mass of water added to or removed from the sub-sample (M_W). Determine the amount of water added to or removed from the sub-sample as a percentage of wet mass (Z)

NOTE: *Where the sample needs to be dried back, determine the loss in mass of the sub-sample (M_W) as the drier mass less the original mass (M). In this case M_W is a negative value.*

(c) Repeat Steps 5.2(c) to (j)

(d) Where the OMC has been straddled as required in Step 5.1(e), proceed to Calculations. Otherwise, repeat Step 5.4 using additional sub-samples

6. Calculations

(a) For each compaction point evaluate the Wet Density (ρ) as required from the formula:

$$\rho = \frac{(M_3 - M_1)}{V}$$

Where:

ρ = Wet Density (t/m³)

M_1 = Mass of mould (g)

M_3 = Mass of mould and compacted specimen (g)

V = Volume of mould (mL)

NOTE: *Where the base plate is retained,* M_3 *and* M_1 *are to include the mass of the base plate and liner.*

(b) Calculate the corresponding Converted Wet Density (*CWD*) adjusted to the field moisture content (*Wf*) for each compaction point from the formula:

$$CWD = \rho \times \frac{100}{(100 + Z)}$$

Where:

CWD = Converted Wet Density (t/m³)

ρ = Wet Density at moisture content of test (t/m³)

$$Z = \frac{M_W}{M} \times 100\%$$

Z = Amount of water expressed as a percentage of wet mass (%).

NOTE: Z is negative if the sample has been dried to below field moisture content.

M_W = Mass of water added to or removed from sub-sample (g) (M_W is negative when water has been removed)

M = Wet mass of sub-sample at field moisture content (g)

(c) Plot the Converted Wet Densities versus the percent-added moisture (Z). Using a procedure described in the Appendix, determine the position of the Maximum Converted Wet Density (*MCWD*) and the added moisture which corresponds to the peak point (Z_m) in %

(d) If required, the Optimum Moisture Content and Maximum Converted Dry Density (*MCDD*) are calculated as follows:

$$OMC = w_f + (1 + \frac{w_f}{100}) Z_m$$

Where:

OMC = Optimum Moisture Content (%)

w_f = Field moisture content (%)

Z_m = Moisture content determined from Step 6(c) (%)

$$MCDD = \frac{MCWD}{(1 + \frac{w_f}{100})}$$

Where:

$MCDD$ = Maximum Converted Dry Density (t/m^3)

$MCWD$ = Maximum Converted Wet Density (t/m^3)

w_f = Field moisture content (%)

7. Reporting

Include the following data and results in the report:

(a) The compaction applied (i.e. Standard or Modified) and the fraction tested

(b) The maximum moisture adjustment for any sub-sample expressed as a percentage of wet mass (Z) to the nearest 0.5%

(c) The maximum converted wet density ($MCWD$) to the nearest 0.01 t/m^3

NOTE: Where the results are to be used for further calculations, report the density values to the nearest 0.001 t/m^3.

(d) The apparent moisture variation Z_m

(e) If required:

(i) The Optimum Moisture Content (OMC), to the nearest 0.5%

(ii) The Laboratory Maximum Converted Dry Density ($MCDD$) to the nearest 0.01 t/m^3

NOTE: Where the results are to be used for further calculations, report the density values to the nearest 0.001 t/m^3 and moisture content values to the nearest 0.1%.

(f) Reference to this test method

Appendix A: Determination of Maximum Converted Wet Density and Apparent Moisture Variation

Determine *MCWD* and Z_m using either a mathematical or graphical procedure as described below.

A.1 Mathematical solution

The *MCWD* and Z_m may be determined by one of the following mathematical procedures:

(i) Non-linear regression plot;

(ii) Cubic spline function;

OR

(iii) Solution for vertex of a parabola with vertical axis, given 3 points closest to the Z_m.

A.2 Graphical Solution - Vertex of a Parabola with Vertical Axis Given 3 Points

(a) From the available results, denote point **B** as the result with greatest density (closest to the *MCWD).*

(b) Denote point **A** as the result with moisture content just lower than that of point **B**.

(c) Denote point **C** as the result with moisture content just higher than that of point **B**.

(d) Draw a horizontal base line through point **A**.

(e) If points **A**, **B** and **C** are equally spaced horizontally (i.e. equal increments of *Z*):

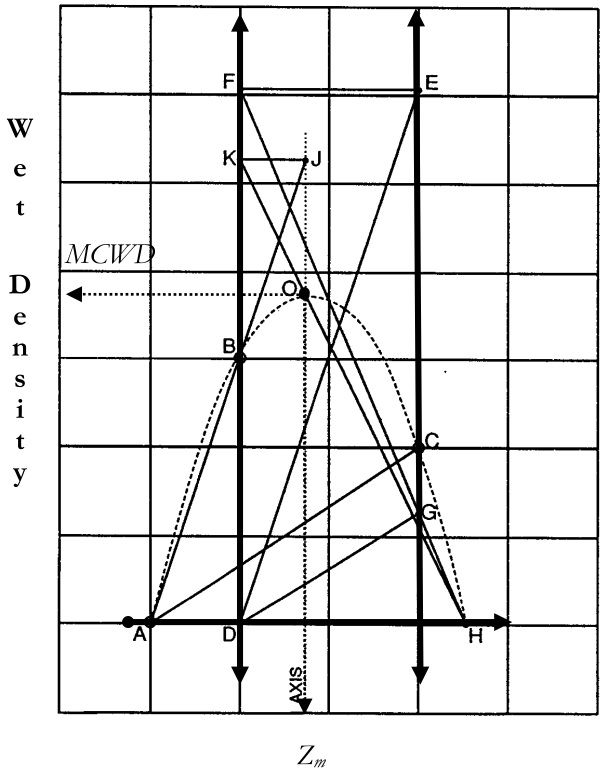
  (i) Point **F** coincides with point **B**.

  (ii) Point **G** is halfway between the baseline and point **C**.

  (iii) Draw line **BG** to intersect the base line at **H**.

(f) If points **A**, **B** and **C** are not equally spaced horizontally.

  (i) Draw vertical lines through points **B** and **C**. Point **D** lies at the intersection of the horizontal line through A and the vertical line through **B**.



Added Moisture Content (*Z*)

Figure 1–Graphical Solution for Peak Point of Parabola

  (ii) Draw a line **DE** parallel to **AB**. Point **E** lies on a vertical line through point **C**. Project **E** horizontally to establish point F on a vertical line through point **B**.

  (iii) Draw a line **DG** parallel to **AC**. Point **G** lies on a vertical line through **C**.

  (iv) Draw line **FG** to intersect the base line at **H**.

(g) Bisect base line **AH** to form the axis of the parabola. This defines Z_m.

(h) Draw line **AB** to intersect axis of parabola at **J**. Project **J** horizontally to **K**, which lies on the vertical line through **B**.

(i) Line **KH** intersects the axis at **O**, the vertex. This defines the *MCWD*.