Test Method T166

Relative compaction of road construction materials

Issue No. 4.0 | 19 April 2022

This version is a draft issued for stakeholder's comments.

The template formatting has been adjusted and RMS has been replaced by Transport for NSW.

Please use the attached comment form and return completed forms to test.method.feedback@transport.nsw.gov.au

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About this release

Title:	Relative compaction of road construction materials
Test method number:	T166
Author:	Materials Technology
Authorised by:	

Summary of changes

Issue number	Clause number	Revision description	Authorised by	Publication date
Issue 4.0	All All 5.1 6.1.3 App A.	Document restructured and reformatted to TfNSW template. Clarified procedure, calculations and reporting requirements. Moisture ratio is required for cohesive materials Added moisture ratio calculations and adjusted OMC where OS is present. Plotting of all test results is required.		
Ed 3 / Rev 0	All	Reformatted template	J. Friedrich	October 2012
Ed 2 / Rev 0	2(c), 4, 5.2, 6.2(b), 7(b)(c)(e) Appendix	List documents. Preparation added. Non-cohesive term now used and revised calculations. Reporting to include plots according to Appendix.	D. Hazell	May 2011
Ed 1 / Rev 0	All	Generally revised – Title changed. Expanded procedure and corrected formulas for Relative Compaction.	G. Donald	November 2007
		Date on test method revised to agree with date on revision	D. Dash	Feb 2001
		Reformatted and revision summary added.	D. Dash	May 1999

NOTE: The functions of the former State Government agency Roads and Maritime Services (RMS or Roads and Maritime) are now administered by Transport for NSW.

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Test Method T166

Relative compaction of road construction materials

1 Scope

This test method sets out the procedure for determining the relative compaction of road construction materials.

2 General

(a) This test method is applicable for material containing up to 40% by mass of particles retained on the 37.5 mm sieve.

(b) The test methods used to determine the field wet density and the relative compaction and is limited by the mass of particles retained on the 37.5 mm sieve obtained from excavating the sample when determining the field wet density:

(i) If ≤ 20% by mass is retained on the 37.5 mm sieve, use either TfNSW test method T119 or TfNSW test method T173.

(ii) If > 20% ≤ 40% by mass is retained on the 37.5 mm sieve, use TfNSW test method T119.

(iii) If fine to medium grained cohesionless materials including one size material or gap graded material use TfNSW test method T173 or TfNSW test method T165.

(iv) If percent mass retained on the 37.5 mm sieve is greater than 40%, do not report the relative compaction as the test result is not valid.

(c) Where the results are to be used in subsequent calculations (e.g., TfNSW Specification QMS Q6, Method for Statistical Calculation for Conformity of lots) use and report all densities values to the nearest 0.001 t/m^3 (e.g., wet densities, dry densities, and OS densities).

(d) The following terms and definitions are used in this test method (Table 1).

Table 1. Terms and definitions

Term	Definition
RC	Relative Compaction determined by dividing the field density by the laboratory determined maximum density as appropriate expressed as a percentage.
OS	Oversize, portion of a sample retained on the 37.5 mm sieve.

3 Equipment

(a) No equipment is required.

4 Preparation

(a) No preparation is required.

5 Procedure

5.1 Cohesive materials

(a) Determine the relative compaction of material under test based on wet densities using:

(i) TfNSW test method T119 or TfNSW test method T173 (measured field wet density).

(ii) TfNSW test method T162 (maximum converted wet density *MCWD*).

(b) Determine the relative compaction of material under test based on dry densities using:

(i) TfNSW test method T119 or TfNSW test method T173 (field dry density).

(ii) TfNSW test method T111 or TfNSW test method T112 (maximum dry density *MDD*).

(c) Determine the moisture ratio based on the field moisture content using:

(i) TfNSW test method T120 (field moisture content and the OMC).

5.2 Non-cohesive materials

(a) Determine the relative compaction of material under test based on dry densities using:

(i) TfNSW test method T119 or TfNSW test method T165 or TfNSW test method T173 (field wet density).

(ii) TfNSW test method T164 (maximum dry density *MDD*).

6 Calculations

6.1 Relative compaction and moisture ratio for cohesive materials

6.1.1 Relative compaction based on wet density

(a) Calculate relative compaction to the nearest 0.5 % based on the wet density where all the material passes the 37.5 mm sieve using the following equation:

$$RC = \frac{FWD}{MCWD} \times 100 \quad \ldots 6(1)$$

Where:

RC = Relative Compaction (%).

FWD = Field wet density (t/m^3) determined from T119 or T173.

$MCWD$ = Maximum converted wet density (t/m^3) determined from T162.

Equation 6(1). RC based on wet density where all material is passing 37.5 mm sieve

(b) Calculate the maximum wet bulk density and relative compaction to the nearest 0.5% where a portion of material (OS) retained on the 37.5 mm sieve is no more than 40% using the following equations:

$$MWBD = \frac{100}{\left(\frac{P_{O37.5}}{J_o}\right) + \left(\frac{100 - P_{O37.5}}{MCWD}\right)} \quad \ldots 6(2)$$

Where:

$MWBD$ = Maximum wet bulk density (t/m^3).

$P_{O37.5}$ = Proportion of oversize retained on the 37.5mm sieve (%) determined form T105 or T119.

J_0 = Density of proportion of oversize retained on the 37.5 mm (t/m^3) determined from T105 or T119.

$MCWD$ = Maximum converted wet density (t/m^3) determined from T162.

Equation 6(2). Maximum wet bulk density

$$RC = \frac{FWD}{MWBD} \times 100 \quad \ldots 6(3)$$

Where:

RC = Relative Compaction (%).

FWD = Field wet density to (t/m^3) determined from T119 or T173.

$MWBD$ = Maximum wet bulk density (t/m^3).

Equation 6(3). RC based on wet density where a portion is retained on the 37.5 mm sieve

6.1.2 Relative compaction based on dry density

(a) Calculate the relative compaction to the nearest 0.5% based on the dry density where all the material passes the 37.5 mm sieve using the following equation:

$$RC = \frac{FDD}{MDD} \times 100 \quad \ldots 6(4)$$

Where:

RC = Relative Compaction (%).

FDD = Field dry density (t/m^3) determined from T119 or T173.

MDD = Maximum dry density (t/m^3) determined from T162, T111, or T112.

Equation 6(4). RC based on dry density where all material is passing 37.5 mm sieve

(b) Calculate the maximum dry bulk density and relative compaction to the nearest 0.5% where a portion of material (OS) retained on the 37.5 mm sieve is no more than 40% using the following equations:

$$MDBD = \frac{100}{\left(\frac{P_{O37.5}}{J_o}\right) + \left(\frac{100 - P_{O37.5}}{MDD}\right)} \quad \ldots 6(5)$$

Where:

$MDBD$ = Maximum dry bulk density (t/m^3).

$P_{O37.5}$ = Proportion of oversize retained on the 37.5mm sieve (%) determined form T105 or T119.

J_0 = Density of proportion of oversize retained on the 37.5 mm sieve (t/m^3) determined form T105 or T119.

MDD = Maximum dry density (t/m^3) determined from T162, T111 or T112.

Equation 6(5). Maximum dry bulk density

$$RC = \frac{FDD}{MDBD} \times 100 \quad \ldots 6(6)$$

Where:

RC = Relative Compaction (%).

FDD = Field dry density (t/m^3) determined from T119 or T173.

$MDBD$ = Maximum dry bulk density (t/m^3).

Equation 6(6). RC based on dry density where a portion is retained on the 37.5 mm sieve

6.1.3 Moisture ratio of cohesive materials

(a) Calculate the moisture ratio to the nearest 1% where all the material passes the 37.5 mm sieve using the following equation:

$$MR = \frac{w_f}{OMC} \times 100 \quad \ldots 6(7)$$

Where:

MR = Moisture Ratio (%).

w_f = Field moisture content (%) determined from T119 or T173.

OMC = Optimum moisture content (%) determined from T162, T111 or T112.

Equation 6(7). Moisture ratio where all where all material is passing 37.5 mm sieve

(b) Calculate the adjusted optimum moisture content to the nearest 0.1% and moisture ratio to the nearest 1% where a portion of material (OS) retained on the 37.5 mm sieve is no more than 40% using the following equation:

$$AOMC = \frac{OMC \times (100 - P_{O37.5})}{100} \quad \ldots 6(8)$$

Where:

$AOMC$ = Adjusted optimum moisture content for Oversize (%).

OMC = Optimum moisture content determined from T111, T112 or T162.

$P_{O37.5}$ = Proportion of oversize retained on the 37.5 mm sieve (%) determined form T105 or T119.

Equation 6(8). AOMC where a portion is retained on the 37.5 mm sieve

$$MR = \frac{w_f}{AOMC} \times 100 \quad \ldots 6(9)$$

Where:

MR = Moisture Ratio (%).

w_f = Field moisture content determined from T119 or T173 (%).

$AOMC$ = Adjusted optimum moisture content for Oversize (%) determined from T105 or T119.

Equation 6(9). Moisture ratio where a portion is retained on the 37.5 mm sieve

6.2 Relative compaction of non-cohesive materials

6.2.1 Relative compaction based on dry density

(a) Calculate the relative compaction to the nearest 0.5% based on the dry density where all the material passes the 37.5 mm sieve using the following equation:

$$RC = \frac{FDD}{MDD} \times 100 \quad \ldots 6(10)$$

Where:

RC = Relative Compaction (%).

FDD = Field dry density (t/m^3) determined from T119, T165 or T173.

MDD = Maximum dry density (t/m^3) determined from T164.

Equation 6(10). RC based on dry density where all material is passing 37.5 mm sieve

(b) Calculate the maximum dry bulk density and relative compaction to the nearest 0.5% where a portion of material (OS) retained on the 37.5 mm sieve is no more than 40% using the following equations:

$$MDBD = \frac{100}{\left(\frac{P_{O37.5}}{J_o}\right) + \left(\frac{100 - P_{O37.5}}{MDD}\right)} \quad \ldots 6(11)$$

Where:

$MDBD$ = Maximum dry bulk density (t/m^3).

$P_{O37.5}$ = Proportion of oversize retained on the 37.5mm sieve (%) determined from T105 or T119.

J_0 = Density of proportion of oversize retained on the 37.5 mm sieve (t/m^3) determined from T105 or T119.

MDD = Maximum dry density (t/m^3) determined from T164.

Equation 6(11). Maximum dry bulk density

$$RC = \frac{FDD}{MDBD} \times 100 \quad \ldots 6(12)$$

Where:

RC = Relative Compaction (%).

FDD = Field dry density (t/m^3) determined from T119, T165 or T173.

$MDBD$ = Maximum dry bulk density (t/m^3).

Equation 6(12). RC based on dry density where a portion is retained on the 37.5 mm sieve

6.2.2 Moisture ratio of non-cohesive materials

(a) Non-cohesive materials do not have an optimum moisture content, therefore moisture ratio cannot be determined.

7 Reporting

Include the following data and results in the report:

(a) Client.

(b) Identification of sample (e.g., Stockpile number and tonnage, chainage and offset, lot number, location, sample number or source as required).

(c) Date sampled.

(d) Sampling method.

(e) Date sample received and tested.

(f) Description of sample or product (e.g., silty clay, DGB20, etc.)

(g) For cohesive material as appropriate:

(i) The compaction used (Standard or Modified).

(ii) The proportion of material retained on the 37.5 mm sieve ($P_{A37.5}$) and on the 19.0 mm sieve ($P_{A19.0}$) to the nearest 1 (%).

(iii) Density of oversize (J_o) to the nearest 0.01 (t/m^3).

(iv) Maximum Converted Wet Density or Maximum Dry Density to the nearest 0.01 (t/m^3) where all material passes the 37.5 mm sieve.

(v) Maximum Wet Bulk Density (*MWBD*) or Maximum Dry Bulk Density (*MDBD*) to the nearest 0.01 (t/m^3), where up to 40% is retained on the 37.5 mm sieve.

(vi) Relative Compaction to the nearest 0.5 (%).

(vii) Moisture Ratio to the nearest 1 (%).

NOTE: Where the results are to be used in subsequent calculations (e.g., TfNSW Specification QMS Q6, Method for Statistical Calculation for Conformity of lots) use and report all densities values to the nearest 0.001 t/m³ (e.g., wet densities, dry densities and OS densities)

(h) For non-cohesive material as appropriate:

(i) The proportion of material retained on the 37.5 mm sieve ($P_{A37.5}$) and on the 19.0 mm sieve ($P_{A19.0}$) to the nearest 1 (%).

(ii) Density of oversize (J_o) to the nearest 0.01 (t/m^3).

(iii) Maximum Dry Density to the nearest 0.01 (t/m^3), where all material passes the 37.5 mm sieve.

(iv) Maximum Dry Bulk Density to the nearest 0.01 (t/m^3), where up to 40% is retained on the 37.5 mm sieve.

(v) Relative Compaction to the nearest 0.5 (%).

NOTE: Where the results are to be used in subsequent calculations, (e.g., TfNSW Specification QMS Q6, Method for Statistical Calculation for Conformity of lots) use and report all densities values to the nearest 0.001 t/m³ (e.g., wet densities, dry densities, and OS densities)

(i) All test results for a compaction lot plotted in accordance with Appendix A with 0 (%) and 5 (%) air voids lines.

(j) Reference to the test methods used to determine field density and maximum density as appropriate.

(k) Reference to this test method.

8 References

The following documents are referred to in this test method:

- Transport T105 (2020). Preparation of samples for testing (Soils). Transport for NSW.
- Transport T111 (2020) Dry density/moisture relationship of road construction materials. Transport for NSW.
- Transport T112 (2020). "Dry density/moisture relationship of road construction materials (Modified compaction)." Transport for NSW.
- Transport T119 (2012). "Field dry density of road construction materials (sand replacement method)." Transport for NSW.
- Transport T120 (2020). "Moisture content of road construction materials (standard method)." Transport for NSW.
- Transport T162 (2020). "Compaction control test (Rapid method)." Transport for NSW.
- Transport T164 (2012). "Maximum dry density of cohesionless materials (by vibration)." Transport for NSW.
- Transport T165 (2012). "Density in-situ of road construction materials (fixed volume extraction)." Transport for NSW.
- Transport T173. (2020). "Field wet density of road construction materials (nuclear gauge in direct transmission method)." Transport for NSW.
- QA Specification Q6 (2013). QA Specification Q6 Quality Management System (Type 6). Transport for NSW.

Appendix A. Plotting test results

When determining the relative compaction for each lot tested, plot on a single graph the field moisture content against the field dry density and the maximum dry density and optimum moisture content (as appropriate) together with the 0% and 5% air voids lines. Figure 1 shows an example of the graphical presentation of field and laboratory test results of a lot when plotted on a graph together with air voids lines.

A.1 Field moisture content against field dry density

(a) Plot the field moisture content (w_f) against the field dry density (FDD) for each test on the lot as determined in TfNSW test methods T119, T165 or T173.

A.2 Maximum dry density against optimum moisture content

(a) Plot the maximum dry density and optimum moisture content as appropriate (as a single point) for each compaction test on the lot:

(i) Maximum Dry Density and Optimum Moisture Content as determined in TfNSW test method T111 or T112 (or other determinations of MDD and OMC).

(ii) Maximum Converted Dry Density and Optimum Moisture Content as determined in TfNSW test method T162.

(iii) Maximum Dry Bulk Density and Adjusted Optimum Moisture Content as determined in TfNSW test method T166.

A.3 Plot of air voids line

(a) Include the plot of air voids lines in accordance with TfNSW test method T105 Appendix A, Process A.13.

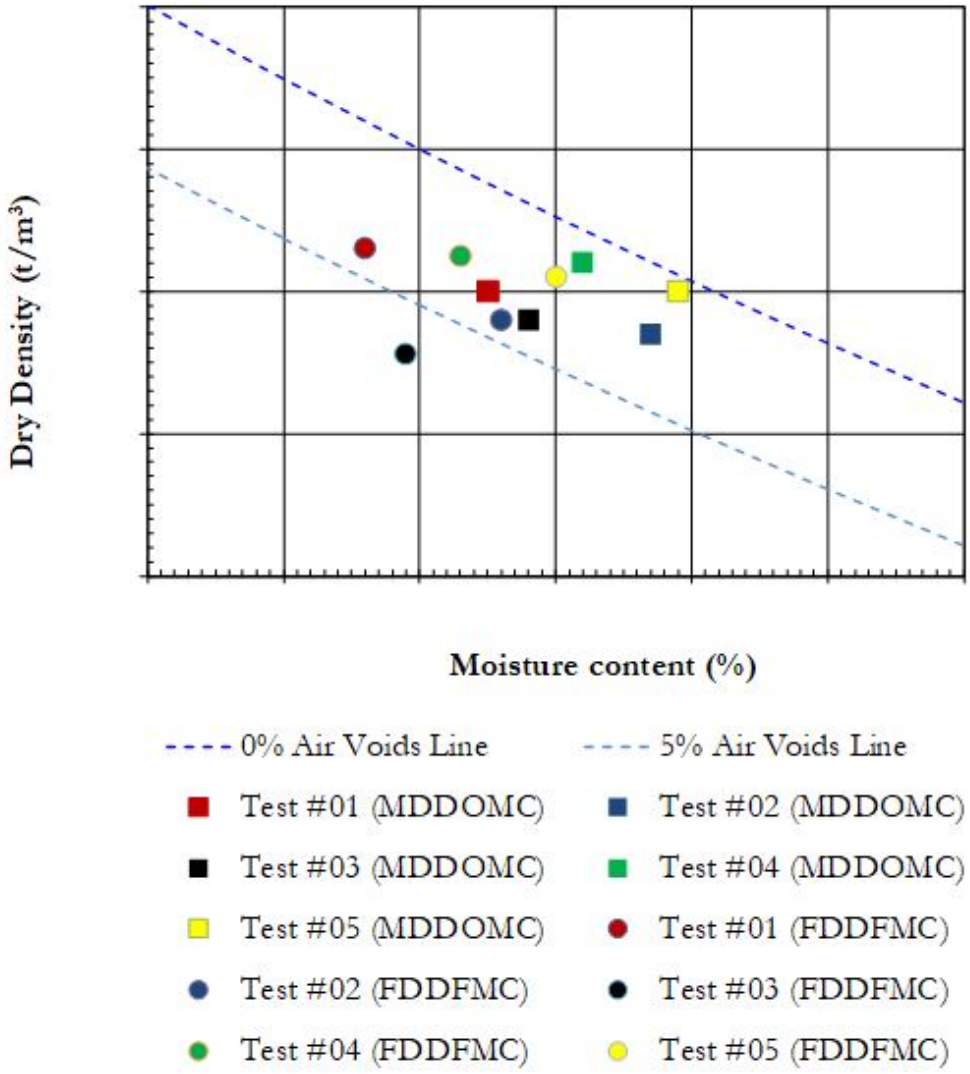

Figure 1. An example of a plot of field and laboratory compaction test results

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