Transport Roads & Maritime Services

NSW GOVERNMENT

Test method T116

Unconfined compressive strength of remoulded road construction materials

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Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D. Dash	May 1999
		Date on Test Method Revised to Agree with Date on Revision Summary	D. Dash	Feb 2001
Ed 2/Rev 0	All	General revision and reformatting. Corrected ambiguity between T116 and T131. Mass of specimen consistent with T111. Added procedure to cap specimens.	G. Donald	September 2007
Ed 2/Rev 1	2(f) note,(i), 3(o), 4(c), 5.1(d)&(e) notes, 5.3(b)&(c), 6(a), 7(i), App	Note on compaction, document list added, extra capping options, OMC testing, note added on scarifying surface, defects, pronumeral for density.	D Hazell	Mar 2010
Ed 2/Rev 2	2(i); 5.2(a); 5.3(a) (c)	Test method list revised. Reworded. Order of capping.	D Hazell	May 2011
Ed 3/ 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 T116 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T116

Unconfined compressive strength of remoulded road construction materials

1. Scope

This Test Method sets out the procedure to determine the Unconfined Compressive Strength (UCS) of remoulded road construction materials (including earthworks).

The method uses Standard or Modified compaction.

2. General

(a) The method is applicable to road construction materials that gain tensile strength with time (e.g. material blended in the field with a cementitious binder, or self cementing materials such as slag)

(b) For samples blended in the laboratory with cementitious binders, refer to T131 for test requirements

(c) For material blended in the field with a cementitious binder, refer to the Specification for any timing constraints imposed during testing

(d) The method is applicable to that portion passing a 19.0 mm AS sieve

(e) A pair of specimens is tested unless otherwise specified

NOTE: For a large number of samples plan the order of work to satisfy any time constraint in this test method.

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

NOTE: Compaction may need to achieve a specified LDR and any change must be noted on the test report.

(g) Curing conditions are either:

(i) Accelerated curing at 65°C for 7 days

OR

(ii) Normal curing at 23°C for 28 days or other time period(s) as specified

(h) Use accelerated curing unless otherwise specified

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

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

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

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

(iv) T162 Compaction Control Test (Rapid Method)

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

(vi) 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

(vii) 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

(viii) AS 2193 Calibration & classification of force-measuring systems

3. Apparatus

(a) A compression testing machine of at least 60 kN capacity and equipped with:

(i) An upper bearing block with a spherical seat

(ii) A load-indicating device that meets the accuracy and repeatability requirements of AS 2193 Grade C testing machines for the range of forces used in the test

NOTE: Where an electronic data acquisition system is used to directly capture and record test data, it must have a precision at least equivalent to the apparatus replaced.

(b) A cylindrical metal mould with an internal diameter of 105 ± 0.5 mm and a volume of 1000 ± 15 mL (i.e. one litre mould). 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

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

(c) 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

(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.

(d) 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

(e) A balance of suitable capacity and a limit of performance of 5g

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

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

(h) A suitable measuring cylinder

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

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

(k) Sealable airtight containers

(l) Newspaper and foil

(m) Dishes of suitable size

(n) Equipment for measuring specimens (e.g. callipers, engineer's try square, seating mould, a spirit level approximately 150 mm long)

(o) Materials and related equipment for capping cylindrical specimens (e.g. plaster of paris or orthopaedic plaster cap, restrained rubber cap, sulfur cap)

(p) A thermostatically controlled oven with good air circulation, which can be maintained at 65°C ± 5°C for accelerated curing.

(q) Options for normal curing are one of the following apparatus:

(i) A humidity cabinet capable of maintaining a humidity of not less than 90% at a temperature of 23°C ± 2°C

(ii) A water bath capable of maintaining a temperature of 23°C ± 2°C, equipped with a snug-fitting lid and perforated metal false bottom with supports to provide a 50 mm space below the perforated plate

(iii) A thermostatically controlled oven with good air circulation, which can be maintained at 23°C ± 2°C

4. Preparation

(a) Where the referring specification specifies time constraints, calculate and apply the timing constraints

NOTE: The start time is measured from initial mixing of the binder with the material.

(b) Prepare the sample in accordance with T105

(c) Determine the OMC of the - 19 mm fraction according to T111 or T162

NOTE: T162 is normally used unless the sample OMC has been determined using T111.

5. Procedure

5.1 Moulding

(a) Assemble the mould, collar and baseplate, and place the assembly on the rigid foundation

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

(c) Remove the sample from the container. Unless otherwise specified, adjust the moisture content to OMC ± 0.5% as determined in Step 4(c). Thoroughly mix the sample. Cover the sample and allow to stand for not less than 5 minutes

NOTE Take care to avoid loss of moisture during moulding.

(d) Compact the sample in the mould using the required 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	300 ± 2.0 mm	450 ± 2.0 mm
No. of uniformly distributed blows per layer	25 for the one litre mould	25 for the one litre mould

NOTE: Before adding the next layer, lightly scarify the existing compacted surface to ensure interlock between layers.

Use only sufficient material to slightly overfill the mould leaving not more than 5 mm to be struck off after removing the collar.

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

NOTE: If overfilled by more than 5 mm or underfilled, the sample is to be replaced by a new sample.

(f) Where a moisture determination is required in Step (j), cover the sub-sample that is remaining after moulding the specimen

NOTE: Ensure that material trimmed from the specimen or used for the slurry does not contaminate the sub-sample.

(g) Level the specimen to the top of the mould by means of the straightedge. Patch any holes developed in the surface by replacing coarse material with smaller sized material. Alternatively, make up a slurry of some of the excess material and trowel the slurry on the top surface of the specimen to provide a smooth and level surface

(h) Remove the mould plus specimen from the base plate and determine the mass (M_3) to the nearest 1 g

(i) Eject the specimen from the mould

(j) Using the sub-sample remaining after moulding the specimen, determine the moisture content (w) in accordance with T120, T121 or T180

(k) Repeat processes Steps (a) to (j) for each additional specimen

NOTE: Provided care has been taken to avoid loss of moisture during moulding of the first specimen the moisture content determination in Step (j) may be omitted for additional specimens.

5.2 Curing of Specimen

(a) Ensure that specimens do not dry out and are kept moist during curing (e.g. wrap each specimen in wet newspaper and seal in foil)

NOTE: Take care to avoid damage to the specimen.

The chemical reactions producing cementitious compounds only take place in the presence of moisture. Strength development ceases when the material dries out.

(b) Place the specimens into the specified curing environment and cure:

(i) For accelerated curing, store the specimens in an oven within a temperature range of 65°C ± 5°C and cure for 7 days ± 6 hours

(ii) For normal curing, store the specimens in an apparatus capable of maintaining a temperature of 23°C ± 2°C and cure for 28 days ± 6 hours

NOTE: When specimens are cured in a water bath, they must be sealed in water-proof containers to prevent water ingress.

5.3 Specimen Preparation Prior to Compression Testing

(a) Remove the specimens from their curing environment and remove any covering. Inspect each specimen and record if the specimen has dried out. Allow specimen to cool

NOTE: Coarse particles of quicklime may hydrate slowly after compaction. In some cases the resulting volume increase will cause compacted specimens to disintegrate.

(b) Examine the condition of both end surfaces of the specimen and record any of the following defects:

(i) Either end of a specimen is convex or concave by >2 mm

(ii) Any edge is broken away in such a manner that the radial or vertical break is >10 mm from the edge line and the corresponding circumferential break (or sum of circumferential breaks) exceeds 10% of the circumference of the specimen

(iii) Any apparent defect that may affect the test results

(c) If a specimen has a defect identified in Step (b), install an end cap from the following alternatives:

NOTE: Only the end of the specimen with a defect need be capped.

(i) Sulfur cap according to AS 1012.9.6.4 Table 1

NOTE: Must be applied before soaking.

(ii) Plaster caps after Step (5.3(d)) according to Appendix A

(iii) Restrained rubber caps after Step (5.3(d)) according to AS 1012.9.6.4 Table 1

When required, the same type of end cap must be used for all specimens within a lot

(d) Immerse each specimen for 4 to 4½ hrs in a bath filled with water at room temperature. Cover the specimen with about 10 mm of water so that the entrapped air may escape

5.4 Compression Testing

(a) Remove each specimen from the bath and drain for at least 15 minutes

(b) Determine two diameters to the nearest 0.5 mm of the specimen, measured at right angles to each other. Calculate the average diameter (D_m) to the nearest 0.5 mm

(c) Place the specimen on the lower bearing block of the compression testing machine. Make sure that the vertical axis of the specimen is aligned with the centre of force of the upper bearing block. Bring the upper bearing block to bear on the specimen, ensuring that the seating load is uniformly applied

(d) Apply the force at a uniform rate on the specimen:

(i) If the machine is mechanised, the rate is to be 60± 6 kN/min

(ii) If the machine has a hand operated pump, the rate is approximately 1 kN/sec

NOTE: Avoid jerking the pump handle, particularly at the beginning and end of each stroke

(e) Record the force at failure of the specimen (P) to the nearest 0.5 kN. The time taken from removing the specimen from the bath to testing to failure is not to exceed 30 minutes

6. Calculations

(a) Calculate the Dry Density (ρ_d) of each specimen as follows:

$$\rho_d = \frac{(M_3 - M_1)}{V} \times \frac{100}{(100 + w)}$$

Where:

ρ_d = Dry Density (t/m³)

M_3 = Mass of mould and compacted specimen (g)

M_1 = Mass of mould (g)

V = Volume of the mould (mL)

w = Moisture content at time of moulding (%)

(b) Calculate the Unconfined Compressive Strength (UCS) of the specimen as follows:

$$\text{UCS} = \frac{P}{\left(\frac{\pi D_m^{\,2}}{4 \times 1000}\right)}$$

Where:

UCS = Unconfined Compressive Strength (MPa)

P = Applied Force (kN)

D_m = Average diameter of the specimen (mm)

7. Reporting

Include the following information, data and results in the report:

(a) Source of sample (i.e. location or laboratory)

(b) The percentage by mass of material retained on the 19 mm AS sieve from T105 (to the nearest 1%)

(c) Type, sources and percentage of binder where applicable

(d) Where binder has been incorporated, the time between initial mixing of binder in the field and completion of moulding in hours and minutes

(e) Standard or Modified compaction

(f) Period and condition of curing

(g) Condition of specimens after curing (i.e. moist or dry). Type of cap, if used and any defects identified in Step 5.3(b).

(h) Moisture content at which specimens were compacted (to nearest 0.5%)

(i) Dry Density (ρ_d) of specimens as moulded to the nearest 0.01 t/m³

(j) Unconfined Compressive Strength in MPa (to nearest 0.05 MPa) for each specimen, and average UCS (to nearest 0.1 MPa) for each pair

(k) Reference to this test method

Appendix A: Plaster Capping of Specimens

Keep the specimen moist during the time taken for capping.

Where an end of the specimen is determined to be deficient, proceed as follows:

(a) Remove loose particles from the end of the specimen

(b) Place the specimen on a level flat surface with the prepared end uppermost

(c) Mix together water and the gypsum plaster to a stiff paste. Apply to the upper surface of the specimen, work into the surface with a small trowel and then shape to form a low dome

(d) Place the flat seating plate on the plaster dome and firmly force the plate into the plaster until:

  (i) Complete coverage of the specimen end is obtained

  (ii) The cap is not more than 6 mm thick

(e) Cover to minimise loss of moisture and allow the specimen to stand until the cap is set

(f) Inspect the finished cap. Remove and replace the cap where the cap has any of the following defects:

  (i) Departs from the plane by more than 0.5 mm

  (ii) Is more than 2 mm out of square from the axis

  (iii) Is more than 6 mm thick

  (iv) Sounds hollow when lightly tapped

  (v) Is made up of more than one layer of capping material