Transport Roads & Maritime Services

NSW GOVERNMENT

Test method T117

California bearing ratio of remoulded specimens of road construction material

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Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D. Dash	April 1999
		Date on Test Method Revised to Agree with Date on Revision	D. Dash	Feb 2001
Ed 2/Rev 0	All	Generally Revised-Title changed Amalgamation of T117 and T117a T117a withdrawn.	G. Donald	November 2007
Ed 2/Rev 1	2(b), 2(e), 5.1(c), 7(e)	New Revision Summary. Clause 2(e) specifies the parameters and adds LMR and LDR. Changed LMR tolerance in Clause 5.1(c) & edited 7(e).	David Hazell	February 2008
Ed 2/Rev 2	1; 2(c), (f), (g); 3(d), (f); 4; 5.1, 5.2(c), (d), (i), (j), 5.3(a), 5.4(d); 6(a), (c); 7(e)	Reference to dynamic deleted. Term 'Static' not used, combined mass with tolerance specified, list test methods. Number of perforations. More detail provided to adjust moisture, moisture content, no. blows, surcharge. Symbol for DD. Symbols added for clarity.	D Hazell	May 2011
Ed 2/ Rev 3	5.3(a)	Clarified surcharge masses.	D Hazell	Oct 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 T117 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T117

California bearing ratio of remoulded specimens of road construction material

1. Scope

This test method sets out the procedure to determine the California Bearing Ratio (CBR) of road construction materials. The specimens are compacted and tested in a laboratory.

NOTE: This method is adapted from AS 1289.6.1.1.

2. General

(a) This method is performed on the portion passing the 19.0 mm AS sieve.

NOTE: The removal of small amounts of material retained on the 19.0 mm AS sieve will have a minor affect on the CBR obtained. However, the removal of a large proportion of material retained than the 19.0 mm AS sieve may have a major effect on the CBR obtained compared with that obtainable with the material as a whole. There is no generally accepted method of testing or of calculation that deals with this difficulty.

(b) This method is used on either unsoaked specimens or specimens that have been soaked for a specified period (e.g. 4 days, 10 days).

(c) Do not use static compaction for this test

(d) 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

(e) The following terms and definitions are used in this Test Method

Term	Definition
Laboratory Moisture Ratio (*LMR*)	The ratio of the moisture content of the specimen to the Optimum Moisture Content (OMC) of the material as determined by T111 or T112 and expressed as a percentage (refer to Calculations).
Laboratory Density Ratio (*LDR*)	The ratio of the Dry Density of the specimen to the Maximum Dry Density (MDD) of the material as determined by T111 or T112 and expressed as a percentage (refer to Calculations).

(f) Use the following unless otherwise specified:

(i) LMR_t = 100% with a tolerance of –3%/+2% at moulding

(ii) LDR_t = 100% with a tolerance of ± 1% for the moulded specimen

(iii) Standard compaction

(iv) The number of days for soaking is 10 days

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

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

(ii) T112 Dry Density/Moisture Relationship of Road Construction Materials

(iii) AS 1289.6.1.1 Soil strength and consolidation tests - Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

(iv) AS 2103 dial gauges and dial test indicators (metric series

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

3. Apparatus

(a) A loading machine equipped with the following:

(i) A moveable head or base capable of controlled travel at a uniform (not pulsating) rate of 1 ± 0.2 mm/min

(ii) A force-measuring device that meets the accuracy and repeatability requirements of AS 2193 Grade C testing machines for the range of forces used in the test. The force-measuring device also is to be capable of indicating seating loads of approximately 50 N and approximately 250 N

NOTE: The force-measuring device is to be calibrated over an appropriate range e.g. calibration of the force-measuring device from 0.1 kN to 1.25 kN would allow reporting of CBR values ranging from 0.75% to 9% at 2.5 mm penetration, and from 0.5% to 6% at 5.0 mm penetration.

(b) A metal penetration piston of 49.6 ± 0.1 mm diameter and approximately 190 mm long

(c) A cylindrical metal mould with an internal diameter of 152 ± 1 mm and internal height of 178 ± 1 mm

(d) A metal extension collar approximately 50 mm high and a perforated metal base plate approximately 10 mm high, both of which can be firmly attached to, and removed from, the mould. Evenly distributed over the base plate is to be a minimum of 20 perforations approximately 3.0 mm in diameter

(e) A metal spacer disc of 150 ± 0.5 mm diameter and 61 ± 0.25 mm thickness

(f) A metal perforated plate of 150 ± 0.5 mm diameter fitted with a metal stem. The total mass of the perforated plate and stem is to be 1.0 ± 0.025 kg. Evenly distributed over the perforated plate is to be a minimum of 42 perforations of approximately 3.0 mm diameter

(g) One annular metal surcharge and one slotted metal surcharge, each having a mass of about 2.25 kg and a diameter of 150 ± 0.5 mm with central hole diameter of 55 ± 1.0 mm, and a combined mass of 4.5 ± 0.05 kg

(h) Two displacement measuring devices for measurement of swell and penetration, each capable of measuring the expected range of travel, graduated to 0.01 mm and meeting the accuracy and repeatability requirements of AS 2103

(i) A rigid support frame, such as a tripod, for mounting the displacement measurement device (e.g. dial gauge) for measuring the amount of swell during soaking

(j) A setting piece (only required when the rigid support frame is to be removed from the mould during the test)

NOTE: The setting piece is used to set the reading on the displacement measuring device attached to the rigid support frame prior to each reading in the swell test.

(k) 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.

(l) A rigid foundation to compact the specimen on (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

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

(n) A balance of at least 15 kg capacity with a limit of performance of not greater than ± 5g

(o) Timer readable in seconds

(p) Soaking tank of sufficient depth to immerse the mould in water

(q) Filter papers, coarse, nominal 150 mm diameter

(r) Mixing apparatus such as a trowel and quartering apparatus such as metal plates approximately 400 mm by 125 mm and 200 mm by 125 mm

(s) A bowl suitable for thoroughly mixing increments of water with the sample. A mixing machine (approximately 11 litre capacity) may be used

(t) A graduated measuring cylinder

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

(v) A 300 mm ruler

(w) Sealable airtight containers suitable for curing moist samples

(x) Dishes of suitable size

4. Preparation

Prepare the test samples in accordance with T105.

NOTE: A second or third sample of -19 mm may be required in Step 5.1.

5. Procedure

5.1 Moisture Adjustment

NOTE: .Adjusting the moisture content to the required LMR and providing curing is important for this test.

(a) Use a sub-sample (-19 mm) to determine the following:

NOTE: Moisture content or OMC results already determined for the -19 mm portion may be used.

(i) The moisture content (w_t) according to T120

(ii) OMC according to T111 but using a -19 mm portion

(b) Calculate the LMR according to Step 6(b)

(c) Where the LMR is within the specified tolerance, proceed to Step 5.2

(d) Where the LMR is outside the specified tolerance, adjust the moisture content of the portion to be moulded

NOTE: The moisture should not be too high as T105 requires the sample to be crumbled before sieving.

Process A.10 in T105 can be used to estimate the water that needs to be added (M_w) based on w_t = OMC.

(i) Add the required quantity of water and thoroughly mix the sample to ensure uniform distribution of moisture

NOTE: A check on moisture content may be required to ensure LMR is met.

(ii) Return the sample to the same container and seal

(iii) Cure the sample according to Process A.6 Curing (b) and (c) in T105

5.2 Moulding

NOTE: Plan testing so that CBR penetration testing falls due on a normal working day, unless other arrangements are made.

(a) Determine the mass of the mould (M_1) in grams

(b) Clamp the mould, with extension collar attached, to the base plate. Insert the spacer disc and place a coarse filter paper on top of the spacer disc

(c) Remove the cured sample from the container. Either immediately before, during or immediately after compaction, obtain a representative portion and use T120 to determine the moisture content at moulding (w). Ensure minimal moisture loss from the portion or sample

NOTE: The sample is assumed to be within the specified tolerance for LMR.

(d) Compact the sample in the mould to achieve the target LDR_t. Compact in layers using the appropriate compaction 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

*NOTE: Compaction to achieve a **LDR** similar to the in situ density, or anticipated service density, may be required for the material being tested.*

Item	Standard Compaction	Modified Compaction
No. of equal layers	3	5
Rammer drop mass (kg)	2.7 ± 0.01	4.9 ± 0.01
Height of drop (mm)	300 ± 2.0	450 ± 2.0
No. of uniformly distributed blows per layer	53 where LDR_t = 100%	53 where LDR_t = 100%
	NOTE: Where $LDR_t \neq$ 100% refer to Process A.12 to determine the number of blows.	

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 underfilled, the sample is to be replaced by a new sample. Record the number of blows per layer.

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

(f) 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

(g) Remove the perforated base plate and spacer disc. Determine the mass of the mould plus compacted specimen and record the mass (M_3) in grams

NOTE: Take care when inverting for the specimen sliding in the mould (sands & gravel).

(h) Place a coarse filter paper on the perforated base plate, invert the mould plus compacted specimen and clamp the perforated base plate to the mould with the compacted specimen in contact with the filter paper

(i) For soaked samples go to Step 5.3. Should soaking be delayed, cover the specimens to avoid moisture loss

(j) Where the sample is not to be soaked:

(i) Place the filter paper, perforated plate and surcharge weights on the compacted specimen in the mould

(ii) Cover the assembly to avoid moisture loss. Allow to stand for at least 4 hours to allow pore pressures to dissipate prior to testing

(iii) After standing, go to Step 5.4

5.3 Preparation of soaked sample

(a) Place the filter paper, perforated plate and stem of 1 kg, and surcharge weights of 4.5 kg on the compacted specimen

(b) Immerse the surcharged specimen in water allowing free access of water to the top and bottom of the specimen

(c) Determine the initial reading for swell using either of the following procedures:

(i) Set the displacement-measuring device to be in contact with the top of the metal stem and record the initial displacement reading (h_1)

OR

(ii) Where the rigid support frame is to be removed from the mould during soaking, use the setting piece. Set the reading on the displacement measuring device against the setting piece before placing the frame on top of the mould and take the initial reading (h_1)

NOTE: Ensure that the frame can be accurately relocated to the same positions on the setting piece and the mould for subsequent readings.

(d) Allow the specimen to soak for the specified number of days, maintaining the water level above the mould during this period

(e) Record the displacement reading (h_2) after the specified number of days of soaking. Where the setting piece was used in Step (c), accurately relocate the frame in the same positions as for the initial readings on the setting piece and mould

(f) Remove the rigid support frame and displacement measuring device

(g) Remove the specimen from the water. Tilt the specimen to remove surface water. Return the mould to the vertical position and allow the specimen to drain downwards for approximately 15 minutes. Take care not to disturb the surface of the specimen during removal of the water

(h) Remove the 5.5 kg surcharge masses (i.e. perforated plate, stem and surcharge)

5.4 Testing

(a) Ensure that the loading machine is fitted with a suitable force-measuring device as specified in Apparatus for the anticipated CBR value

(b) Uncover the compacted specimen

(c) Without delay, place the annular surcharge on the surface of the specimen and then place the mould assembly in position beneath the penetration piston. Seat the penetration piston at the smallest possible load not exceeding:

(i) 50 N for expected CBR values equal to or less than 30%,

OR

(ii) 250 N for expected CBR values exceeding 30%

NOTE: The load is required to ensure satisfactory seating of the penetration piston and is considered as the zero load when plotting the load-penetration curve.

(d) If unsoaked, uncover the specimen

(e) Place the slotted surcharge to provide a total surcharge mass of 4.5 kg. Read, or reset to zero, the force-measuring device and displacement measuring device

NOTE: The displacement measuring device is to be mounted such that no other displacements in the equipment can influence the actual measured penetration.

(f) Apply the load uniformly so that the rate of penetration is 1 ± 0.2 mm/min. Record the load readings at consecutive penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5 mm as required below:

NOTE: Where data is captured electronically, ensure that recording commences prior to applying the load.

(i) Stop the test when a penetration cannot be achieved without damaging the apparatus (e.g. exceeding proving ring capacity or mechanical limits) and record the maximum penetration obtained

(ii) Where a penetration of at least 2.5 mm cannot be achieved, stop further testing and report the maximum penetration achieved

(iii) Where the load-penetration curve continues to be concave upwards at 7.5 mm penetration, additional readings at 10 mm and 12.5 mm are to be taken

(g) Remove the mould assembly from the machine and eject the specimen from the mould

(h) Determine moisture contents in accordance with T120 of both the following portions:

(i) A vertical slice of at least 1000 g over the full depth of the specimen (w_t)

(ii) Approximately the top 30 mm layer from the remainder of the specimen (w_{t30})

6. Calculations

(a) Calculate the Dry Density (ρ_D) of the sample before soaking as follows:

NOTE: ρ_D can also be designated as 'DD'.

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

$$V = \left(\frac{\pi D_m^{\,2}}{4 \times 1000} \right) \times (h_3 - h_4)$$

Where:

ρ_D = Dry Density (t/m³)

M_3 = Mass of mould and compacted specimen (g)

M_1 = Mass of mould (g)

V = Effective volume of the mould (mL)

w = Moisture content at time of moulding (% from T120)

D_m = Average internal diameter of the mould (mm)

h_3 = Height of the mould (mm)

h_4 = Height of the metal spacer disk (mm)

(b) Calculate the Laboratory Moisture Ratio (expressed as a percentage) as follows:

$$LMR = \frac{w}{OMC} \times 100$$

Where:

LMR = Laboratory Moisture Ratio (%)

w = Moisture content at time of moulding (%)

OMC = Optimum Moisture Content of the material as determined by T111 or T112 as appropriate (%)

(c) Calculate the Laboratory Density Ratio (expressed as a percentage) as follows:

$$LDR = \frac{\rho_D}{MDD} \times 100$$

Where:

LDR = Laboratory Density Ratio (%)

ρ_D = Dry Density of the sample (t/m³)

MDD = Maximum Dry Density of the material as determined by T111 or T112 as appropriate (t/m³)

(d) Calculate the Swell as follows:

$$S = \frac{(h_2 - h_1)}{117} \times 100$$

Where:

S = Swell (%)

h_1 = The initial displacement reading for swell (mm)

h_2 = The displacement reading for swell after the soaking period (mm)

(e) Plot the load-penetration curve at a suitable scale, which allows the force value (kN) to be determined for the calculation of the CBR value as specified in the table of Clause 7(j). Where the load-penetration curve concaves upwards initially, because of surface irregularities or other causes, adjust the zero point. Draw a tangent through the steepest part of the curve to intersect the horizontal scale. This point is the corrected zero point

NOTE: The load-penetration curve may be plotted by automatic means. Examples of typical load-penetration curves and corrected zero points are shown in AS 1289.6.1.1 Figure 6.

(f) Using the corrected values, determine the loads corresponding to penetrations of 2.5 mm and 5.0 mm ($P_{2.5}$ and $P_{5.0}$ respectively)

(g) Calculate the CBR as follows:

$$\text{CBR} = \text{Greater of: } \frac{P_{2.5}}{13.2} \times 100 \text{ OR } \frac{P_{5.0}}{19.8} \times 100$$

Where:

CBR = California Bearing Ratio (%)

$P_{2.5}$ = Load corresponding to penetration of 2.5 mm (kN)

$P_{5.0}$ = Load corresponding to penetration of 5.0 mm (kN)

(h) Record the greater calculated value as the CBR value of the sample

7. Reporting

Include the following data and results in the report:

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

(b) The compaction rammer used (i.e. Standard or Modified)

(c) The period of soaking in days

(d) The MDD and OMC of the material as determined by T111 or T112 as appropriate

(e) The target and the sample Laboratory Density Ratios (LDR_t and LDR) and the target and the sample Laboratory Moisture Ratios (LMR_t and LMR) to the nearest 1%

(f) The Moisture Content of the top 30 mm layer after penetration (to the nearest 0.1%)

(g) The Moisture Content of the full depth of the specimen after penetration (to the nearest 0.1%)

(h) The Swell as a percentage of the initial height (to the nearest 0.1%)

(i) Where the load-penetration curve is corrected by more than 2 mm, attach a plot of the Load-penetration Curve

(j) The California Bearing Ratio of the sample according to the table below, and the penetration at which it was determined

For CBR between (%)	Report CBR value to the nearest (%)
0 - 5	0.5
5 - 20	1
20 - 50	5
> 50	10

(k) Reference to this test method