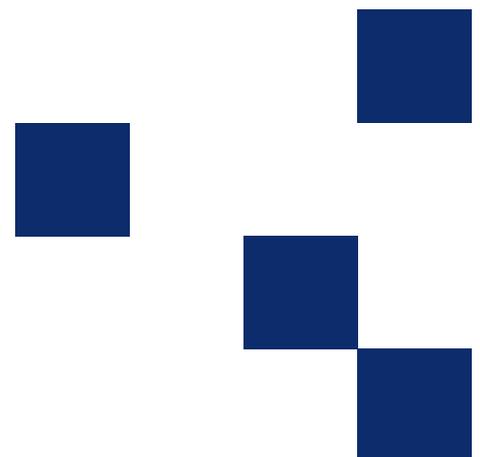




# Test method T132

Determination of the California bearing ratio of road materials modified or stabilised with proportions of cement, lime or other cementitious materials

OCTOBER 2012



---

## 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	D.Dash	Feb 2001
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 T132 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

## Test method T132

# Determination of the California bearing ratio of road materials modified or stabilised with proportions of cement, lime or other cementitious materials

### 1. Scope

- (a) This test method sets out the procedure for the determination of the California Bearing Ratio (CBR) of specimens of road materials (soil, gravels, crushed rocks, etc.) modified or stabilised by the incorporation of small quantities of cement, lime or other cementitious binders.
- (b) The method is not applicable to heavily bound materials or to materials containing larger amounts of cement because of the high resistance to penetration usually exhibited by such materials.
- (c) The method is applicable to both laboratory investigations and the testing of samples obtained from the field.
- (d) The specimens may be compacted using Standard Compaction, Modified Compaction, or compacted to such other densities as may be specified.
- (e) The method is applicable to that part of a sample which passes a 19.0 mm AS sieve, and is based on the method described in Australian Standard 1289.

### 2. Apparatus

- (a) A loading machine equipped with a moveable head or base capable of controlled travel at a uniform (not pulsating) rate of 1 mm/min. The machine shall be equipped with a load-indicating device readable and accurate in accordance with the following table:

CBR	Readable and Accurate to at least
< 2	10 N
2 - 5	25 N
5 - 10	50 N
10 - 20	110 N
> 20	225 N

- (b) A metal penetration piston of  $49.6 \pm 0.1$  mm diameter approximately 190 mm long.
- (c) A cylindrical metal mould with an internal diameter of  $152 \pm 0.5$  mm and internal effective height of  $178 \pm 0.5$  mm equipped with a metal extension collar 50 mm high and a perforated metal base plate 10 mm high, both of which can be firmly attached to the mould. The perforation in the base plate should not exceed 3 mm in diameter.
- (d) A metal spacer disc of  $150 \pm 0.5$  mm diameter and  $61 \pm 0.25$  mm thickness.
- (e) A perforated metal plate of  $150 \text{ mm} + 0.0 \text{ mm} - 0.5 \text{ mm}$  diameter and 6 mm high fitted with an adjustable stem. The perforations in the plate should not exceed 3 mm in diameter.
- (f) One annular metal surcharge and several slotted metal surcharges, each having a mass of  $2.25 \text{ kg} \pm 25 \text{ g}$  and a diameter of  $150 \pm 0.5$  mm with a central hole of  $55 \pm 0.5$  mm diameter.
- (g) A metal tripod (to support the dial gauge for measuring the amount of swell during soaking).
- (h) Dial gauges with a travel of 25 mm reading to 0.02 mm.
- (i) A metal rammer with a  $50 \text{ mm} \pm 0.5 \text{ mm}$  diameter face and a drop mass of  $2.7 \text{ kg} + 10 \text{ g} - 25 \text{ g}$  equipped with a suitable device to control the height of drop to a free fall of  $300 \text{ mm} \pm 2 \text{ mm}$ .

- (j) A metal rammer with a  $50 \text{ mm} \pm 0.5 \text{ mm}$  diameter face and a drop mass of  $4.9 \text{ kg} + 10 \text{ g} - 30 \text{ g}$  equipped with a suitable device to control the height of drop to a free fall of  $450 \text{ mm} \pm 2 \text{ mm}$ .
- (k) 37.5 mm and 19.0 mm AS sieves
- (l) A metal mixing and quartering tray
- (m) Mixing apparatus such as a trowel and quartering apparatus such as metal plates 400 mm by 125 mm and 200 mm by 125 mm.
- (n) Sample divider (riffle box) of appropriate size openings (optional)
- (o) A thermostatically controlled oven with good air circulation, capable of maintaining a temperature within the range of  $105^{\circ}\text{C}$  to  $110^{\circ}\text{C}$
- (p) A balance of suitable capacity readable and a limit of performance of 5g
- (q) Equipment for the determination of moisture content in accordance with T120, T121 or T180.
- (r) A jack, lever and frame or other device suitable for extruding specimens from the mould
- (s) A bowl suitable for thoroughly mixing increments of water with the test sample. A mixing machine (11 litre capacity) may be used.
- (t) Soaking tank of sufficient depth to immerse the mould in water
- (u) Filter papers, coarse, 150 mm diameter
- (v) A measuring cylinder, 100 mL
- (w) A porcelain mortar, 180 mm diameter, with porcelain and rubber pestles.
- (x) Metal dishes approximately 225 mm and 350 mm diameter.
- (y) A steel straightedge about 300 mm long, 25 mm wide and 3 mm thick, preferably with a bevelled edge
- (z) A 300 mm rule
- (aa) A rigid foundation on which to compact the specimen e.g. a concrete floor or a concrete block of at least 100 kg mass
- (bb) Airtight containers, suitable for curing moistened test specimens.

### 3. Sampling and Processing - Field Stabilised Materials

- (a) Materials stabilised in the field should be sampled as soon as practicable after the completion of mixing. Unless otherwise specified sampling shall be carried out within one hour of the commencement of mixing.
- (b) Immediately after each sample has been taken, it shall be sealed in an airtight container, sheltered and transported as soon as practicable to the laboratory for processing.
- (c) Except where otherwise specified the preparation and compaction of the test specimens, in accordance with *Clauses 4* and *6*, shall be completed within approximately one hour (60 - 75 minutes) of the commencement of mixing.

### 4. Preparation of Sample

- (a) If materials being used in a laboratory investigation have been previously prepared using T105, proceed directly to (e).  
When testing materials modified or stabilised in the field commence, immediately the sample is remove from the airtight container at (d).
- (b) Allow the sample to dry sufficiently to enable it to be crumbled. If necessary, dry the sample at a temperature not exceeding  $50^{\circ}\text{C}$ .
- (c) Break up any aggregations of particles in such a way as to avoid crushing any discrete particles. All aggregations or particles are to be broken down so that if the sample were screened on a 4.75 mm AS sieve only discrete particles would be retained. A rubber pestle should be used to avoid breaking sound pieces of mineral matter. Adhering material should be brushed from coarse pieces.

When in doubt as to whether lumps are to be broken, place some in water and boil. If slaking occurs, the material should be broken further with the rubber pestle.

- (d) Weigh the sample to be tested, then screen it on 37.5 mm and 19.0 mm AS sieves. Weigh, then discard, the material retained on the 37.5 mm and 19.0 mm AS sieves. Calculate the percentages retained on each of the two sieves.
- (e) Thoroughly mix all material passing the 19.0 mm AS sieve and reduce as necessary by quartering or riffing to provide;
  - (i) Not less than 7000 g of material for preparation of a California Bearing Ratio specimen (where a duplicate pair of specimens is to be moulded the portion prepared should not be less than 10000 g) and,
  - (ii) A further portion, of appropriate size, for moisture content determination by one of T120, T121 or T180
- (f) Where the moisture content of the material being tested is judged to be well below optimum curing, after an initial addition of water, may be required (refer *Clause 9 (b)*). Such initial curing must be carried out prior to the addition of the additive. In such cases the processes listed under *Clause 6* should be carried out after the initial curing.

## 5. Preparation of Additives for Laboratory Investigations

**WARNING: Cement and hydrated lime are relatively safe but care is required to protect the eyes and hands during use. Quicklime may be dangerous in the presence of moisture because of its highly caustic nature. Even small amounts of perspiration on the skin may react with quicklime and cause skin burns. Quicklime is especially dangerous to the eyes. Safety glasses, long sleeved coats and gloves should be worn, and protective cream applied to the hands and arms as required, when using cement, quicklime or hydrated lime in the laboratory.**

### 5.1 Cement

- (a) Cement used in laboratory investigations should be the same type, from the same source of supply or manufacture, as the cement proposed for use in the field. Unless otherwise specified or approved, the cement should be Type GP - General Purpose Portland Cement complying with the relevant requirements of AS 3972 - Portland and Blended Cements.
- (b) Where Blended Cements are specified for use in stabilisation works they should, unless otherwise specified, be Type GB - General Purpose Blended Cements complying with the relevant requirements of AS 3972 - Portland and Blended Cements.
- (c) Cement should be stored in sealed containers and protected from moisture until used. Cement which has been stored for three months or longer should not be used for laboratory investigations.

### 5.2 Lime

- (a) Hydrated lime shall comply with Specification 3054 - Hydrated Lime. No preparation is required prior to use.
- (b) Quicklime shall comply with Specification 3053 - Quicklime. Unless otherwise specified quicklime shall be of the High Reactive Quicklime type  
When laboratory investigations are being carried out using quicklime of very similar grading to that which will subsequently be used in the field the quicklime should be used as supplied.  
In all other cases, unless the additive being used has been supplied in ground form, the quicklime used in laboratory investigations shall be ground to pass a 2.36 mm AS sieve prior to use (refer *Clause 9 (d)*).
- (c) Lime and lime-pozzolan mixtures should be stored in airtight containers and protected from moisture and carbon dioxide until used.
- (d) Lime which is caked or shows other signs of absorption of moisture or carbon dioxide should not be used in laboratory investigations.

- (e) Except where the additive is known to be fresh and has been obtained from quality assured suppliers, the amount of available lime, expressed as calcium oxide and calcium hydroxide should be determined (using T430) each time hydrated lime or quicklime is used in a series of laboratory investigations.

### 5.3 Supplementary Cementitious Materials

#### 5.3.1 Fly Ash

- (a) Fly ash shall comply with the requirements of AS 3582.1, Fine grade.

#### 5.3.2 Ground Granulated Iron Blast Furnace Slag

- (a) Slag used shall comply with the requirements of AS 3582.2 Slag - Ground granulated iron blast furnace, together with the following additional requirements:
- (i) The source of material prior to milling shall be of cementitious grade, and shall have a glass content greater than 90%.
  - (ii) Mineral gypsum shall be added during the milling process to provide appropriate setting times.  
The Sulphuric Anhydride content of the final product, determined by testing in accordance with AS 3583.8, shall not exceed 3.0%.
  - (iii) The Fineness Index of the final product, determined by testing in accordance with AS 2350.8, shall be not less than 350 m<sup>2</sup>/kg.

### 5.4 Other Cementitious Stabilising Agents

- (a) Unless otherwise specified cementitious stabilising agents other than those specified in *Clauses 5.1, 5.2 and 5.3* shall be used as supplied.
- (b) Samples of such materials intended for use in laboratory investigations shall be stored in airtight containers (or as otherwise recommended by the manufacturer) until used.

### 5.5 Storage Time for Blended Stabilising Agents

- (a) Blended stabilising agents which have been stored for three months or longer should not be used for laboratory investigations.

## 6. Procedure

- (a) Clauses (c), (d) & (e) do not apply when testing materials which have been modified or stabilised in the field.
- (b) Determine the moisture content of the smaller test portion prepared in *Clause 4 (e)* in accordance with T120, T121 or T180.
- (c) Take the larger test portion prepared in *Clause 4 (e)* above and determine its mass to the nearest 1 g. Using the moisture content determined in (b) calculate the dry mass of this portion.
- (d) Calculate the required amount of prescribed cementitious additive as a percentage of the dry mass of the test portion. Weigh out this quantity of additive.
- (e) Add the required amount of the prescribed additive to the test portion, thoroughly mixing the materials to a uniform colour.  
Where the prescribed additive is quicklime, add a quantity of water equal to about two-thirds of the mass of the quicklime added to the materials. Carefully mix as necessary, observing the safety precautions given above. Slaking will occur rapidly with the generation of heat. The magnitude of the reaction will depend on the amount of quicklime present. Cover the mixture and allow to stand for 10 - 15 minutes. Re-mix to break up any lumps which may have formed.
- (f) Add sufficient water to provide a moisture condition suitable for compacting the test specimens. Unless otherwise specified aim for a moisture content slightly dry of, but as close as practical to, the optimum moisture content appropriate to the intended compactive effort, as determined by T130, for the particular additive content.  
Where the moisture content of the material being tested is judged to be well below optimum curing, after an initial addition of water, may be required (refer *Clause 9 (b)*). Such curing must be

carried out prior to the addition of the additive. In such cases the processes listed under this *Clause* should be carried out after the initial curing.

- (g) Thoroughly mix the added water into the material.
- (h) Place the mixture in a sealed container and allow to cure at a temperature of  $23^{\circ} \pm 2^{\circ}\text{C}$ . Unless otherwise specified the test specimens should be moulded approximately one hour (60 - 75 minutes) after commencement of mixing.
- (i) Weigh the mould and record the mass ( $M_2$ ). 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.
- (j) Thoroughly re-mix the cured test portion to break up any lumps which may have formed, and determine the moisture content by one of T120, T121 or T180 on an appropriately sized portion.
- (k) If necessary adjust the moisture content to that provided in (f) above.
- (l) Compact the mixture into the mould by the specified compactive effort. Unless otherwise specified, use Standard Compaction.
  - (i) **Standard Compaction:**  
Compact the mixture into the mould in three layers not varying in compacted thickness by more than 5 mm. Subject each layer to 53 uniformly distributed blows of a 2.7 kg rammer falling freely from a height of 300 mm.  
*Or*
  - (ii) **Modified Compaction:**  
Compact the mixture into the mould in five layers not varying in compacted thickness by more than 5 mm. Subject each layer to 53 uniformly distributed blows of a 4.9 kg rammer falling freely from a height of 450 mm.
- (m) Use only sufficient material to slightly overfill the mould leaving not more than 5 mm to be struck off after removing the collar.
- (n) Free the material from around the collar and then carefully remove the collar.
- (o) Level the compacted material by means of the straightedge. Patch with smaller material any holes developed in the surface by removal of coarse material.
- (p) Remove the perforated base plate and spacer disc. Weigh the mould plus compacted specimen and record the mass ( $M_1$ ). Measure and record the height of the specimen (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 specimen in contact with the filter paper. Place the stem and perforated plate on the compacted specimen and apply a surcharge of 4.5 kg.
- (q) Thoroughly mix the remaining material. Then check the moisture content ( $w$ ) by one of test methods T120, T121 or T180.
- (r) Immerse the surcharged specimen in water allowing free access of water to the top and bottom of the specimen. Place the metal tripod and dial gauge in position on top of the mould with the dial gauge in contact with the adjustable stem. Record the initial dial gauge reading ( $D_1$ ), for measurement of swell. Allow the specimen to soak for four days, or such other period as has been specified, maintaining the water level above the mould during this period.
- (s) Where a duplicate specimen is to be moulded from the one test portion carefully mix the remaining material then repeat processes (i) to (r).  
Provided care has been taken to avoid loss of moisture during moulding of the first specimen the moisture content determinations in (j) and (q) may be omitted for the duplicate specimen.
- (t) After four day's soaking, record the dial gauge reading ( $D_2$ ). Remove the tripod and dial gauge and remove the specimen from the water. Tilt the specimen to remove surface water. Remove the surcharges and perforated plate and allow the specimen to drain downwards for 15 minutes. Take care not to disturb the surface of the specimen during removal of the water. Commence the penetration test immediately.
- (u) Place a 2.25 kg surcharge on the surface of the specimen and place the mould assembly in position beneath the penetration piston. Commence the penetration test immediately using the loading

machine fitted with suitable proving ring as specified in *Clause 2(a)* for the anticipated CBR value. Seat the penetration piston with the smallest possible load not exceeding 45 N. Replace other surcharges to provide a total surcharge of 4.5 kg. Read, or set to zero, the load indicator and penetration gauge.

- (v) Apply the load uniformly so that the rate of penetration is approximately 1 mm/min. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0 and 7.5 mm.
- (w) The following is to be adopted if penetration beyond a given level cannot be achieved:
  - (i) Penetration up to and including, 2.5 mm:  
The CBR test is not appropriate and must be abandoned.
  - (ii) Penetration in excess of 2.5 mm:  
Terminate the test at that point to avoid damage to the equipment.
- (x) Record the maximum penetration achieved.
- (y) Remove the mould assembly from the machine and eject the specimen from the mould. Determine the moisture content of the top 30 mm layer and also determine the moisture content of a sample taken from the full depth of the specimen.

## 7. Calculations

- (a) Compute the mass of the specimen  $M_3$ , before soaking as follows:

$$M_3 = M_1 - M_2$$

Where

$$M_1 = \text{mass of mould + specimen}$$

$$M_2 = \text{mass of mould}$$

- (b) Calculate the dry density of the specimen before soaking as follows:

$$\text{Dry Density} = \frac{M_3 \times \frac{1}{V}}{100 + w}$$

Where

$$M_3 = \text{mass of compacted specimen}$$

$$w = \text{percentage moisture content determined in Clause 6 (g).}$$

$$V = \text{volume of mould (mL)}$$

- (c) Plot the load penetration curve. In some instances the load penetration curve may concave upwards initially, because of surface irregularities or other causes, and in such cases the zero point is adjusted. Draw a tangent through the steepest part of the curve to intersect the horizontal scale. This point is the corrected zero point. Examples of corrections are shown in AS 1289.
- (d) Using the corrected values determine the loads corresponding to penetrations of 2.5 mm and 5.0 mm and calculate the percentage ratio of these loads to the standard loads of 13.3 kN and 20.0 kN respectively. These percentage ratios are the CBR values. The CBR reported is normally that at 2.5 mm penetration. When the CBR at 5.0 mm penetration is greater, repeat the test. If the check test gives a similar result, report the CBR at 5.0 mm penetration.
- (e) Calculate the swell as a percentage of the original height as follows:

$$\text{Swell} = \frac{D_2 - D_1}{h} \times 100 \quad \text{t/m}^3$$

Where

$D_1$  = dial gauge reading before soaking (mm)

$D_2$  = dial gauge reading after soaking (mm)

$h$  = initial height (mm)

## 8. Reporting

**Include the following data and results in the report:**

- (a) Types, sources and proportions of all additives, including, where lime is used in laboratory investigations, the available lime expressed as calcium oxide and calcium hydroxide. (The available lime shall have been obtained from either the Product Certification or by testing in accordance with T430.
- (b) Percentages of material retained on 37.5 mm and 19.0 mm AS sieves
- (c) Moisture content at which specimen was compacted
- (d) Compactive effort applied (Standard / modified / other - specified).
- (e) Dry density of specimen as compacted in  $\text{t/m}^3$  to the nearest  $0.01 \text{ t/m}^3$ .
- (f) Soaking period
- (g) Moisture content of specimen after penetration
- (h) Swell.
- (i) Maximum penetration (where test terminated because of resistance to further penetration)
- (j) CBR of specimen and the penetration at which it was determined

For CBR between	Report Values to nearest
0 and 5%	0.5
5 and 20%	1
20 and 50%	5
in excess of 50%	10

## 9. Techniques

- (a) The removal of small amounts of material retained on the 19.0 mm AS sieve will affect the CBR obtained only by amounts comparable with the experimental error involved in measuring the CBR. The removal of a large proportion of material coarser 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.
- (b) Materials being tested during laboratory investigations may need curing to ensure even distribution of added moisture. Sandy materials may be satisfactory cured in one hour, but heavy clays may require a minimum of several days.  
Such curing must be carried out prior to the addition of the cementitious additive, i.e. prior to the commencement of the processes listed under *Clause 6*.
- (c) Moisture content determinations may be made using T120, T121 or T180. However T121 and T180 may only be used when results have previously been calibrated, against those from T120, according to the method described in AS 1289.B3.1, for the range of materials being used.
- (d) The coarser particles of quicklime may hydrate slowly after compaction. In some cases the resulting volume increase will cause compacted test specimens to disintegrate.

Potential problems associated with volume increase on hydration are best highlighted during laboratory testing so wherever possible the laboratory testing should be carried out using the same additive (of the same grading) as will be used in the field. However, when the source of the additive for field stabilisation is still to be determined a uniform additive, ground to pass a 2.36 mm AS sieve, should be used.