Transport Roads & Maritime Services

Test method T144

Hydrated lime for road construction materials (Lime demand test)

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 Summary	D Dash	Feb 2001
Ed 2/ Rev 0	All	Revised Test – Title changed. -2.36 mm used. Uses smaller sub-samples, water not boiled, less stirring, report lime demand and lime saturation.	D Hazell	Feb 2009
Ed 2/ Rev 1	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 T144 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T144

Hydrated lime for road construction materials (Lime demand test)

1. Scope

This test method sets out the procedure for determining the percentage of hydrated lime required to satisfy demand in road construction materials.

NOTE: The Test Method is based on Main Roads Queensland Q133-1998 Lime Demand Test. The method has been altered so that the mass of sub-sample determines the volume of water required to achieve a dilution of 30 g in 75 mL.

2. General

(a) The method is applicable to that portion passing a 2.36 mm AS sieve

NOTE: The fine portion is mainly responsible for the lime demand with minimal affect from intermediate and coarse fractions.

(b) A soil will react with the calcium hydroxide in lime through cationic exchange and pozzolanic responses from reactive clay minerals. The method determines the lime demand of the existing material using an extended pH test and gives a minimum hydrated lime application rate for soil modification and stabilisation

NOTE: The lime content corresponds well with optimum lime contents for long term effective stabilisation. The design rates based on hydrated lime may need to be converted to quicklime.

(c) The following materials are required for the test:

(i) Fresh hydrated lime in accordance T105 Appendix B

(ii) Distilled or de-ionised water

(iii) Neutral and high pH buffer solutions for the pH meter (e.g. pH 7 and pH 10 to 12)

NOTE: The shelf life of pH 7 buffer solutions is about 12 months while that of pH 10 to 12 buffer solution is about 6 months. Refrigerate buffer solutions and avoid contamination through reuse or becoming carbonated by exposure to air.

3. Apparatus

(a) A pH meter complete with combination type high alkaline pH electrode with a scale accurate and readable to 0.1 pH

NOTE: A suitable electrode is manufactured using a medium lithium glass for measuring pH up to 12.4.

(b) A balance of at least 1 kg capacity and a limit of performance of 0.1 g

(c) A balance of at least 500 g capacity and a limit of performance of 0.01 g

(d) Beakers 100 mL with watch glasses (at least 9)

(e) A suitable measuring cylinder

(f) Magnetic stirrer and magnetic stirrer bars

(g) Rubber-tipped glass stirring rods

(h) Wash bottle

(i) Timer

4. Preparation

(a) Samples shall be prepared in accordance with T105. The proportion passing the 2.36 mm AS sieve ($P_{2.36}$) is required for the calculations

(b) Determine the available lime content of the hydrated lime as calcium hydroxide to be used in the laboratory investigation in accordance with T430

(c) Determine the mass (M_1) of 9 beakers to be used for each sub-sample and label each

(d) Divide the sample into 10 sub-samples passing the 2.36 mm AS sieve with a mass in the range 35 ± 5 g

NOTE: 1 sub-sample for moisture content, 8 for the test and 1 as a spare.

(e) Determine the moisture contents (w) using one -2.36 mm sub-sample in accordance with T120

(f) Place each of the 9 sub-samples in a 100 mL beaker and carry out the following:

(i) Determine the mass (M_2) of each beaker plus the moist sub-sample.

(ii) Cover each with a watch glass

(g) Set up the pH meter in accordance with the operating procedure. Calibrate using neutral and high buffer solutions. After each use, wash the electrode and leave in a beaker of distilled or de-ionised water

NOTE: In the absence of an operating procedure the manufacturer's instructions must be followed.

5. Procedure

5.1 Adding Lime

(a) Place 3 g of hydrated lime in a separate 100 mL beaker. Add 75 mL of distilled or de-ionised water to the hydrated lime. Stir the lime solution vigorously for 2 minutes with the magnetic stirrer. Cover with a watchglass and stand for 2 to 2¼ hrs

(b) Calculate the required mass of binder 'M_B' to be added to each of the 8 sub-samples according to Calculation 6(a) where the binder contents 'B' are:
0%, 1%, 2%, 3%, 4%, 5%, 6% and 7%

NOTE: Experience with the material may alter the % lime increments to exceed the pH of the lime solution.

(c) Calculate the required volume of water 'V_C' to be added to each of 8 sub-samples according to Calculation 6(b)

(d) To each of 8 beakers containing the sub-samples:

(i) Remove the cover

(ii) Add the required volume 'V_C' of distilled or de-ionised water

(iii) Add the required mass of lime 'M_B'

(iv) Stir the soil-lime mixture vigorously for 1 minute. Ensure that all of the material has been wetted

(v) Replace cover. Label each sub-sample with the lime content 'B'

NOTE: One sub-sample is a spare.

5.2 Determining pH

(a) After the required time after preparing the lime solution in Step 5.1(a), carry out the following:

(i) Restart the stirrer and lower the pH electrode into the solution until the bulb is just covered

(ii) Read the pH meter at 1 minute intervals or longer and continue readings until 3 successive values are within 0.05 pH. Record the 3 values to the nearest 0.01 pH

NOTE: Readings should stabilise within 1 to 2 minutes.

(iii) Remove the electrode from beaker, wash with distilled water and check the reading of the meter using the high pH buffer solution according to Step 4(g). If the reading varies by more than 0.05 pH from that determined during calibration, recalibrate the pH meter according to Step 4(g) and repeat 5.2(a)

(b) Starting with the beaker containing the soil-lime mixture with the lowest added lime content:

(i) Stir the mixture with the magnetic stirrer and lower the pH electrode into the suspension until the bulb is just covered

(ii) Read the pH meter at 1 minute intervals or longer and continue readings until 3 successive values are within 0.05 pH. Record the 3 values to the nearest 0.01 pH

NOTE: Readings should stabilise within 1 to 2 minutes.

(iii) Repeat for each of the 8 soil-lime mixtures

(c) If the pH of a beaker with soil-lime mixture is not at least equal to the pH of the lime solution, prepare a further soil-lime mixture with a higher content of lime

NOTE: Use the spare sub-sample if available.

(i) Determine the mass of binder according to Step 5.1(b)

(ii) Prepare the soil-lime mixture according to Step 5.1(c)

(iii) Determine the pH according to Step 5.2(b)

6. Calculations

(a) Calculate the mass of the lime (M_B) to be added to each sub-sample as follows:

$$M_B = M_w \times \frac{B}{(100 + w)}$$

$$M_w = M_2 - M_1$$

Where:

M_B = Mass of lime (g)

M_w = Mass of moist sub-sample (g)

B = Target lime content (%)

M_2 = Mass of moist sub-sample and beaker (g)

M_1 = Mass of beaker (g)

w = Moisture content of sub-sample (% from T120)

(b) Calculate the volume of water (V_C) to be added to each beaker with soil-lime mixture as follows:

NOTE: The calculation is based on a combined dry mass of 30 g being mixed in 75 mL of water.

$$V_C = 2.5M_W \times \frac{(100 + B)}{(100 + w)} \text{ …OR … } 2.5M_B \times \frac{(100 + B)}{B}$$

Where:

V_C = Volume of water (mL)

M_w = Mass of moist sub-sample (g)

M_B = Mass of lime (g)

B = Target lime content (%)

w = Moisture content of sample (% from T120)

(c) Calculate the average pH value for each soil-lime mixture from the 3 readings that are within 0.05 pH

(d) Plot a graph of pH versus % mass of lime (B) added for each sub-sample tested. Join each point.

(i) Draw the line parallel to the 'x' axis corresponding to the pH of the lime solution

(ii) Record the Lime Demand (L_D) where the pH reaches a plateau (i.e. the lowest pH value for three successive soil-lime mixtures that vary by no more than 0.05 pH)

(iii) Record the point (L_1) where the two lines intersect

NOTE: The Lime Demand should be the same as the pH of the hydrated lime mixture $L_D = L_1$. However, the presence of cations such as sodium in the soil pore water may reduce the solubility of the hydrated lime and reduce the pH of the solution so that $L_D < L_1$.

(e) Calculate the percentage of material ($P_{-2.36}$) passing the 2.36 mm sieve

(f) Calculate the percentage of lime (L_S) needed to saturate the whole soil as follows:

$$L_S = \frac{L_1 \times P_{-2.36}}{100}$$

Where:

L_S = Percentage of lime to saturate the whole soil (%)

L_1 = Percentage of lime required to saturate the sample (%)

$P_{-2.36}$ = Percentage of material passing the 2.36 mm sieve (%) that was obtained during preparation (Step 4(a))

7. Reporting

Include the following results in the report:

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

(b) Type and source of hydrated lime

(c) The available lime content expressed as calcium hydroxide of the hydrated lime used in the laboratory investigation (from T430)

(d) The Lime Demand (L_D) to the nearest 0.5% for the 2.36 mm portion

(e) The percentage of lime by mass (L_S) to the nearest 0.5% needed to saturate the whole soil

(f) Reference to this Test Method