

Australian Standard[®]

AS 1289.3.9.1:2015

Methods of testing soils for engineering purposes

Method 3.9.1: Soil classification tests— Determination of the cone liquid limit of a soil

1 SCOPE

This Standard sets out a method for the determination of the cone liquid limit of a soil using a cone penetrometer. The definition of liquid limit inherent in this method is not the same as that in the method using the Casagrande apparatus (AS 1289.3.1.1) although the values can be numerically similar.

NOTE: The potential difference in values between the standard method for liquid limit (AS 1289.3.1.1) and the cone liquid limit may be of great significance in testing materials for compliance with specifications. In such cases the two methods should not be regarded as interchangeable.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1152 Test sieves

1289 Methods of testing soils for engineering purposes

1289.0 Part 0: General requirements and list of methods

1289.1.1 Method 1.1: Preparation of disturbed soil samples for testing

1289.2.1.1 Method 2.1.1: Soil moisture content tests—Determination of the moisture content of a soil—Oven drying method (standard method)

1289.3.1.1 Method 3.1.1: Soil classification tests—Determination of the liquid limit of a soil—Four point Casagrande method

BS

2000 Bitumen and bitumen binders

2000-49 Part 49: Determination of needle penetration

3 APPARATUS

The following apparatus is required:

- (a) An appropriately sized container, with close fitting cover, made from a non-absorbent material.
- (b) An appropriately sized flat plate approximately 10 mm thick made from non-absorbent material.
- (c) Appropriately sized palette knives.
- (d) A manual or automatic release penetrometer generally complying with BS 2000-49, with the exception of the total mass of the needle and shaft [see Step (e)], and generally as illustrated in Figure 1.

- (e) A metal right cone of length not less than 32 mm and an included angle of $30 \pm 1^\circ$. The cone shall have a smooth, unblemished, polished surface and shall be replaced when the point can no longer be felt when brushed lightly with a fingertip when the tip of the cone is pushed through a hole of 1.5 ± 0.1 mm diameter bored through a metal plate 1.75 ± 0.1 mm thick. The cone is fitted to the penetrometer in the manner shown in Figure 1. The combined mass of the cone and the sliding shaft shall be 80.00 ± 0.05 g.
- (f) A rigid cup of near constant internal diameter of not less than 53 mm and internal height not less than 40 mm with a smooth rim parallel to a flat base.
- (g) Apparatus for moisture content determination, as described in AS 1289.2.1.1.
- (h) A wash bottle and potable water.
NOTE: Distilled, demineralized or deionized water should be used for when testing for reference purposes. For saline soils or other special purposes consideration should be given to using compatible water.
- (i) A metal straightedge (optional).

4 PROCEDURE

The procedure shall be as follows:

- (a) Obtain a test portion, prepared in accordance with AS 1289.1.1, and pass enough material through the 425 μ m sieve to produce 250 g of soil. Alternatively, all soil that passes a 425 μ m sieve may be used in the natural state with minimal further preparation.

NOTES:

- 1 When a soil is tested in the natural condition the results may differ from those obtained if the soil has been air-dried or oven-dried at low temperature (50°C).
- 2 If the plasticity index is to be calculated using the results from this test then use the same method of preparation for both the liquid limit and the plastic limit tests.

- (b) Mix the sample thoroughly in the container, or on the flat plate, using the palette knife while incrementally adding water from the wash bottle until the soil becomes a homogenous paste.

NOTES:

- 1 Inadequate mixing may result in an erroneous value being obtained for the liquid limit (usually below the true value). This is due to the time necessary for water to penetrate into absorptive particles and into the internal structure of some clays, and for mechanical disturbance to break up aggregations of finer particles, particularly clays. The sample should be mixed to a paste by using firm pressure with the palette knives against the surface of the container or the flat plate. For highly plastic clays other techniques may be needed, in the initial stages of water addition, to bring the material to a suitable consistency.
- 2 Soils of medium to high plasticity will require mixing times of more than 3 min. Mixing times of over 5 min may be required for high plasticity clays to obtain uniform distribution of moisture.
- 3 The consistency of the soil mixture should be such that, when tested according to Steps (e) to (k), the cone penetration is about 15 mm.

- (c) Cover the soil in a container and allow it to cure for at least 12 h at room temperature.

NOTE: After final mixing and before testing the sample should stand at least 12 h in a container with a close fitting lid to minimize moisture loss and to allow the water to permeate throughout the soil. Certain soils, particularly clayey soils, may need to stand for at least 24 h to allow thorough permeation of the water through the soil. If tested with inadequate curing of the sample unreliable and/or non-repeatable results will be obtained.

- (d) After completion of the curing thoroughly remix the cured soil for more than 1 min

- (e) Carefully fill the clean cup with the soil paste using a palette knife to place the soil in the bottom of the cup and exert sufficient pressure on the knife to exude the paste outwards to ensure removal of any air from the mixture. Continue adding the soil to the cup in this manner until the soil is above the level of the cup rim.

NOTES:

- 1 The presence of air bubbles within the soil sample in the cup can affect the penetration of the cone, leading to unreliable results. This aspect is critical and care is essential in the filling of the cup to avoid entrapping air.
 - 2 When not otherwise required for mixing or filling the cup, the soil sample in the container should be covered with either a close fitting lid or a damp cloth to prevent the sample from drying out.
- (f) Holding the straight edge or palette knife at low angle to the cup surface and using less than three strokes remove excess material to leave a smooth surface that is level with the rim of the cup.
 - (g) Carefully place the cup plus levelled soil centrally under the cone making sure that both the cup and the penetrometer stand are squarely seated on firm clean and horizontal base.
 - (h) Lower the cone carefully so that its tip just contacts the surface of the soil then clamp it in that position. Carefully lower the dial gauge plunger to contact the top of the sliding shaft and record the dial gauge reading, (R_1), to the nearest 0.1 mm. Alternatively, where the cone and dial gauge are mounted on the same arm, the initial reading (R_1) may be taken before the cone is lowered to the surface of the soil.
 - (i) Release the cone and allow to freely penetrate into the soil for a period of 5 ± 1 s. Then reclamp it taking care not to jerk the apparatus.
 - (j) Lower the dial gauge plunger carefully to contact the top of the sliding shaft and record the dial gauge reading, (R_2), to the nearest 0.1 mm.
 - (k) Determine the cone penetration as ($R_2 - R_1$), in millimetres.
 - (l) Lift out the cone and clean it carefully. Return the soil in the cup to that remaining in the container and remix for about 30 s. Clean and dry the cup and repeat Steps (e) to (k).
 - (m) If the two penetration determinations differ by not more than 1.0 mm, obtain and record their mean value and proceed to Step (n) but if the two cone penetration determinations differ by more than 1.0 mm, return to Step (l) and repeat Steps (e) to (k) until two successive penetrations differ by not more than 1.0 mm.

NOTE: Failure to obtain agreement on repeat penetrations can be the result of either the inclusion of air bubbles in the soil in the cup (in which case the practice of filling the cup should be assessed) or insufficient curing of the soil (in which case a further period of curing in an airtight container should be allowed).

- (n) With a palette knife return the material from the cup to the container and remix the soil for about 30 s. Remove a quantity of soil (about 10 g) from the container and determine the moisture content in accordance with AS 1289.2.1.1.

NOTES:

- 1 The quantity of 10 g, which is taken as the moisture content sample, is less than that required by AS 1289.2.1.1; however, because of the uniformity of the soil that constitutes the sample, it is considered to be a satisfactory quantity.
- 2 In soils of low plasticity, it is possible that moisture movements in the vicinity of the cone during the penetration by the cone will mean the moisture content of the material around the penetration hole is not representative. For these soils, sampling for moisture content determination has to be from the container. For soils of medium to high plasticity, the sample for moisture content determination may be taken from the soil around the penetration hole in the cup. A sample of 10 g is adequate.