NEW ZEALAND STANDARD

METHODS OF TESTING SOILS FOR CIVIL ENGINEERING PURPOSES

Part 2
Soil classification tests

TEST 2.2
DETERMINATION OF THE LIQUID LIMIT

2.2.1
Scope
This method covers the determination of the liquid limit of a soil which has not been dried below natural water content. The method may also be used on previously dried soils (see Note (1)).

2.2.2
Related documents

2.2.2.1
The provisions of Part 1 of this Standard are applicable to, and shall be read in conjunction with, this method of test. Reference is made to Tests 2.1 and 3.4 of this Standard.

2.2.2.2
Reference is made in this method of test to the following British Standard:

BS 903 – Methods of testing vulcanized rubber Part A26:1969 Determination of hardness.

2.2.3
Apparatus
(a) A flat glass or other smooth non-absorbent mixing plate (a convenient size is 10 mm thick and 500 mm square).
(b) Two palette knives with blades about 150 mm long and 25 mm wide, one palette knife with a blade about 100 mm long and 10 mm wide, and one plasterer's small trowel.
(c) A mechanical device incorporating the details illustrated in fig. 2.2.1 (see Note (2)).
(d) A shock-absorbent base approximately 175 mm square and 24 mm thick made from a double-glued thickness of wood fibre softboard (Pinex) (see Note (3)).
(e) A grooving tool incorporating the details illustrated in fig. 2.2.2 (see Note (4)).
(f) An evaporating dish (a convenient size is about 150 mm diameter) or a thin plastics sheet.
(g) Apparatus for water content determination as specified in Test 2.1 (see Note (5)).
(h) A wash bottle with a fine jet or spray containing distilled water.
(j) A non-corrodible airtight container for storage of excess sample.

2.2.4
Adjustment of apparatus
(a) Inspect the liquid limit device to determine that it is clean, dry, and in good working order so that the cup falls freely and does not have noticeable wobble. There should be no pronounced groove in the cup caused by the grooving tool. Also inspect the grooving tool to determine that it is clean and dry, and that the critical dimensions are as shown in fig. 2.2.2 (see Note (4)).
(b) Adjust the height to which the cup is lifted so that, when the cup is raised to its maximum height by turning the handle, the 10 mm gauge will just pass between it and the base.
(c) Place the liquid limit device on the shock absorbent base and ensure that this base is in position whenever blows are being counted.

2.2.5
Selection of material
(a) If other test results, such as natural water content or plastic limit, are to be correlated with the liquid limit, ensure that the material used for their determination is from the same well mixed sample. Do not mix layers of soil which may have different plasticities.
(b) Samples on which this test is carried out will be normally one of the following two kinds:
(1) *Whole soils at natural water content where all or nearly all the material would pass a 425 μm test sieve.*
Use as received, separating coarse particles by hand and discarding them during the early stages of the mixing process.
(2) *Fractions of whole soils passing a 425 μm test sieve.*
Usually these will have been separated by

Single User PDF Terms & Conditions

You have material which is subject to strict conditions of use. Copyright in this material is owned by the New Zealand Standards Executive. Please read these terms and conditions carefully, as in addition to the usual range of civil remedies available to Standards New Zealand on behalf of the New Zealand Standards Executive for infringement of copyright, under New Zealand law every person who infringes copyright may be liable to a fine of up to $10,000 for every infringing copy or imprisonment of up to 5 years, or a fine of up to $150,000 or imprisonment not exceeding 5 years.

You have access to a single-user licence to read this non-revisable Adobe Acrobat PDF file and print out and retain ONE printed copy only.

We retain title and ownership of the copyright in this PDF file and the corresponding permitted printed copy at all times.

Under this license use of both the PDF file and the single permitted printed copy of this PDF file you may make are restricted to you. Under no circumstances are you permitted to save, sell, transfer, or copy this PDF file, the one permitted printed copy of this PDF file, or any part of either of them.

You undertake that you will not modify, adapt, translate, reverse engineer, decompile, disassemble or create derivative works based on any of the downloaded PDF file, nor will you merge it with any other software or document, even for internal use within your organization.

Under no circumstances may this PDF file be placed on a network of any sort without our express permission.

You are solely responsible for the selection of this PDF file and any advice or recommendation given by us about any aspect of this PDF file is intended for guidance only and is followed or acted upon entirely at your own risk.

We are not aware of any inherent risk of viruses in this PDF file at the time that it is accessed. We have exercised due diligence to ensure, so far as practicable, that this file does not contain such viruses.

No warranty of any form is given by us or by any party associated with us with regard to this PDF file, and you accept and acknowledge that we will not be liable in any way to you or any to other person in respect of any loss or damage however caused which may be suffered or incurred or which may arise directly or indirectly through any use of this PDF file.

Regardless of where you were when you received this PDF file you accept and acknowledge that to the fullest extent possible you submit to New Zealand law with regard to this licence and to your use of this PDF file.

the method specified in 1.6.5.2 (a) of Part 1. Use as received (see Notes (1) and (6))

2.2.6
Procedure

(a) Take a specimen of at least 250 g, place it on the mixing plate and mix thoroughly at either natural water content or with addition of sufficient distilled water in small increments to make the material workable, using the large palette knives or the trowel, or both.

(b) Continue mixing and adding water until the water content is slightly higher than the liquid limit. The desired consistency is equivalent to that requiring 10 to 15 blows in the liquid limit device. With experience the required consistency may be judged without carrying out a trial in the device.

(c) Collect into a compact mass and cover with an evaporating dish or similar cover. Label the cover with the sample number of the specimen.

(d) Leave at least overnight at a reasonably constant temperature. This allows the water to reach equilibrium with the soil grains (see Note (7)).

(e) Remix on the mixing plate. Experience has shown that mixing for about 5 to 10 min is required to ensure thorough mixing at this stage (see Note (8)). Take care that thin smears of soil in a partially dry condition on the mixing plate are not mixed back into the specimen. A damp cloth or plastic sponge may be used to wipe the mixing plate as required. Gather the specimen into a compact mass.

NOTE – The following steps (f) to (h) inclusive should be carried out as rapidly as is consistent with careful work.

(f) From the specimen, place sufficient material in the cup of the liquid limit device, with the cup resting on the base, so that after it is levelled off with the small palette knife, the surface is horizontal and coincides with the lower edge of the cup. Remove any excess soil above the horizontal surface. Keep the excess of the specimen on the mixing plate covered to minimize evaporation.

(g) Form a smooth, full depth groove in the material in the cup with a single stroke of the grooving tool. The groove must be on the diameter of the cup passing through the centre of the hinge, and the grooving tool must be used with the bevelled edge facing the direction of movement. The stroke must be towards the lower edge of the cup and the tool held normal to the cup throughout the stroke. Should the single stroke of the tool tear the sides of the groove, remix the soil in the cup and gradually form the groove with no more than three strokes, cutting deeper each time. The completed groove must be no larger than that normally formed with a single stroke of the tool (see Note (9)).

(h) Rotate the handle of the liquid limit device at 2 rev/s. Count the number of blows required to cause the two parts of the soil to come in contact at the bottom of the groove over a length of 13 mm. The handle of the grooving tool shown in fig. 4 may be used to gauge this length (see Notes (10), (11) and (12)). If the number of blows required to close the groove is:

(1) Between 15 and 25 inclusive, record the number of blows and proceed to step (j);

(2) Less than 15, some drying and mixing will be necessary, as in step (q).
Return the material from the cup to the mixing plate. Wash and dry the cup of the liquid limit device. Repeat from step (e).

(3) Greater than 25, return the material from the cup to the mixing plate and mix with the remainder of the specimen. Wash and dry the cup of the liquid limit device. Thoroughly mix in an additional small quantity of water and allow a further period of curing of at least 2 h, depending on the amount of water added. Repeat from step (e).

(j) Add the material removed by the grooving tool, together with a little extra from the mixing plate, to that remaining in the cup. Thoroughly mix the material in the cup and level it off as before.

(k) Repeat steps (g) to (j) until the difference between the number of blows for closure in two consecutive determinations is not greater than one (see Note (13)). Record the number of blows for closure from the last determination.

(m) With the small palette knife take about 5 to 10 g of the material from adjacent to the groove, and determine the water content as specified in Test 1. Take particular care to ensure that the mating surfaces of the weighing bottle remain clean. Record the number of the weighing bottle.

(n) Add the material remaining in the cup to that on the mixing plate.

(p) Wash and dry the cup of the liquid limit device, the grooving tool and the palette knives.

(q) Spread and mix the specimen on the mixing plate for several minutes, thus allowing some water to be lost by evaporation. To assist this process when a heavy clay is being tested, an electric fan may be used to increase the air flow over the specimen. Ensure that excessive drying does not take place so that the subsequent blow count would exceed 35. Gather the specimen into a compact mass.

(r) Repeat steps (f) to (q) until determinations of the number of blows have been made at four separate water contents. Ideally, two determinations will be made with the number of blows lying between 15 and 25 and two lying

between 25 and 35. Retain the remaining portion of the specimen in a sealed container until the calculations have been completed.

2.2.7
Calculations

(*See* Form 2.2, 2.3, 2.4). Plot the relationship between water content and corresponding number of blows on a semi-logarithmic chart with the percentage water contents as ordinates on the linear scale and the number of blows as abscissae on the logarithmic scale. Draw the best straight line fitting the plotted points. This is known as the flow curve.

2.2.8
Reporting of results

2.2.8.1

Report the following value:

The liquid limit (LL) of the soil (the water content corresponding to the intersection of the flow curve with the 25 blows abscissa) to the nearest whole number, written without a percentage symbol. (See Note (5)).

2.2.8.2

State whether the material used in the test was whole soil, or fraction passing a 425 μm test sieve.

2.2.8.3

State the history of the sample; for example, natural state, air-dried, oven-dried or unknown.

2.2.8.4

State that the result was obtained in accordance with this Standard Test Method.

NOTES ON TEST 2.2

(1) *Effects of drying.* Wherever possible soils should be at natural water content when preparation for testing is begun. If drying has occurred before testing, the limit value will probably have changed. The plasticity of soils containing organic colloids and certain types of inorganic colloid such as allophane (commonly derived from volcanic rocks – see Test 3.4) is highly sensitive to drying. The effects of drying can be determined by comparing the limit values of specimens tested from "undried", "air-dried" and "oven-dried" states. Soils shall not be assumed to be unaffected by drying without specific test.

(2) *Specification of the base.* The base of the liquid limit apparatus is made either of four nominally 12.5 mm thick laminations of vulcanized rubber bonded into a block of the dimensions given in fig. 2.2.1, or from a single vulcanized rubber block (natural rubber with carbon black loading finished to the dimensions given in fig. 2.2.1. The hardness of the finished block, measured on the upper and lower surfaces of the complete block by Method N given in Part A26 of BS 903 at 20 ±2 °C shall be in the range 79 to 99 IRHD. The hardness of the base shall have been checked within a period of two years prior to the apparatus being used. When not in use the liquid limit machine should be stored in a cool place to avoid rapid deterioration of the rubber. Palette knives used for liquid limit sample preparation can become very sharp so that care must be exercised to maintain the upper surface of the rubber base in good condition free from minor cuts and gouges.

(3) *Need for shock absorbent base.* Ever since Casagrande (Casagrande, A. (1932) Research on the Atterberg limits of soils, public roads 13, 121-130, 36.) first described this mechanical device for determination of liquid limits, operators have found that the rigidity of its support has a measurable influence on the blow count. Some laboratories have attempted to avoid this problem by carrying out all such tests at a specific point on a laboratory bench but this does not help interlaboratory correlation. The shock absorbent base reduces the influence of bench support.

(4) *Wear on the grooving tool.* When the tip of the grooving tool has worn to a width of 2.5 mm, the tool shall be reshaped to the proper dimensions or replaced. It is useful to have a standard check gauge of the correct dimensions against which the tool can be checked.

(5) Either a 0.001 g balance or a 0.01 g balance may be used in this test. To achieve the reporting accuracy given in 2.2.8.1, a balance readable and accurate to 0.001 g must be used. If the 0.01 g balance is used, this must be stated on the report form, and the liquid limit shall be reported as a range of values symmetrical about the calculated result, as follows:
   (a) For values equal to or less than 50, the liquid limit shall be reported as whole numbers with a range of 2.
   (b) For values between 50 and 125, the liquid limit shall be reported as whole numbers with a range of 4.
   (c) For values equal to or greater than 125, the liquid limit shall be reported as whole numbers with a range of 8.

(6) Although the method specified in 1.6.5.2 (a) is preferable, an alternative method can be used if the percentage material retained on the 425 μm test sieve is not great. This can be achieved by rubbing the wet soil through the sieve until a sufficient quantity is obtained. The sieve for this process should not be one of the set used for particle size analysis, as the rubbing of a wet soil through a sieve results in rapid wear of the sieve. The wear, however, will not have any appreciable effect on the liquid limit obtained for the sample under test. If this method is used, the fact shall be stated.

(7) A curing period of 24 h is recommended for most soils. Some heavy clays may require longer than 24 h to establish equilibrium and may require remixing at intervals to hasten the process. Some soils of low clay content, especially if of low activity, may not require such long periods of curing and the test may be made almost immediately after mixing. A few soils oxidize rapidly in air, with a clear colour change. If this is observed, special procedures for excluding air during the mixing and curing process shall be devised.

(8) Certain soils may require as much as 40 min continuous mixing immediately before testing to obtain reliable results.

(9) With soils of low plasticity it is sometimes difficult to cut a smooth groove in the soil with the grooving tool specified. As an alternative to the standard grooving tool, the Hovanyi tool (Hovanyi, P., 1958: A new grooving tool. Geotechnique 8(2): 78.) (fig. 2.2.3) may be used. If it is used, this fact shall be recorded. An "ASTM type" tool (fig. 2.2.4), although not preferred, may also be used. The technique of using this tool is not to insert it in one stroke and force the soil apart, but to form the groove by several strokes if necessary until the correct groove shape and depth are obtained. Care must be taken that the sample does not slide on the surface of the cup during the grooving process, as this would completely negate the test. If the ASTM type tool is used, this fact shall be recorded. It does not necessarily follow that, because a smooth groove can not be obtained, the soil is non-plastic, and in such cases it shall be recorded that the liquid limit test could not be applied (NA).

(10) Sometimes the soil flows so as to leave a gap between two areas of contact. The test shall continue until there is a length of continuous contact for 13 mm.

(11) Some soils tend to slide on the surface of the cup instead of the soil flowing. If this occurs, the result shall be discarded and the test repeated until flowing does occur. If after additional increments of water sliding still occurs, the test is not applicable and a note shall be made that the liquid limit could not be obtained.

(12) *One-point method.* If flow curves are plotted on a log-log chart, it is found that their slopes are reasonably constant over a wide range of liquid limit. Thus if a single point on the flow curve close to the liquid limit is accurately determined, the standard slope may be used to calculate the liquid limit. This single point must lie between 20 and 30 blows and the water content must be determined in duplicate. Calculate the liquid limit from the following formula:

$$LL = w\left(\frac{n}{25}\right)^{0.1}$$

where LL = liquid limit expressed to the nearest whole number
w = water content corresponding to n blows (%)

For convenience the factor $\left(\frac{n}{25}\right)^{0.1}$ is tabulated below:

No. of blows	*Factor*	*No. of blows*	*Factor*
20	0.978	26	1.004
21	0.983	27	1.008
22	0.987	28	1.012
23	0.992	29	1.015
24	0.996	30	1.019
25	1.000		

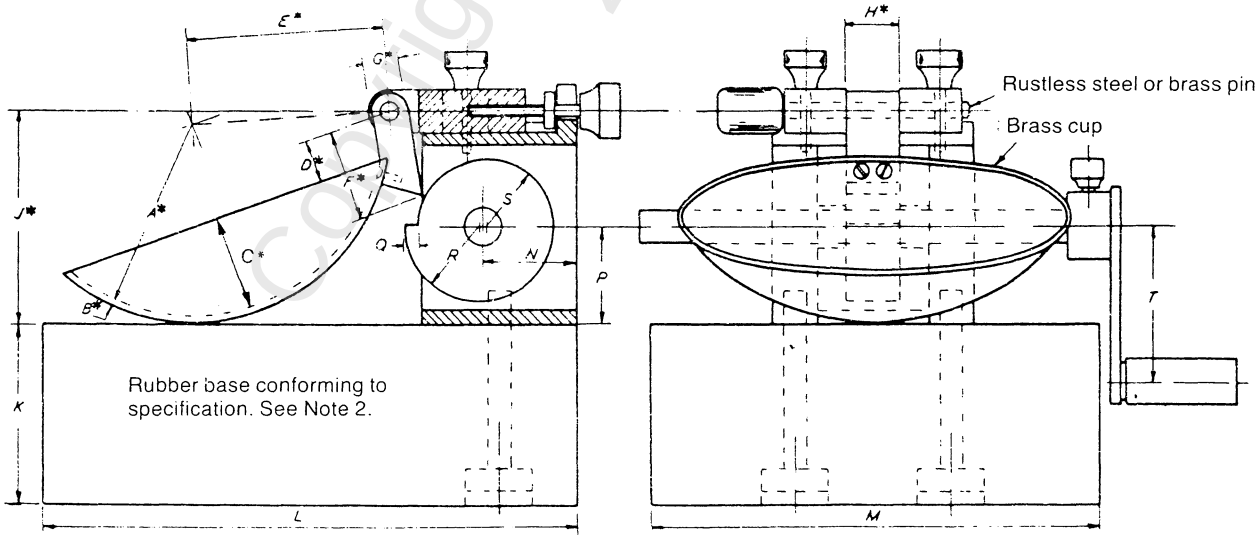
The main advantage of this method is speed, but it should not be undertaken unless a considerable number of liquid limit determinations have been carried out by the full standard method, and until some skill has been developed in handling soils and the apparatus.

(13) Care shall be taken to see that the sample does not dry out rapidly between repeat tests as the number of blows for closure will increase gradually as the sample dries out. Some low plasticity materials may need to be tested in a humid room to prevent rapid drying.

Dimensions

Letter	*A**	*B**	*C**	*D**	*E**	*F**	*G**
mm	54 ±0.5	2 +0, −0.4	27 ±0.5	12.5 ±0.5	56 ±0.5	25 ±0.5	10 ±0.5

Letter	*H**	*J**	*K*	*L*	*M*	*N*	*P*	*Q*	*R*	*S*	*T*
mm	16 ±0.5	60 ±0.5	50	150	130	27	28	6	22	19	45



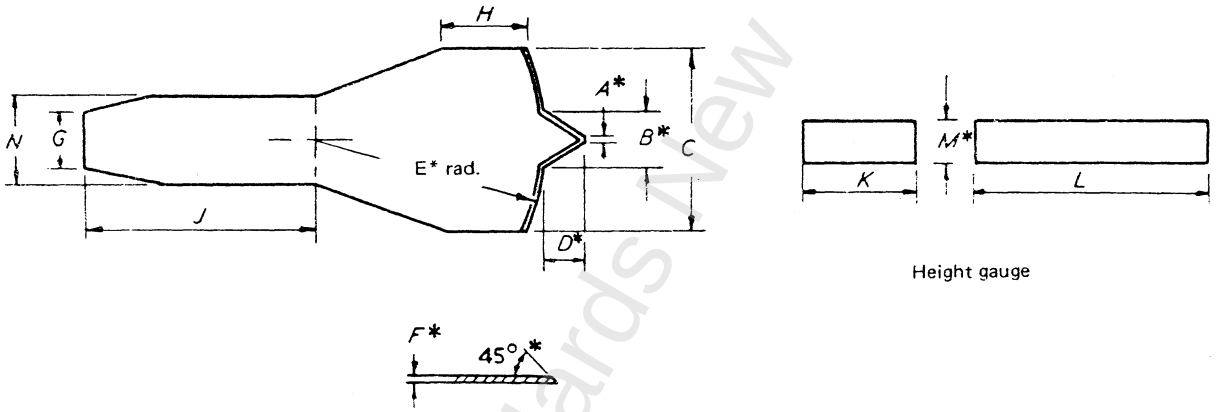
This design has been found satisfactory, but alternative designs may be employed provided that the essential requirements are fulfilled. (Essential dimensions are indicated by an asterisk.)

Fig. 2.2.1
LIQUID LIMIT APPARATUS

Dimensions

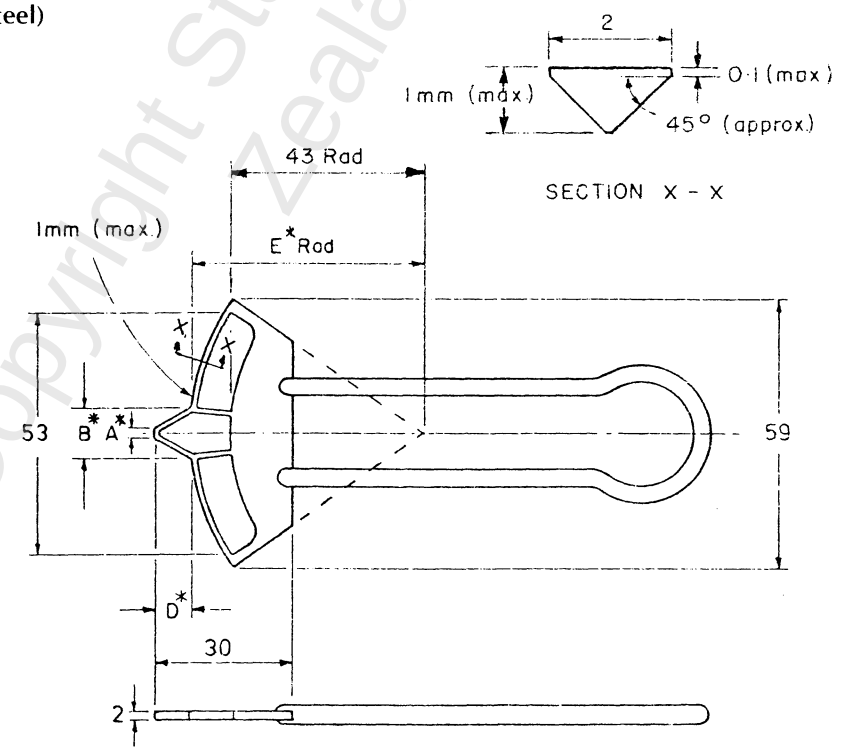
Letter	*A**	*B**	*C*	*D**	*E**	*F**
mm	2 ±0.25	11 ±0.25	40	8 ±0.25	50 ±0.5	1.5 ±0.15

Letter	*G*	*H*	*J*	*K*	*L*	*M**	*N*
mm	13	20	50	25	50	10 ±0.25	20



This design has been found satisfactory, but alternative designs may be employed provided that the essential requirements are fulfilled. (Essential dimensions are indicated by an asterisk.)

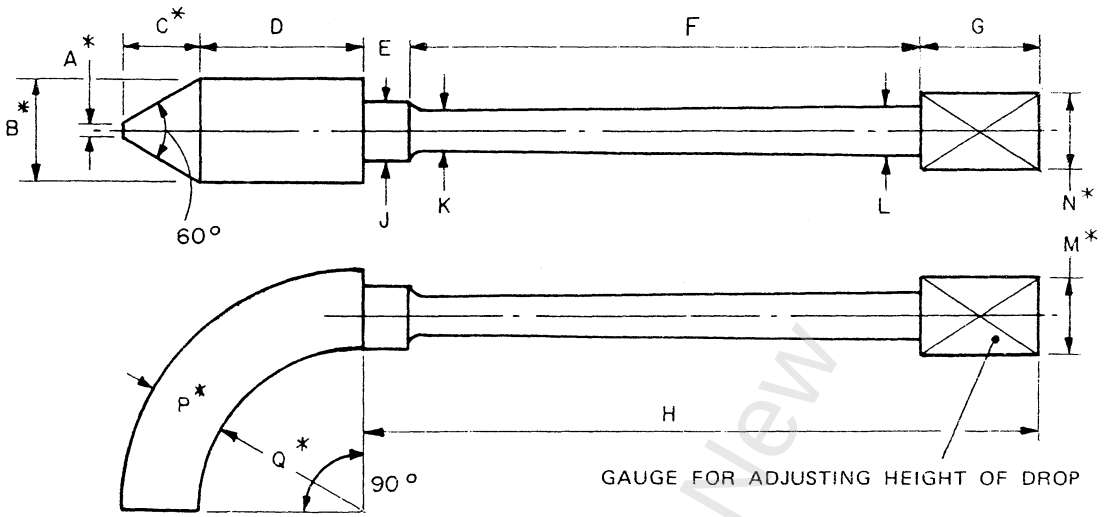
Fig. 2.2.2
GROOVING TOOL AND HEIGHT GAUGE
(Brass or stainless steel)



Letter	A*	B*	D*	E*
mm	2 ± 0.25	11 ± 0.25	8 ± 0.25	50 ± 0.5

This design has been found satisfactory, but alternative designs may be employed provided that the essential requirements are fulfilled. (Essential dimensions are indicated by an asterisk.)

Fig. 2.2.3
HOVANYI GROOVING TOOL



Letter	A*	B*	C*	D	E	F	G	H
mm	2 ± 0.25	13.5 ± 0.25	10 ± 0.25	22	6	68	16	90

Letter	J	K	L	M*	N*	P*	Q*
mm	8	5	6	10 ± 0.25	10 ± 0.25	10 ± 0.25	22 ± 0.25

Fig. 2.2.4
ALTERNATIVE GROOVING TOOL

This design has been found satisfactory, but alternative designs may be employed provided that the essential requirements are fulfilled. (Essential dimensions are indicated by an asterisk.)

Form 2.2, 2.3, 2.4
DETERMINATION OF THE LIQUID AND PLASTIC LIMITS, PLASTICITY INDEX AND WATER CONTENT (Tests 2.2, 2.3 and 2.4)

Job:
Location:
Depth(s):
Test details:*

Test performed on fraction passing 425 μm sieve/whole soil
History: Natural/air-dried/oven-dried/unknown
Soil equilibrated with water for ..... h
Liquid limit machine no.

Sample no.:
Tested by:
Date:

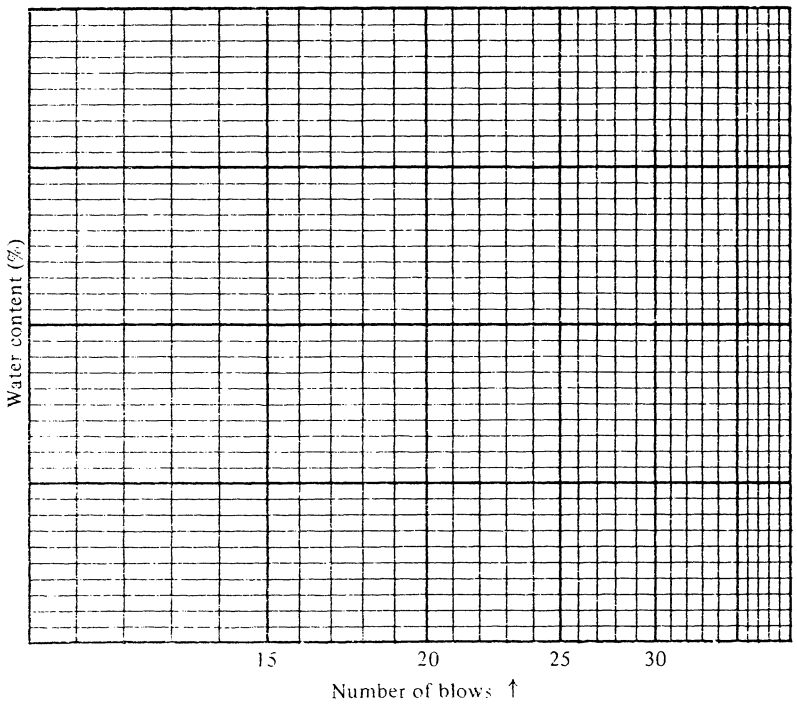
Checked by:
Date:

Test no.		*1*	*2*	*3*	*4*	*5*	*6*
Type of test †							
No. of blows (liquid limit test)							
Container no.							
Mass of container and wet soil	M_2 g						
Mass of container and dried soil	M_3 g						
Mass of container	M_1 g						
Mass of water	$M_2 - M_3$ g						
Mass of dried soil	$M_3 - M_1$ g						
Water content $w = \frac{M_2 - M_3}{M_3 - M_1} \times 100$	%						

Water content ..... %
Liquid limit .....
Plastic limit .....
Plasticity index ....

* Delete inappropriate words.

† Water content test to be marked w; Liquid Limit, *LL*; and Plastic Limit, *PL*.



NOTES