METHOD A2

THE DETERMINATION OF THE LIQUID LIMIT OF SOILS BY MEANS OF THE FLOW CURVE METHOD

1 SCOPE

The liquid limit of a soil as defined below is determined by using the device specified to plot a curve of the number of taps necessary to obtain a specific consistency of the soil fines against the moisture contents in three trials. Provision is also made for the calculation of the liquid limit from a one-point determination if that method is specified

Definition

The liquid limit of a soil is the moisture content, expressed as a percentage of the mass of the oven-dried soil, at the boundary between the liquid and plastic states The moisture content at this boundary is arbitrari1y defined as the liquid limit and is the moisture content at a consistency as determined by means of the standard liquid limit apparatus

2 APPARATUS

2.1 A liquid limit device (Figure A 2/1) The base of the apparatus must be made of hard rubber with a Shore D value of 85 -95 at 23±2EC.

2 2 A grooving tool (Figure A 2/11)

2 3 A calibrating plate with a thickness of 10 0 mm (t01 mm)

2 4 A porcelain evaporating dish with a diameter of about 100 mm

2 5 A spatula with a slightly fbxibie blade about 100 mm long and 20 mm wide

2 6 A burette with a capacity of 50 ml or 100 ml

2 7 Suitable container such as weighing bottles with a capacity of 30 ml to 45 ml or matched watch glasses which will prevent the loss of moisture during weighing

2 8 A balance to weigh up to 100 gram accurate to 0 01gram.

2.9 A drying oven thermostatically controlled and capable of maintaining a temperature of 105 to 110 C

3 METHOD

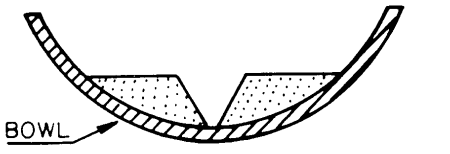
3.1 Calibration of the liquid limit device.

The height to which the bowl is raised on rotating the handle shall be adjusted by means of the 10 mm calibrating plate. The plate is placed on the hard rubber base and

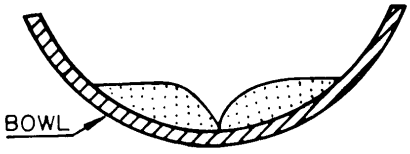
the bowl is allowed to rest on the plate. The hinged support of the bowl is now moved backwards or forwards by means ot the thumbscrew until the cam, on rotation, just raises ihe bowl free of the plate. The lock-screw is then tightened and the fall again checked. The device should preferably be checked daily.

3.2 Test procedure for plastic soils

48 grams of the thoroughly mixed soil fines (i.e. the material passing the 0,425 mm sieve), obtained in accordance with the standard method of preparation (Method A1), are weighed out and transferred to a porcelain dish. Distilled water is added by means of a burette and the moist material is then thoroughly mixed for 10 minutes with a spatula (see 5.1). In order to facilitate mixing, the water should be added in small quantities. When sufficient water has been mixed with the soil to form a stiff consistency, approximately three-quarters of the wet soil is transferred to the brass bowl of the liquid limit device, mixed slightly and flattened out in the front portion of the bowl with the spatula. The material is then divided into two equal portions with one cut of the grooving tool. The groove should fall along the centre-line drawn through the cam-follower attached to the bowl. The device is then operated at a speed which results in two taps per second being applied to the soil, until the lower parts of the faces of the two soil portions have flowed together and made contact across a distance of about 10mm. The number of taps required to close the groove across this distance is recorded and a sample of approximately 2 to 3 grams, representative of the total thickness of the layer, is transferred to a tared weighing bottle (or other suitable container) for the determination of its moisture content.
The procedure is repeated for two additional determinations on the soil in the bowl of the liquid limit device. However, before each test 2 to 3 grams material from the porcelain dish are added to the material in the bowl so as to ensure that the quantity of material in the bowl is approximately the same for all the determinations. Sufficient distilled water-is added each time in order to obtain three samples of varying consistencies, such that at least one determination will be made in preferably each of the following ranges of tap: 28-35, 22-28 and 15-22. The test should preferably proceed from the drier to the wetter condition of the soil The moist material which has been left over in the bowl is at once transferred to the shrinkage trough tor the determination of the linear shrinkage (see Method A4).



DIVIDED SOIL CAKE BEFORE TEST



SOIL CAKE AFTER TEST

The moist material which has been left over in the porcelain dish is set aside for the determination of the plastic limit (see Method A3).
The containers with the soil samples are weighed, after which the samples are oven dried to constant mass at 105 to 110EC. As a rule the material is dried overnight. When the containers are removed from the oven, the lids are replaced to prevent the absorption of hygroscopic moisture, and after being allowed to cool, they are weighed again. The loss in mass is the mass of water which is then expressed as a percentage of the oven-dried mass of soil. The appended Form A2/1 (or similar) may be used for recording the mass determinations which should be accurate to 0,01 gram.

3.3 Test procedure for slightly plastic or non-plastic soils.

The procedure is the same as for plastic soils, except that special care should be taken in the cutting of the groove. After the wet material has been transferred to the bowl, it is again mixed slightly and then bedded down in the bowl by pressing it down with the spatula and tapping the bowl a few times before grooving. The groove should be cut in the material in a manner such as to avoid tearing of the sides of the groove or slipping of the soil cake in the bowl. Instead of making one clear cut, a succession of light cuts which gradually result in the required cut may be found to work better. When tapping, the operator should ensure that the soil portions actually flow together and do not slide together. If the soil portions slide together, the material should be re-mixed slightly and the test repeated. If the soil portions continue to slide, it must be accepted that the liquid lim it cannot be determined .

4. CALCULATIONS

4.1 Moisture Content (%)

The moisture content of the soil is expressed as a percentage of the mass of the oven-dried soil and is calculated as follows:

$$\text{Moisture content (\%)} = \frac{\text{Mass of water}}{\text{Mass of oven-dried soil}} \times 100$$

The calculations should be carried out to the first decimal figure.

4.2 Liquid limit

A "flow curve" representing the relationship between moisture content and corresponding number of taps is then drawn by plotting the moisture contents as ordinates on a natural scale and the number of taps as abscissae on a logarithmic scale. The flow curve should be a straight line drawn as nearly as possible through the three plotted points (see appended example Figure A2/lll).
The moisture content corresponding to 25 taps is then read off from the curve and is taken as the liquid limit of the soil and reported to the nearest whole number on the A1/2 Form (or similar form).

5 NOTES

5.1 It has been found that the liquid limit of certain materials is influenced by the time of mixing. There is a tendency, particularly noticeable in the case of decomposed dolerites and certain pedogenic materials, for the liquid limit to increase as the time of mixing is increased, although this increase will, of course, not continue indefinitely. Hence it was considered necessary to stipulate a mixing time and a period of ten minutes was decided on.

5.2 One Point method

The liquid limit may also be determined by means of the one-point method which is considered a derivation of the flow curve method described above. According to the one-point method, the test is carried out at one consistency of the soil sample and the liquid limit is calculated by means of a formula.
The test procedure is the same as for the first determination in the flow curve method, except that the number of taps for groove closure should be restricted to between 22 and 28 taps. After the moisture content has been determined, the liquid limit corresponding to 25 taps is calculated using the following formula:

$$LL = W_N \times (N \div 25)^{0,12}$$

where

N = number ot taps required to close the groove at the moisture content, W_N

To simplify the calculation of the LL above, values of $(N \div 25)^{0,12}$ are given in the table below for various values of N

N	$(N \div 25)^{0,12}$
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014

The test is duplicated by adding 2 to 3 grams of material from the porcelain dish to the material in the bowl of the liquid limit device and repeating the procedure.
The calculations should be carried out to the first decimal figure and the average of the two determinations is taken as the liquid limit, which is reported to the nearest whole number on a suitable form such as the A1/2 Form.
The moist material which has been left over in the bowl of the liquid limit device after the duplicate determination is at once transferred to the linear shrinkage trough for the determination of the linear shrinkage (see Method A4).
The remainder of the moist material in the porcelain dish is set aside for the

determination of the plastic limit (see Method A3).

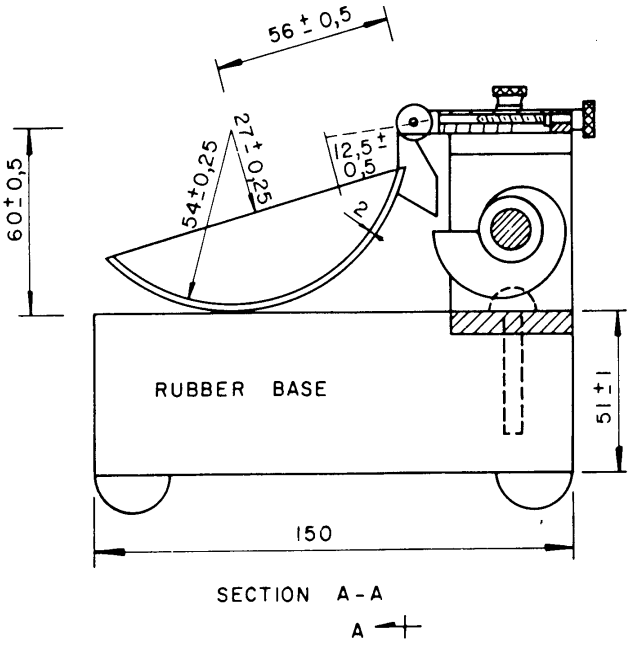
5.3 The bowl and the hard rubber base will be found to wear and these parts should be inspected regularly. If the bowl is badly worn, it should be replaced. If the base is badly worn, it should be reversed, machined off level or replaced.

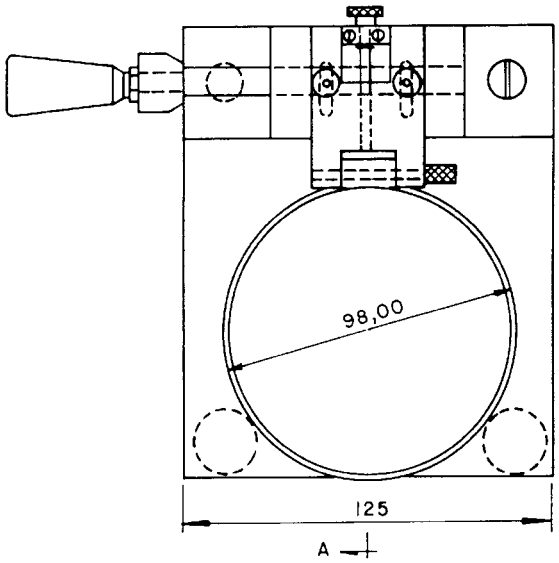
5.4 The groover should also be inspected regularly and its head reversed or replaced whenever the cutting edge becomes slightly worn.

5.5 In the case of dispute, the flow curve method shall be the referee method.

REFERENCES

AASHTO Designation T89t0
ASTM Designation D423-66

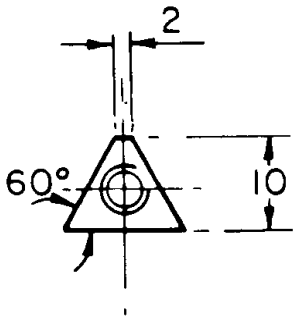




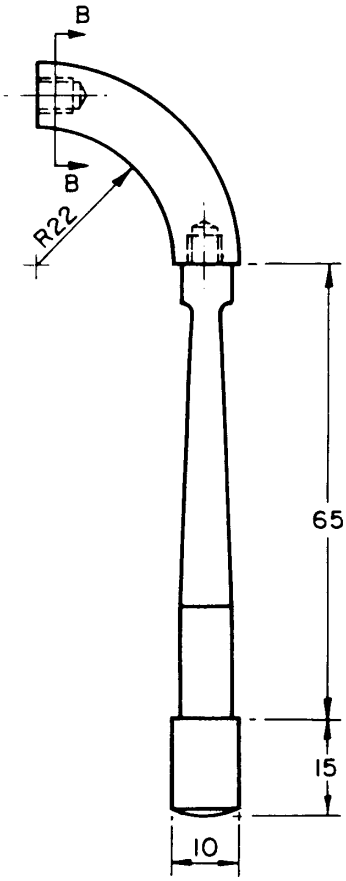
PLAN

FIGURE A2/I

Liquid Limit device



SECTION B-B



PLAN

FIGURE A2/II

The grooving tool

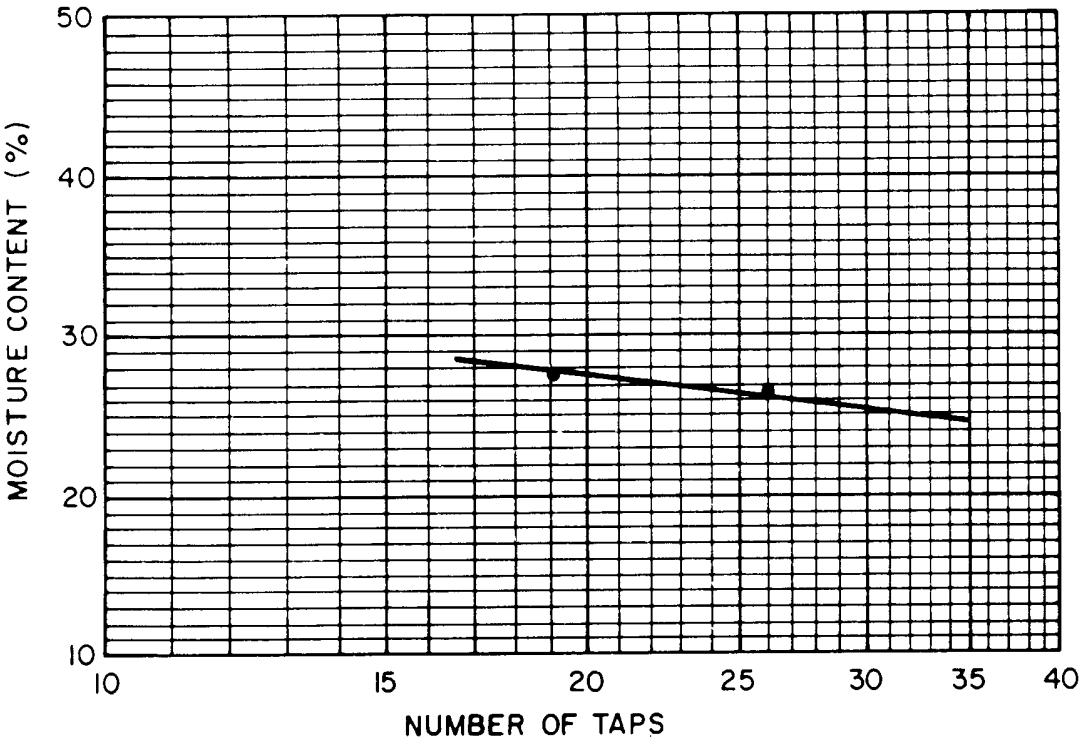


FIGURE A2/III

Example of a flow curve

SAMPLE NO./MONSTER NR.

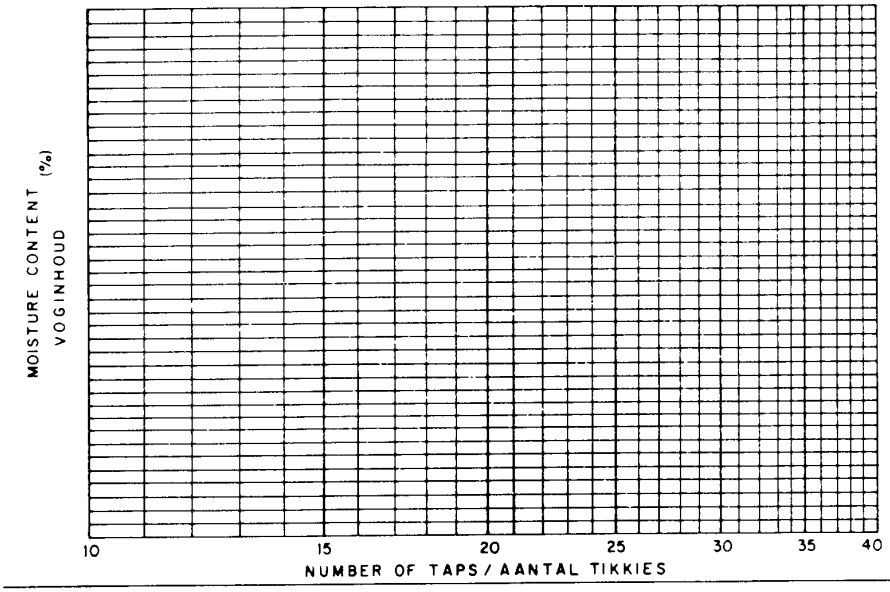
	MOISTURE CONTENT VOGINHOUD			PLASTIC LIMIT PLASTISITEITSGRENS		CALCULATION BEREKENING
TROUGH NO. TROGGIE NR						L.L. VG ____
MASS OF CONTAINER AND WET MATERIAL MASSA VAN HOUER EN NAT MATERIAAL						P.L. PG ____
MASS OF CONTAINER AND DRY MATERIAL MASSA VAN HOUER EN DROË MATERIAAL						P.I. PI ____
MASS OF CONTAINER MASSA VAN HOUER						REPORTING RESULTAAT
MASS OF MOISTURE MASSA VAN VOG						L.L. VG ____
MASS OF DRY MATERIAL MASSA VAN DROË MATERIAAL						P.I. PI ____
% MOISTURE % VOG						
NUMBER OF TAPS AANTAL TIKKIES						

SHRINKAGE (mm) x =
KRIMPING (mm)

LINEAR SHRINKAGE = $x \times f$
LINEÊRE KRIMPING = %

$\left(f = \frac{100}{150} \times \frac{0,8}{1-0,008N}\right)$

TROUGH NO. ____
TROGGIE NR



N	f
15	0,606
16	0,612
17	0,617
18	0,623
19	0,629
20	0,635
21	0,641
22	0,647
23	0,654
24	0,660
25	0,667
26	0,673
27	0,680
28	0,687
29	0,694
30	0,702
31	0,709
32	0,717
33	0,725
34	0,733
35	0,741

SAMPLE NO./ MONSTER NR

	MOISTURE CONTENT VOGINHOUD			PLASTIC LIMIT PLASTISITEITSGRENS		CALCULATION BEREKENING
TROUGH NO. TROGGIE NR						L.L. VG ____
MASS OF CONTAINER AND WET MATERIAL MASSA VAN HOUER EN NAT MATERIAAL						P.L. PG ____
MASS OF CONTAINER AND DRY MATERIAL MASSA VAN HOUER EN DROË MATERIAAL						P.I. PI ____
MASS OF CONTAINER MASSA VAN HOUER						REPORTING RESULTAAT
MASS OF MOISTURE MASSA VAN VOG						L.L. VG ____
MASS OF DRY MATERIAL MASSA VAN DROË MATERIAAL						PI PI ____
% MOISTURE % VOG						
NUMBER OF TAPS AANTAL TIKKIES						

SHRINKAGE (mm) x =
KRIMPING (mm)

LINEAR SHRINKAGE = $x \times f$
LINEÊRE KRIMPING = %

$\left(f = \frac{100}{150} \times \frac{0,8}{1-0,008N}\right)$

TROUGH NO. ____
TROGGIE NR

FORM A2/1

Recording sheet for the determination of the Atterberg constants