OPERATING INSTRUCTIONS

California Bearing Ratio, BS, ASTM and In-situ

24-9182 to 24-9341

ELE International Chartmoor Road, Chartwell Business Park Leighton Buzzard, Bedfordshire, LU7 4WG England phone: +44 (0) 1525 249200 fax: +44 (0) 1525 249249 email: ele@eleint.co.uk http://www.ele.com ELE International, a division of Hach Lange Ltd.	***Distributor:***	**ELE International** Soiltest Product Division PO Box 389, Loveland, CO 80539 USA phone: +1 (800) 323 1242 fax: +1 (970) 663 9781 email: soiltest@eleusa.com http://www.eleusa.com

Contents

1 Introduction

1.1 The California Bearing Ratio test or CBR test is an empirical test which was first developed in California, USA, for estimating the bearing value of highway subgrades. The test follows a standardised procedure, although the British (BS 1377) and American standard (D 1883) differ in many minor ways, resulting in sets of equipment to suit each technique.

1.2 The in-situ test was developed by the US Corps of Engineers and follows a standard procedure specified in BS 1377 and ASTM D 4429. It offers a means of estimating in-situ CBR on the construction site.

1.3 This manual is intended as a guide to the various techniques involved and is divided into 3 parts. Part 1 British Standards, Part 2 American Standards and Part 3 In-situ Testing. Where appropriate reference is made to the operating instructions for the various test machines available from ELE International.

1.4 To obtain a detailed understanding of the California Bearing Ratio test, the related calculations, and the evaluation of results, it is recommended that the reader refers to a copy of "Manual of Soil Laboratory Testing", Volume II by K H Head. Available from ELE (reference 90-0080), and the relevant standards.

1.5 Throughout this document the products are listed in unit quantity unless otherwise stated. The operator will need to define his expected quantity requirements.

2 Part 1 BS 1377 Methods of Test for Soils for Civil Engineering Purposes

2.1 General requirements for sample preparation

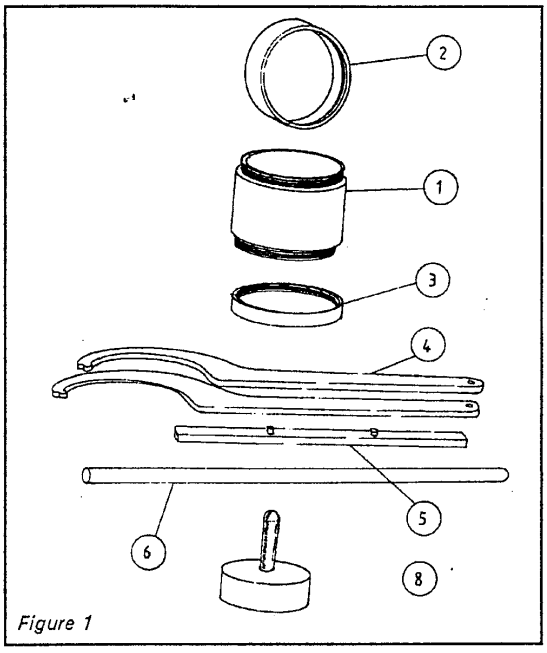

Figure 1

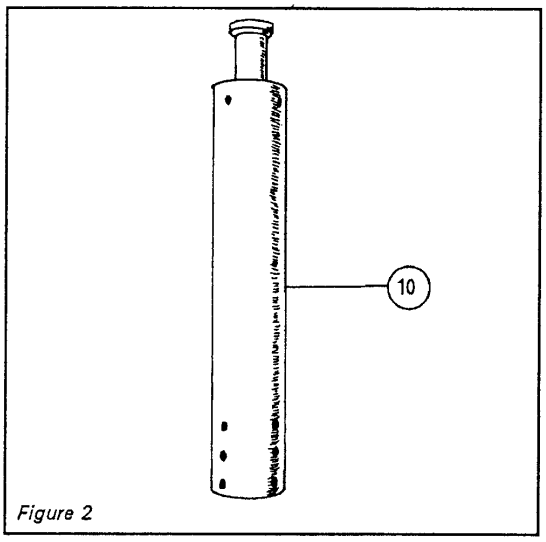

Figure 2

2.1.1 Laboratory static compaction (figure 1)

Methods 1 and 2

1	Mould body	24-9198
2	Extension collar	24-9200
3	Solid base plate (2 no.)	24-9204
4	C-spanner (2 no.)	24-9208
5	Base plate tool	24-9210

6	Tamping rod	34-0130
7	Concrete compression machine (minimum 300 kN capacity)	
8	Static compaction plug 1 no. required for method 1 and 3 no. required for method 2	24-9212
9	Filter papers	24-9220

2.1.2 Laboratory dynamic compaction (figures 1 and 2)

Methods 3 and 5

1	Mould body	24-9198
2	Extension collar	24-9200
3	Solid base plate (2 no.)	24-9204
4	C-spanner (2 no.)	24-9208
5	Base plate tool	24-9210
9	Filter papers	82-7876
10	2.5 kg rammer*	24-9002
	or 4.5 kg rammer*	24-9004

* alternative auto compactor 24-9090 series

2.1.3 Field sampling

1	Mould body	24-9198
15	Cutting collar	24-9206
2	Extension collar	24-9200
3	Solid base plate	24-9204
4	C-spanner (2 no.)	24-9208
5	Base plate tool	24-9210
17	Shovel	81-0240
18	Perforated base plate	24-9202
	Driving rammer	29-5440

2.1.4 Miscellaneous requirements

BS sieves
Metal straight edge
Balance 25 kg
Spatula
Apparatus for moisture content
Trays and scoops
Sample extruder

2.2 Requirements for swelling (figure 5)

Additional equipment to that used for sample preparation

18	Perforated base plate*	24-9202
19	Swell plate*	24-9260
20	Swell tripod*	24-9262
21	Swell dial gauge*	24-9275

* one required for each mould assembly. Each assembly will also require an extension collar 24-9200.

22	Soaking tank	24-9268
23	2 kg surcharge weight (annular)	24-9214
24	2 kg surcharge weight (split)	24-9216

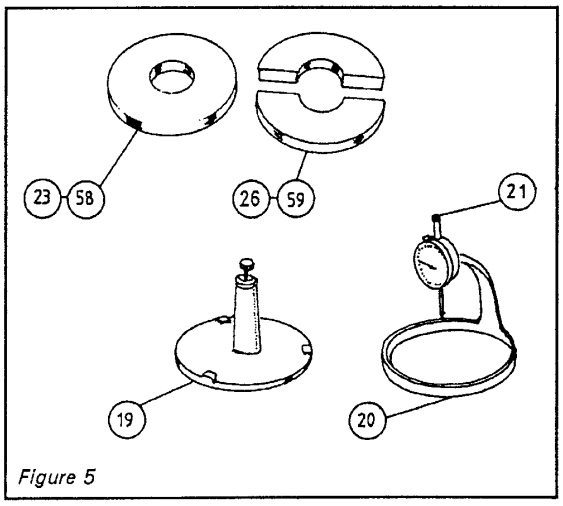

Figure 5

2.3 Requirements for penetration test (figure 6)

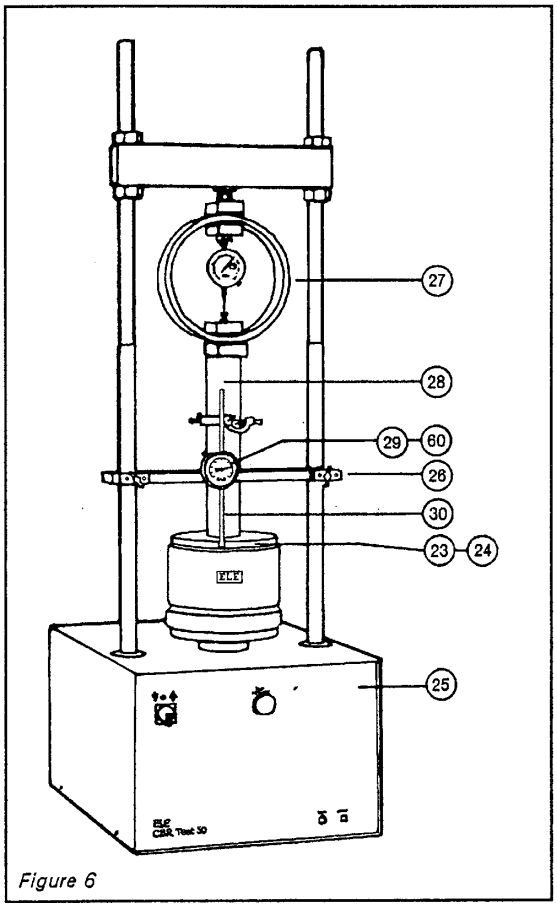

Figure 6

2.3.1 Standard laboratory test

Method

Additional equipment to that used for compaction and swelling

25	CBR load frame with *	24-9150 series
26	Stabilising bar	
27	Load measuring device	78-0760
28	Penetration piston	24-9182

29	Penetration gauge	24-9186
30	Bracket and adaptor	24-9188

* alternative load frames – 25-3700 series or 25-3516 series

2.4 Operational notes

2.4.1 Use of moulds

The CBR mould is designed to allow various components to be fitted to the mould body.

To obtain a long life, it is essential to keep the threaded sections of all components clean, free from dirt and lightly oiled.

Note: oiling is essential during the swelling stage.

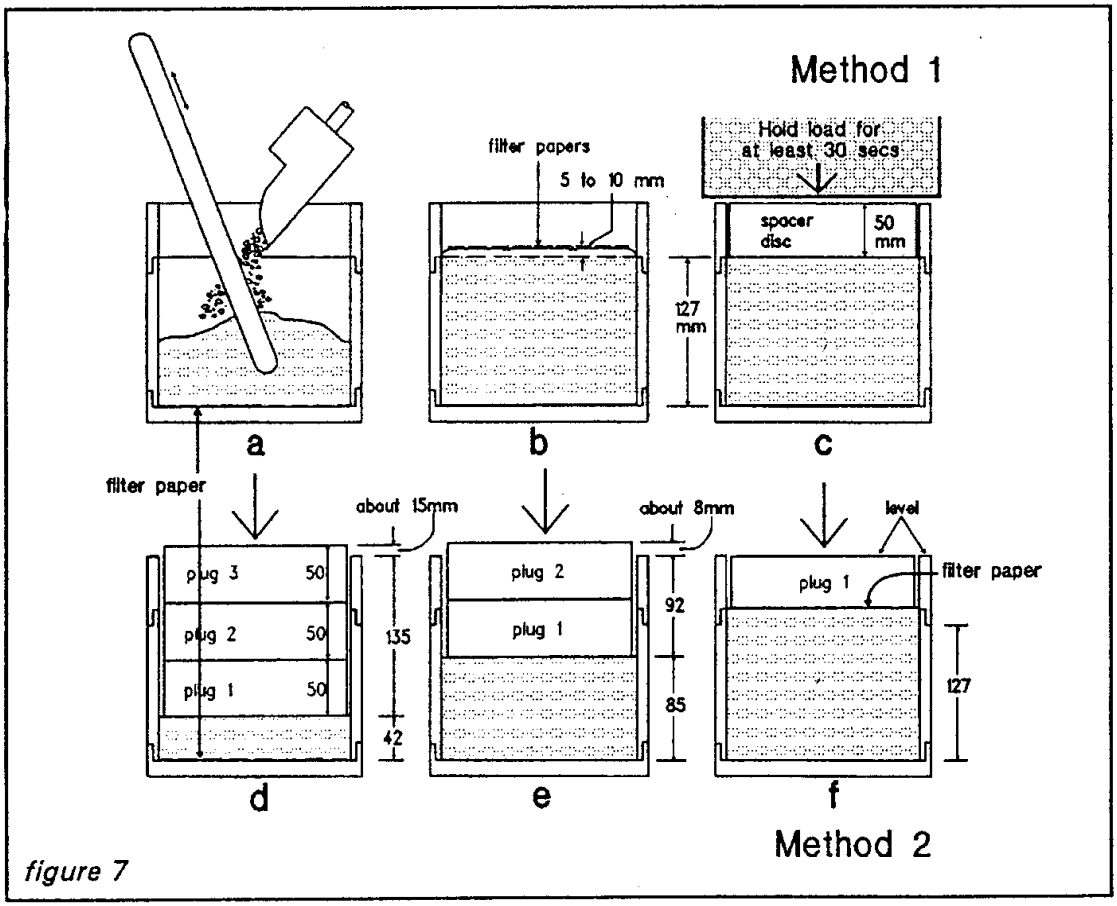

figure 7

2.4.2 Compaction (static) (figure 7)

Two methods are used, in both cases pre-determined quantities of soil are pressed into the mould body using a compression machine.

In method 1, all the soil is tamped into the mould before using of the compaction plugs to compress the soil until the top of the plug is level with the top of the extension collar.

In method 2, the sample is split into 3 equal parts and each layer is compressed in turn. Three compaction plugs are required for this procedure.

Each plug is provided with a detachable handle for ease of placing in the mould Dynamic compaction (using rammer) (figure 8).

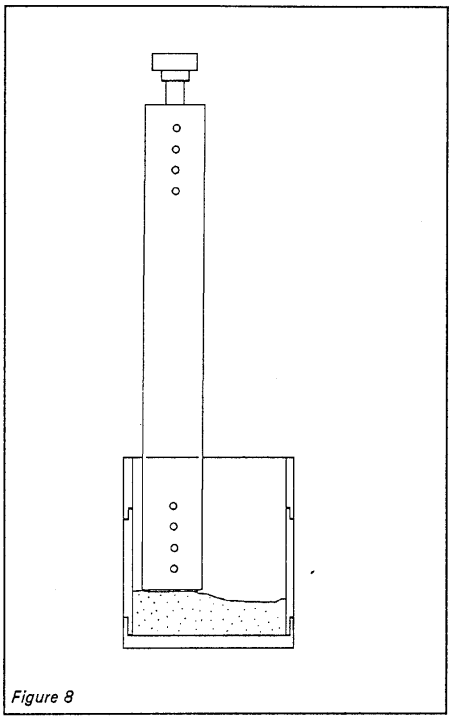

Figure 8

The correct use of a rammer is to hold the casing vertical just above the surface of the soil, raise the rammer to its maximum height and allow it to free fall. The operation is repeated evenly over the soil surface until the required number of blows have been applied.

Automatic compactors are available as an alternative to hand rammers.

Where large numbers of tests are required, the use of an automatic compactor is preferred. Operation of this type of product is detailed in the respective instruction manual.

2.4.3 Field sampling (figure 10)

The CBR mould may be used to obtain samples direct from the field.

Fit a cutting ring to one end of the mould and an extension collar to the other. Two solid base plates will also be required with grease or wax to seal the sample after collection and trimming.

Prepare the ground at the place to be sampled and then press the mould assembly into the ground until full. Recover by digging out; remove the collar and cutting shoe, then trim off both ends and seal with the two base plates.

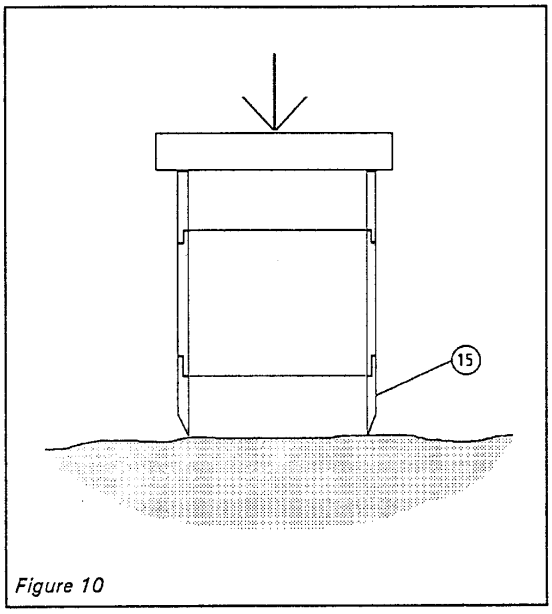

Figure 10

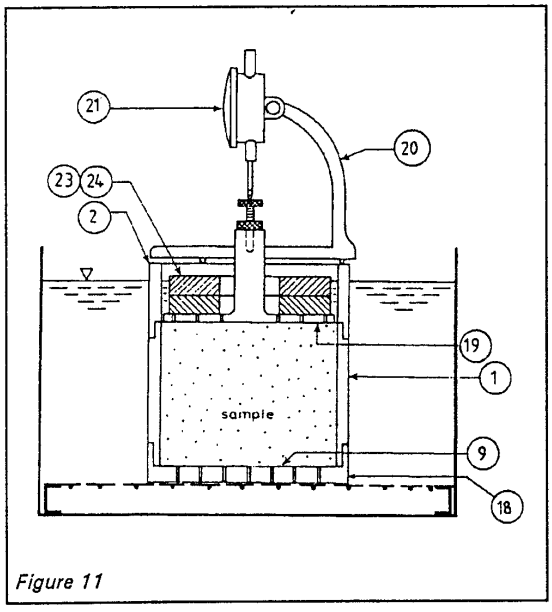

Figure 11

2.4.4 Swelling (figure 11)

Often the lowest CBR value will be obtained when the soil is in a saturated condition. Soaking the sample will cause swelling which must be recorded for corrections to volume and density to be determined.

To achieve saturation, the solid base plate of the mould is replaced by a perforated plate.

The apparatus is assembled as shown, with the swell plate placed on the surface of the soil and the tripod and swell gauge resting on top of the extension collar.

Surcharge weights should be added to represent the designed overburden loads expected in the completed road structure (2 kg represents approximately 70 mm of pavement construction).

Maintain the water level in the tank until the soaking procedure is completed.

After completing saturation and when not in use keep the various parts of the apparatus dry.

2.4.5 Penetration (figure 12)

The technique calls for a penetration plunger of specified cross-sectional area to be pressed into the soil at a constant rate of 1mm/min, to a depth not exceeding 7.5 mm. The force applied to achieve the penetration is recorded at intervals of penetration. From the data obtained the CBR value can be determined.

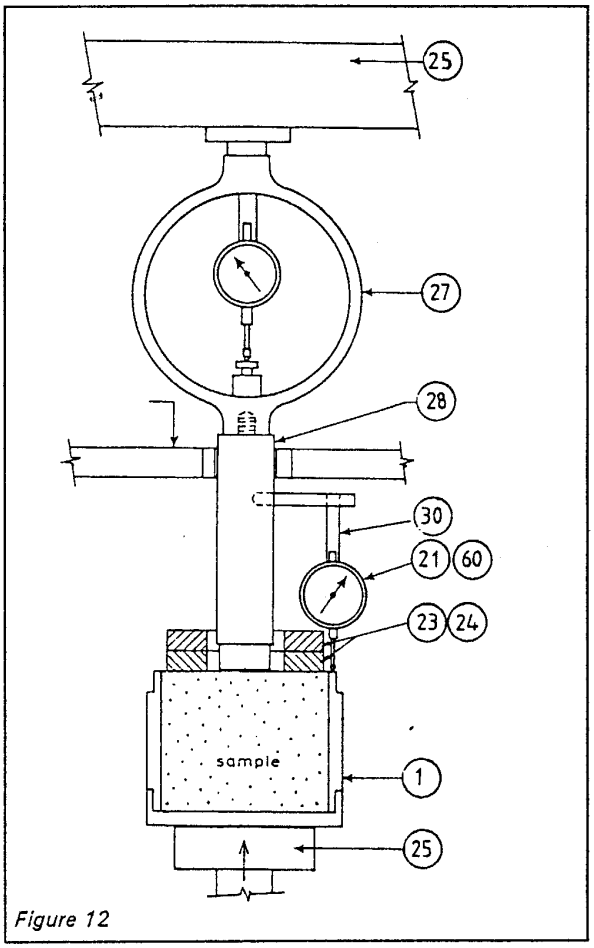

Figure 12

Different models of CBR load frames are available to carry out the test. Details are given in the ELE Materials Testing catalogue.

The prepared test sample and mould should be assembled as shown.

Include surcharge weight to represent the design overburden loads of the road structure.

During loading there is a tendency for the plunger to move sideways. To prevent this, a stabilising bar (26) is fitted to the load frame assembly.

It is essential to keep the bearing of the stabilising bar clean and lightly oiled.

3 Part 2 In-situ Field CBR Test

3.1 Introduction

The in-situ test was developed by the US Corps of Engineers and follows a standard procedure specified in BS 1377 and ASTM D4429. It offers a means of estimating in-situ CBR on the construction site.

3.2 Requirements

3.2.1 In-situ test (figure 13) BS 1377

36	Ball seating attachment	24-9300
31	45 kN mechanical jack	24-9290
34	Load ring (28 kN)	78-0760
39	Bracket and adaptor	24-9188
29	Penetration dial gauge	24-9186
41	Set of extension rods	24-9308
42	Datum bar assembly	24-9312
28	Penetration piston	24-9182
63	Surcharge weight (annular) 4.5 kg	24-9320
64	Surcharge weight (slotted) 4.5 kg	24-9322

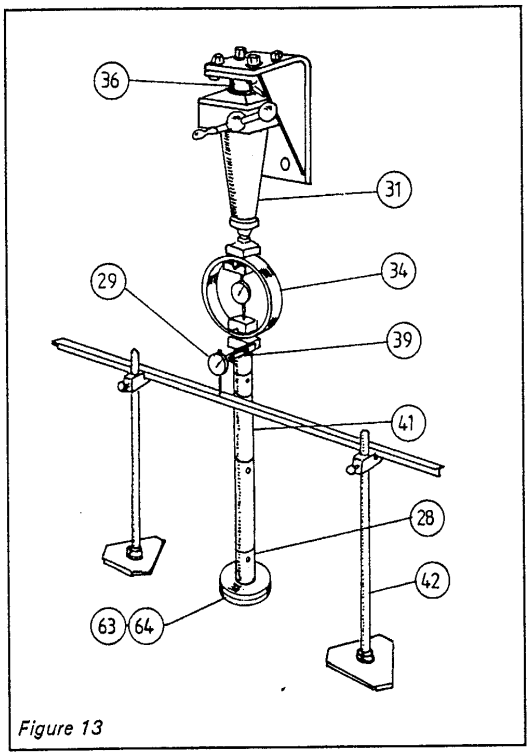

Figure 13

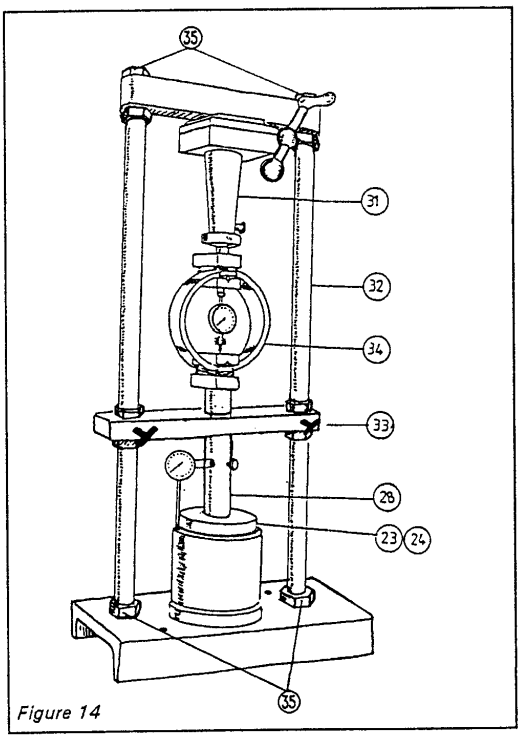

Figure 14

3.2.2 Laboratory conversion (figure 14)

32	Conversion frame and	29-9341
33	Stabilising bar	
23	Surcharge weight (annular) 4.5 kg	24-9320
24	Surcharge weight (split) 4.5 kg	24-9322

3.2.3 In-situ test (figure 13) ASTM D 4429

34	10 kN load ring	78-0460
	28 kN load ring	78-0760
28	Penetration piston	24-9182

40	Penetration dial gauge	24-9184
39	Bracket and adaptor	24-9188
31	45 kN (10,000 lb) mechanical jack	24-9290
36	Ball seating attachment	24-9300

3.3

3.3.1

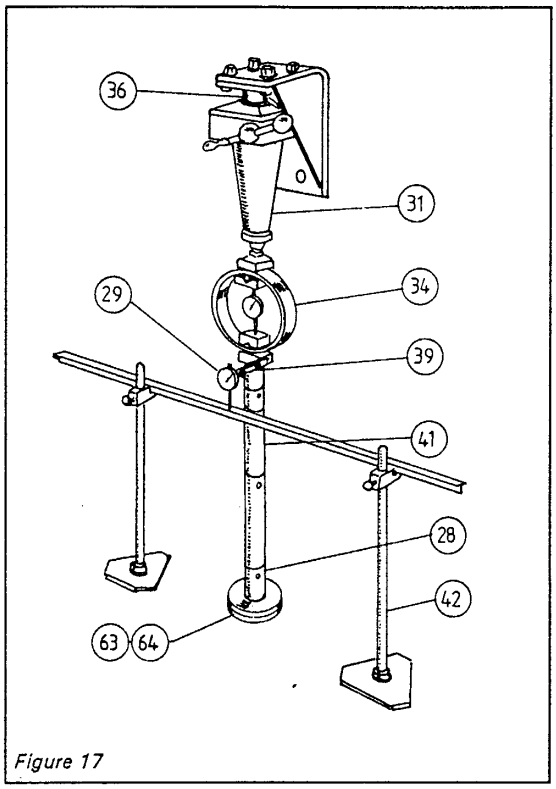

Figure 17

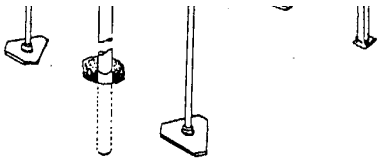
Figure 15

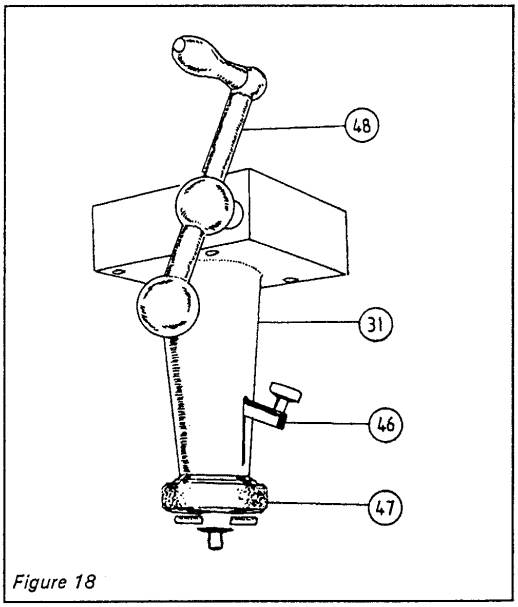

Figure 18

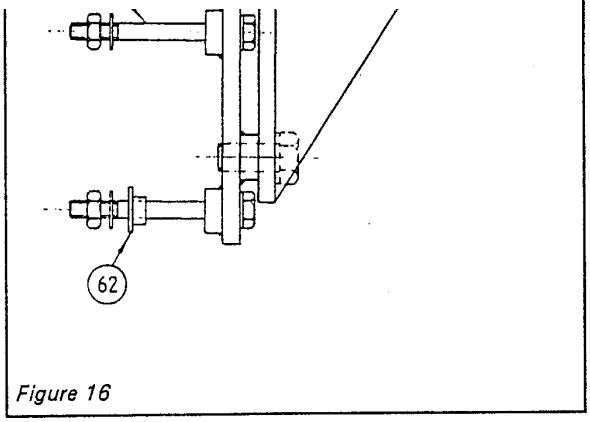

Figure 16

To carry out an in-situ penetration test requires a stable reaction force, that will permit the required rate of penetration of the plunger.

A bracket is available (24-9298) for ELE equipment and is designed to fit Landrover series 90 and 110 in place of the standard tow bar attachment.

It comprises the bracket (38) and an attachment plate (61) supplied with the necessary fixing bolts (63).

Note: 2 bushes (62) are provided and are required on the two lower bolts when fitting to certain types of Landrover.

The bracket can also be mounted to any rigid vertical surface that can absorb the required energy (30 kN or more) and is provided with 4 x M16 bolts and 4 nuts and bolts.

Any mobile reaction should be jacked up off the road wheel suspension springs before conducting a test.

3.3.2 Assembly (figures 16 and 17)

With the 8 bolts provided, first assembly the ball seating to the mechanical jack and then to the bracket.

With the mechanical jack fully retracted, connect the load ring onto the threaded piston.

Jack the reaction to the required height and select the length of extension rod (see table 1) to fit between the load ring and the penetration plunger.

The maximum available run out for the jack is 100 mm. To take up the necessary daylight the jack can be run out quickly by pulling out the key (46) and rotating the knurled head to the jack (47). Hold the load ring to prevent rotation.

Alternatively the reaction support jacks could be lowered. Care must be taken not to apply a load to the penetration plunger.

Connect the penetration dial gauge to the load ring by using either the adaptor or the bracket and the adaptor.

Arrange the datum bar assembly to align with the dial gauge and adjust to a convenient zero point.

Note: ensure that the supports for the datum bar stand on firm ground.

Place the required surcharge weights around the plunger to represent expected total overburden.

	Effective length
Upper adaptor	55 mm
Extension 1	50 mm
Extension 2	50 mm
Extension 3	254 mm
Extension 4	356 mm
Extension 5	457 mm
Extension 6	610 mm
Lower adaptor	30 mm
Penetration piston	69 mm

Table 1 Extension rods

3.3.3 Test procedure

The principle of the test is to determine the load required during the procedure to cause the plunger to penetrate the soil at the rate of 1 mm/min (1.27 mm/min ASTM).

The penetration gauge rotates one mm/revolution or 0.05 inch/revolution according to the type fitted, which equals the required rate/minute. Using a suitable clock, wind the hand crank (48) at a rate to achieve the required rate of penetration.

Readings of load should be taken at each 0.25 mm of penetration (each ¼ gauge pointer rotation) up to 7.5 mm penetration or at the specified penetration for ASTM type tests.

As detailed in the introduction, reference should be made to “The Manual of Soil Laboratory Testing” for appreciation of the data, calculations and analysis of the results obtained.

3.4 Laboratory conversion (figure 19)

3.4.1 When considering the operation of site laboratories, there may be the requirement to conduct both in-situ and laboratory tests for CBR. The ELE conversion frame permits the use of the in-situ jack unit to conduct CBR tests in the laboratory.

3.4.2 The ball seating (36) is not required in the laboratory test.

Before use check that the 4 nuts (35) securing the columns are tight.

Assemble the jack (31) to the mounting pad on the conversion frame.

3.4.3 Assemble the other components as for the standard laboratory test.

3.4.4 Conduct the penetration test in accordance with the preferred standard laboratory test.

Note: fit the appropriate penetration gauge for ASTM or BS tests.

4 Part 3 ASTM D 1883 Standard Test for California Bearing Ratio of Laboratory Compacted Soils

4.1 Requirements for compaction
Laboratory (figure 20)

50	Mould body	24-9228
	Solid Base Plate	24-9234
52	Extension collar	24-9230
53	Spacing disc	24-9238
54	Rammer 5.5 lb	24-9063
55	Rammer 10 lb	24-9070

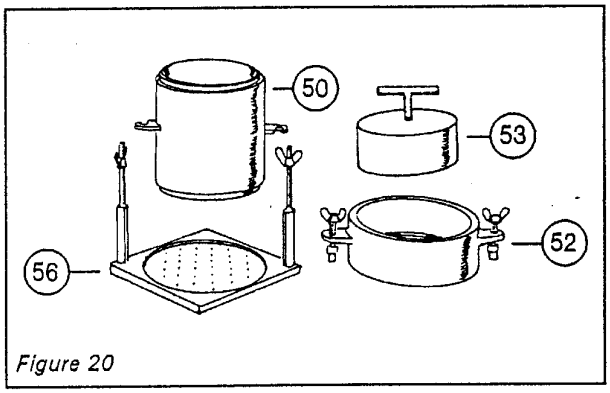

Figure 20

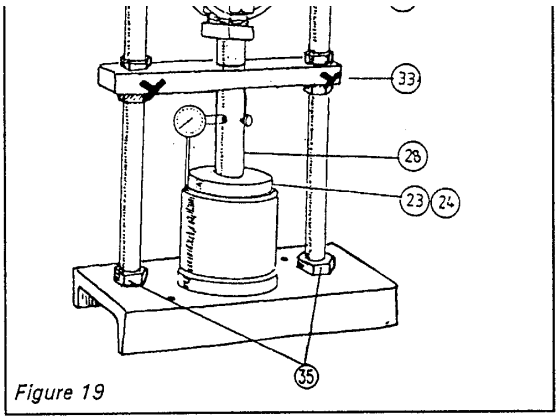

Figure 19

56	Perforated base plate	24-9232
9	Filter papers	24-9250

4.1.1 Field sampling

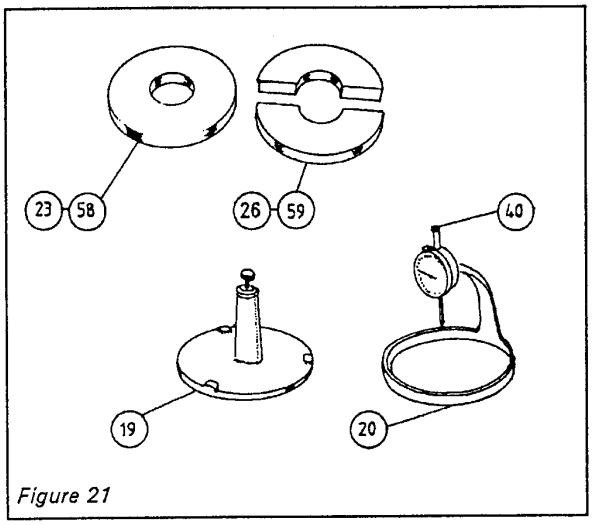

Figure 21

Although this is not listed in the standard, ELE offer a cutting collar (24-9236), to permit the use of the mould body to cut samples in the field.

The operator will work in a similar manner to that for the British Standard. However, care must be taken not to damage the lugs on the side of the mould body. Also, a suitable container that can be sealed will be required to hold the sample until testing.

4.1.2 Miscellaneous equipment

ASTM sieves
Metal straight edge
Balance 25 kg
Moisture content apparatus
Spatula
Trays and scoops

4.2 Requirements for swell (figure 21)

Additional equipment to that used for compaction

56	Perforated base plate*	24-9232
19	Swell plate*	24-9260
20	Swell tripod*	24-9262
40	Penetration/swell dial gauge*	24-9184

* one required for each mould assembly

22	Soaking tank	24-9268
58	10 lb surcharge weight (annular)	24-9243
59	5 lb surcharge weight (split)	24-9244

4.3 Requirements for penetration test (figure 22)

4.3.1 Standard laboratory test

Additional equipment to that required for compaction and swell

25	CBR load frame * with	24-9150 series
26	Stabilising bar	
27	Load measuring device	78-0760
28	Penetration piston	24-9182
60	Penetration/swell gauge	24-9184
30	Bracket and adaptor	24-9188

* Alternative 25-3700 series or 25-3516 series

4.4 Operational notes

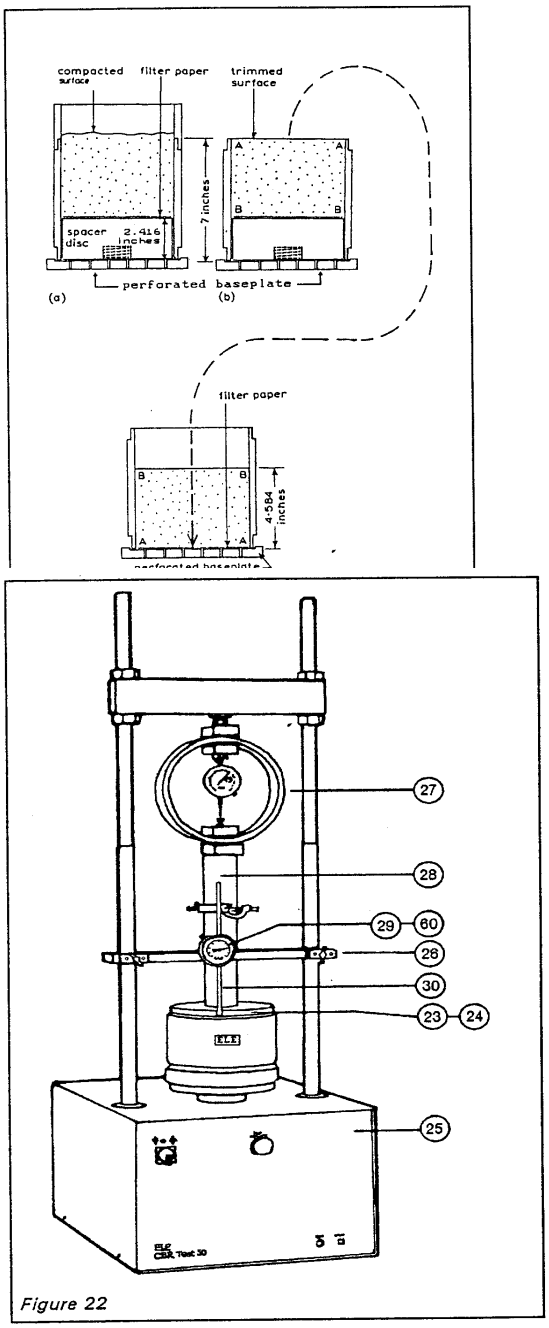

Figure 22

4.4.1 Compaction (figure 23) (see ASTM D1883)

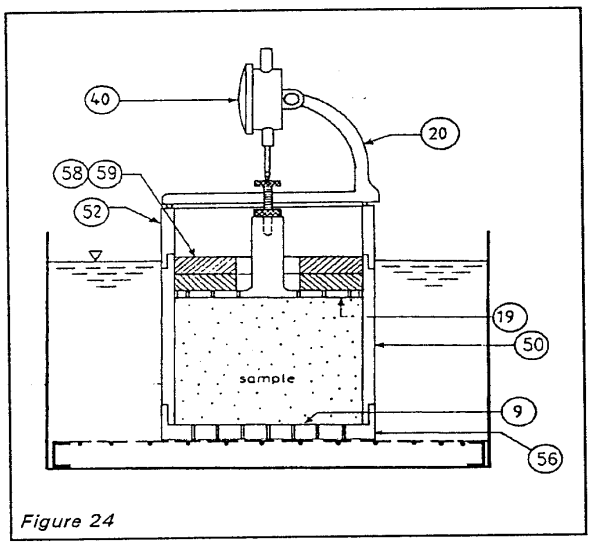

Figure 24

Assemble the solid mould base plate and collar to the mould body.

Place the spacer disc into the mould with the extraction handle hole facing down, and place a filter disc on top.

Fill and compact the soil according to the selected procedure detailed in ASTM D698 or ATSM D1557.

When the compaction is complete, remove the extension collar and scrape off the surplus soil.

Place a filter disk on the surface of the soil, fit another baseplate. Invert the complete assembly and remove the original baseplate. Screw in the handle of the spacer disk and remove the disc.

4.4.2 Swelling (figure 24)

Assemble the apparatus as shown using the required surcharge weights to represent the designed overburden pressure.

Ensure free access of the water to both upper and lower surfaces of the soil.

4.4.3 Penetration (figure 25)

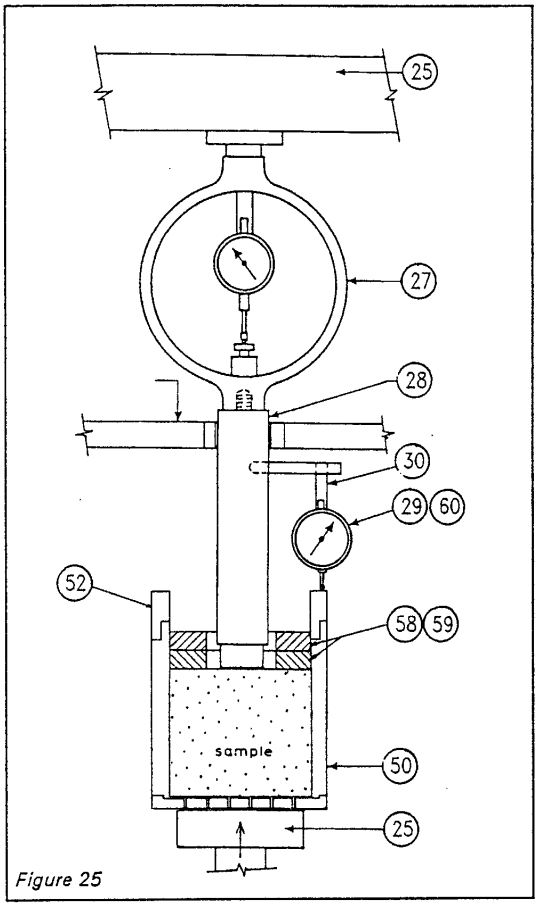

Figure 25

The penetration test will be conducted in a similar manner to that for British Standard methods, except that the rate of penetration should be 0.05 in/minute (1.27 mm/minute).

Refer to the relevant standard or to the “Manual for Soil Laboratory Testing” for interpretation of results.

5 Maintenance

5.1 Moulds

Moulds, collars, base plates etc. should be kept clean, dry and lightly oiled.

5.2 Swell equipment

5.2.1 Swell gauges should be checked for free movement of the mechanism. When not in use, keep stored away from moist and dusty atmospheres.

5.2.2 Surcharge weights should be stored dry.

5.2.3 Regularly oil the adjustable anvil of the swell plate.

5.3 Penetration equipment

5.3.1 The care and maintenance of the load frame and load measuring device will be detailed in the relevant operating instructions.

5.3.2 Check the penetration gauge for free movement. Store away from dusty laboratory conditions.

5.3.3 Clean the end of the plunger after each test or series of tests.