OPERATING INSTRUCTIONS

California Bearing Ratio, BS, ASTM and In-situ
24-9182 to 24-9341
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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

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

Figure 1
6 Tamping rod 34-0130
7 Concrete compression machine (minimum 300 kN capacity) 24-9182 to 24-9341
8 Static compaction plug
   1 no. required for method 1 and 24-9212
   3 no. required for method 2
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
2.3 Requirements for penetration test (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
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.

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).

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.
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.

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball seating attachment</td>
<td>24-9300</td>
</tr>
<tr>
<td>45 kN mechanical jack</td>
<td>24-9290</td>
</tr>
<tr>
<td>Load ring (28 kN)</td>
<td>78-0760</td>
</tr>
<tr>
<td>Bracket and adaptor</td>
<td>24-9188</td>
</tr>
<tr>
<td>Penetration dial gauge</td>
<td>24-9186</td>
</tr>
<tr>
<td>Set of extension rods</td>
<td>24-9308</td>
</tr>
<tr>
<td>Datum bar assembly</td>
<td>24-9312</td>
</tr>
<tr>
<td>Penetration piston</td>
<td>24-9182</td>
</tr>
<tr>
<td>Surcharge weight (annular) 4.5 kg</td>
<td>24-9320</td>
</tr>
<tr>
<td>Surcharge weight (slotted) 4.5 kg</td>
<td>24-9322</td>
</tr>
</tbody>
</table>

3.2.2  Laboratory conversion (figure 14)

<table>
<thead>
<tr>
<th>Component</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion frame and</td>
<td>29-9341</td>
</tr>
<tr>
<td>Stabilising bar</td>
<td></td>
</tr>
<tr>
<td>Surcharge weight (annular) 4.5 kg</td>
<td>24-9320</td>
</tr>
<tr>
<td>Surcharge weight (split) 4.5 kg</td>
<td>24-9322</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 kN load ring</td>
<td>78-0460</td>
</tr>
<tr>
<td>28 kN load ring</td>
<td>78-0760</td>
</tr>
<tr>
<td>Penetration piston</td>
<td>24-9182</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Effective length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper adaptor</td>
</tr>
<tr>
<td>Extension 1</td>
</tr>
<tr>
<td>Extension 2</td>
</tr>
<tr>
<td>Extension 3</td>
</tr>
<tr>
<td>Extension 4</td>
</tr>
<tr>
<td>Extension 5</td>
</tr>
<tr>
<td>Extension 6</td>
</tr>
<tr>
<td>Lower adaptor</td>
</tr>
<tr>
<td>Penetration piston</td>
</tr>
</tbody>
</table>

**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)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Mould body</td>
<td>24-9228</td>
</tr>
<tr>
<td>51</td>
<td>Solid Base Plate</td>
<td>24-9234</td>
</tr>
<tr>
<td>52</td>
<td>Extension collar</td>
<td>24-9230</td>
</tr>
<tr>
<td>53</td>
<td>Spacing disc</td>
<td>24-9238</td>
</tr>
<tr>
<td>54</td>
<td>Rammer 5.5 lb</td>
<td>24-9063</td>
</tr>
<tr>
<td>55</td>
<td>Rammer 10 lb</td>
<td>24-9070</td>
</tr>
<tr>
<td>56</td>
<td>Perforated base plate</td>
<td>24-9232</td>
</tr>
<tr>
<td>9</td>
<td>Filter papers</td>
<td>24-9250</td>
</tr>
</tbody>
</table>
4.1.1 Field sampling

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*
- 19 Swell plate*
- 20 Swell tripod*
- 40 Penetration/swell dial gauge*

* one required for each mould assembly

- 22 Soaking tank
- 58 10 lb surcharge weight (annular)
- 59 5 lb surcharge weight (split)
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
4.4.1 Compaction (figure 23) (see ASTM D1883)

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)

![Diagram showing a penetrometer]
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.