1. **SCOPE**

1.1. **Description**

This method describes the test used to evaluate the thickness and bearing capacity of the subbase and subgrade using the Dynamic Cone Penetrometer (DCP).

1.2. **Application Of Test**

The DCP is used as a rapid means of assessing the sequence, thickness and in-situ bearing capacity of the unbound layers and underlying subgrade that comprise the pavement structure.

1.3. **Units Of Measure**

Readings are taken in mm for each blow of the hammer and read directly from the graduated steel rule attached to the instrument.

2. **APPARATUS AND MATERIALS**

2.1. **Equipment Required**

A Dynamic Cone Penetrometer (Figure 240-20-1), complete with replacement tips, two 25 cm spanner wrenches, a 10 mm x 250 mm breaking rod and one 6 mm (1/4”) allan wrench.

A stool or sturdy box for the person responsible for holding the instrument perpendicular to the surface. The end gate of a vehicle may be used instead.

A jack designed to retrieve the rod after the test (Figure 240-20-1).

If testing paved sections, a coring machine, a bar and a tamping tool for removal and replacement of asphalt and/or base coarse materials.

2.2. **Materials Required**

Sufficient cold mix to replace the core extracted on pavement sections.
3. **PROCEDURE**

3.1. **Description of Equipment Preparation**

The equipment is assembled as shown in Figure 240-20-1. It is important that all the screwed joints be kept tight during testing. The joints should be secured with wrenches before beginning each test. It may be necessary to use a non-hardening thread locking compound. Operating the DCP with loose joints will reduce the life of the instrument. The threaded portions may occasionally require repair with a tap and die set.

3.2. **Sample Preparation**

No preparation is necessary if the test is to start from surface. The instrument is held in an perpendicular position. The weight of the drop hammer seats the cone before the test begins.

The DCP is capable of penetrating through asphalt and base course materials. Tests in these materials causes additional wear on the instrument. Asphalt should be removed by coring. An area large enough to accommodate the base of the instrument is removed and the base course materials excavated to the subbase or subgrade. Before recording the zero reading of DCP (Figure 240-20-2), the drop hammer should be released once, to seat the cone in any disturbed material that may be present after excavation.

3.3. **Test Procedure**

Normally three people are needed to complete the test. One person stands on the stool and holds the apparatus by the handle while the second person lifts the drop weight. The third observes the readings and records them on the appropriate form.

The steel rule attached to the guide foot is placed through the slot in the hand guard. The foot is placed on the surface to be tested and the cone tip passed through the guide hole. The entire apparatus is then held by the handle perpendicular to the surface. The technician observes the reading on the rule at the top of the hand guard and records this as the Zero Reading of DCP (Figure 240-20-2).

The drop weight is then raised to its maximum height and released. It is extremely important to gain maximum height for each drop but care must be taken not to strike the weight against the handle. Doing so would cause the instrument to withdraw and results would be in question. The readings are taken with each blow of the weight. If the penetration rate is below 20 mm/blow, the frequency of readings may be decreased to:
4. RESULTS AND CALCULATIONS

4.1. Collection of Test Results

All the pertinent location data, the number of blows and depth readings are recorded on the Dynamic Cone Penetrometer Test form (e.g. Figure 240-20-2).

4.2. Calculations

The field data is reduced in terms of penetration versus corresponding number of blows. The number of blows is then plotted horizontally along the x-axis and the penetration reading plotted vertically along the y-axis (Figure 240-20-3).

Depending on the pavement structure and environmental conditions the plot is divided into "best fit" straight lines. The slope values are then calculated by the change in penetration versus the change in the number of blows observed over the range for that particular straight line section - expressed as mm/blow (Figure 240-20-3).

Determine the relationship between DCP slope and CBR using the model derived by Kleyn and Van Harden (Figure 240-20-4). The soil layer DCP value is converted to CBR by projecting the corresponding soil layer DCP slope value from its location on the x-axis vertically up to Line No 1 and then horizontally over to the y-axis. This is a slow process and can be eliminated using a spreadsheet program and the following equation:

\[ \log \text{CBR} = 2.628 - 1.273 \log(DCP) \]

where DCP = penetration mm/blow.
4.3. Reporting Results

A report of the CBR results containing date of testing, location, depth of each layer and corresponding layer CBR (Figure 240-20-5) should be sent to the engineer in charge of the project.

5. CALIBRATIONS, CORRECTIONS, REPEATABILITY

5.1. Tolerances and Repeatability

The cone is case-hardened but requires replacing. The cone should be replaced when its diameter is reduced by more than 10 percent, when its surface is badly gouged or the tip very blunt. The cone should be examined for wear before any test. A visual comparison to an new cone is a quick way to decide if the test should proceed. When used on subbase and subgrade materials, the cone can be expected to last 30 to 40 tests before replacement.

The DCP has a relatively high degree of repeatability. Should the rod leave its vertical alignment, no attempt should be made to correct this, as contact between the bottom rod and the sides of the hole lead to erroneous results. It is recommended that if the rod is deflected, a second test in the same vicinity should be completed.

5.2. Sources of Error

When used on base course material, the DCP consistently produces high and sometimes misleading results. The type, coarseness and compaction of the granular particles affect the penetration. While the DCP can be driven through asphalt and base course it is recommended that the results from these materials be viewed with some caution.

6. ADDED INFORMATION

6.1. References

AYERS, Michael E., THOMPSON, Marshall R., and UZARSKI, Donald R. Rapid Shear Strength Evaluation of In Situ Granular Materials. Transportation Research Record 1227.

HARISON, J.A., Correlation of CBR and Dynamic Cone Penetrometer Strength Measurement of Soils. Australian Road Research 16(2), June, 1986


Transportation Road Research Laboratory, Operating Instructions for the TTRL Dynamic Cone Penetrometer. Great Britain, 1883.

VAN VUUREN, Rapid Determination of CBR with the Portable Dynamic Cone Penetrometer. Reprint from "The Rhodesian Engineer". September, 1969.

FIGURE 240-20-1
TRRL DYNAMIC CONE PENETROMETER
### DYNAMIC CONE PENETROMETRE TEST

<table>
<thead>
<tr>
<th>C.S</th>
<th>Km</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test No.</td>
<td>Lane Direction</td>
<td></td>
</tr>
<tr>
<td>Wheel Path:</td>
<td>Outer Inner Other</td>
<td></td>
</tr>
<tr>
<td>Zero Reading of D.C.P.</td>
<td>Test started@</td>
<td>A.C. Base</td>
</tr>
<tr>
<td>Subbase</td>
<td>Subgrade</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. Blows</th>
<th>SUM/BLOWS</th>
<th>mm</th>
<th>No. Blows</th>
<th>SUM/BLOWS</th>
<th>mm</th>
<th>No. Blows</th>
<th>SUM/BLOWS</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 240-20-2**
Determination of CBR from DCP Test Results

<table>
<thead>
<tr>
<th>C.S.</th>
<th>km</th>
<th>Layer</th>
<th>From</th>
<th>To</th>
<th>Depth</th>
<th>Blow Count</th>
<th>No. of Blows</th>
<th>DCP (mm/blow)</th>
<th>Layer Log CBR</th>
<th>Layer CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-04</td>
<td>42.1</td>
<td>1</td>
<td>0</td>
<td>180</td>
<td>180</td>
<td>9</td>
<td>9</td>
<td>20.00</td>
<td>0.97</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>180</td>
<td>370</td>
<td>190</td>
<td>16</td>
<td>7</td>
<td>27.14</td>
<td>0.80</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>370</td>
<td>1000</td>
<td>630</td>
<td>28</td>
<td>12</td>
<td>52.50</td>
<td>0.44</td>
<td>2.7</td>
</tr>
</tbody>
</table>

**FIGURE 240-20-3**

**DCP TEST RESULT CS 5-04, Km 43.1**

- DCP (mm/blow) = 20.00, CBR = 9.4
- DCP (mm/blow) = 27.14, CBR = 6.4
- DCP (mm/blow) = 52.50, CBR = 2.7

**FIGURE 240-20-5**

- Penetration (mm) vs. Number of Blows
- Depth intervals and corresponding DCP values and CBRs
FIGURE 240-20-4  DCP - CBR RELATIONSHIP

1. KLEYN and VAN HEERDEN (60° cone)
2. SMITH and PRATT (30° cone)
3. VAN VUUREN (30° cone)
## APPROVAL SHEET

New [X] Revision [ ] Date of Previous Document ___ ___

Effective Date: 94-03-18

Description of Revision (Reason for Revision):

Review/Implementation Process:

- Internal review in Technical Standards & Policies Branch

Other Manuals/Policies Affected:

- Nil

Follow Up/Training Required:

- Check with Districts on whether procedures are being followed

Comments/Concerns/Implications (Budget/Environment/Stakeholders):

Prepared and Recommended by  G. Wasyliw 92-04-16

Approval Recommended by  R.A. Widger 94-03-15

Approval Recommended by  A.R. Gerbrandt - -

Approved by  D.G. Metz 94-03-18

Electronic File Updated 94-03-30

Update Mailed - -