Method of Test for
THE DETERMINATION OF IN-PLACE STIFFNESS BY THE DYNAMIC CONE PENETROMETER (DCP)
DOTD TR 645-10

INTRODUCTION

The locations of DCP testing shall be selected by the Engineer. In locations where the subgrade is being assessed, DCP testing should be conducted to at least 36 in. (914.4 mm) into the subgrade unless otherwise directed by the Engineer.

The DCP can be used to measure the stiffness of cohesive and non-cohesive soils, base course aggregates, recycled asphalt pavement, recycled concrete pavement, blended calcium sulfate and in some instances chemically (cement or lime) stabilized or treated soils. Under no circumstance should the DCP be used to measure the stiffness of Concrete or Asphalt pavements as well as large size (> 1 in. diameter) aggregate.

There are generally 5 types of typical sections that will be assessed with the DCP as shown in Table 1. The Engineer shall provide specific instructions on the testing regime for each type.

Table 1

Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Pavement	Pavement	Base course	Base course	Subgrade
Base course	Base course	Subgrade layer	Subgrade	
Subgrade layer	Subgrade	Subgrade		
Subgrade				

Only an Authorized DCP operator is to conduct the DCP tests. Completion of DCP training conducted by DOTD is required for authorization.

I. Scope

A. The DCP can be used to measure the stiffness of cohesive and non-cohesive soils, base course aggregates, recycled asphalt pavement, recycled concrete pavement, blended calcium sulfate and in some instances chemically (cement or lime) stabilized or treated soils. Under no circumstance should the DCP be used to measure the stiffness of Concrete or Asphalt pavements as well as large size (> 1 in. diameter) aggregate.

B. Reference Documents

1. ASTM D6951-03, Standard Test Method for Use of Dynamic Cone Penetrometer in Shallow Pavement Applications
2. DOTD TR 602M/602-96, Measuring Thicknesses and Widths of Base and Subbase Courses and Aggregate Type Surface Courses

II. Apparatus

A. The Schematic for the DCP is shown in Figure 1 (Source: ASTM D6951-03). The components of the DCP are typically constructed of stainless steel with the exception of the replacement tip, which is typically made of hardened tool steel or wear resistance material.

1. 17.6 lb (8 kg) hammer with a tolerance of 0.022 lb (0.010 kg).
2. Fixed Drop hammer height of 22.6 in. (575 mm) with a tolerance of 0.039 in. (1 mm).
3. 5/8 in. (16 mm) diameter upper steel drive rod and handle.
4. 5/8 in. (16 mm) diameter lower steel drive rod.
5. Coupler assembly
6. Anvil 2 in. (50 mm) diameter x 2.5 in. (62.5 mm) long (min)**.**
    a) Measuring rod or tape measure: The scale should have increments of 0.04 in. (1 mm) and a minimum length of 36 in. (914.4 mm).
    b) Optional sliding attachment: An optional sliding attachment may be used to hold the scale vertical while conducting tests
7. Extension rod. Length varies from 12 in. (304.8 mm) to 36 in. (914.4 mm).
8. Extraction jack as shown in Figure 4. (Source: ASTM D6951-03)
9. Rotary hammer drill capable of drilling at least a 1 in. (25 mm) diameter hole through the pavement. Alternatively, augering with a coring rig is allowed (refer to TR 602M/602-98).
10. Cone tips. There are two types of cone tips as shown in Figures 2 and 3: Type I (reusable) and Type II (disposable). The Type I tip may be used repeatedly (up to 250 times) and has inclined angle of 60 degrees and base diameter of 0.787 in. (20 mm). Type II cone tips are used only once and its dimensions are similar to Type I cone tips. The tolerances for both types of cone tips are ± 1 degree for the tip angle and ± 0.010 in. (0.25 mm) for their diameter.

Note A-1: Wet coring is not allowed.

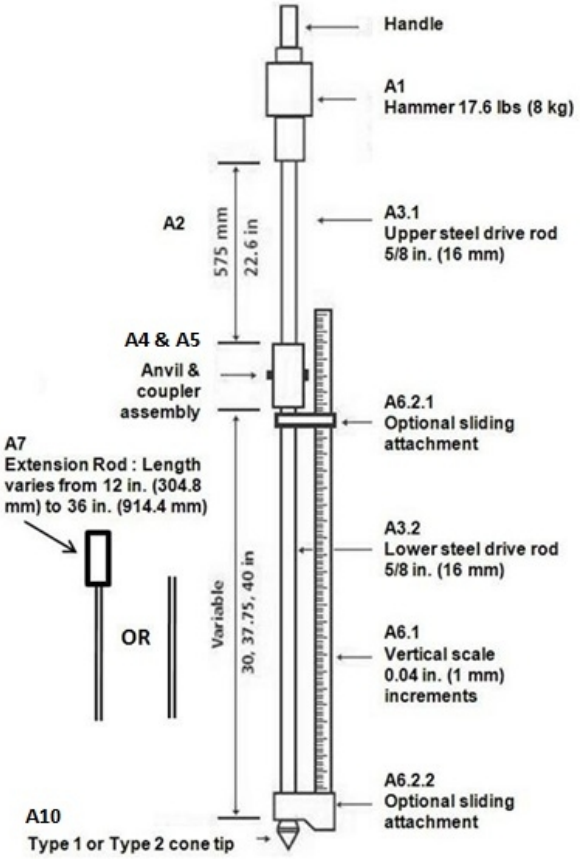

FIG 1: Schematic of DCP device

11. In addition to the DCP, DCP assembly tools as recommended by the manufacturer, lubricating oil, and a data recording sheet shown later may be required. Data may also be typed into an excel spreadsheet template which is available to all DOTD personnel at http://www.ltrc.lsu.edu/downloads.html.

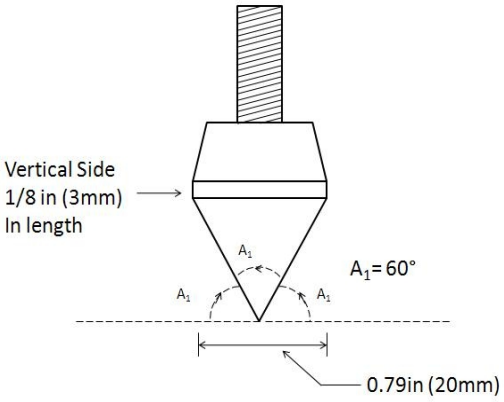

FIG 2: Type 1 Reusable Tip

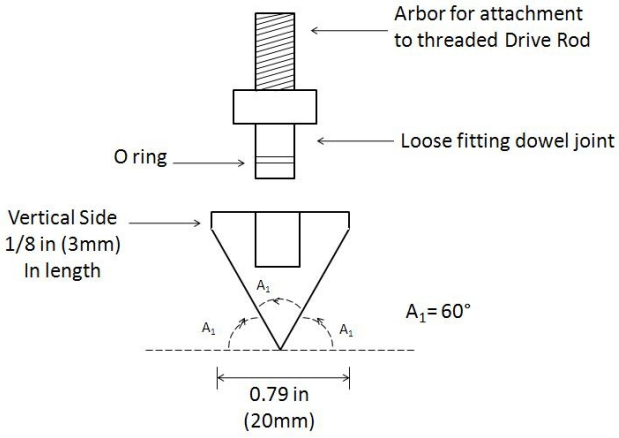

FIG 3: Type 2 Disposable Tip

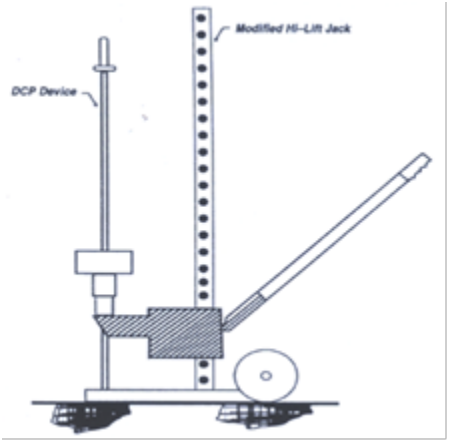

FIG 4: Extraction Jack

III. Health Precautions

Care must be taken with hand placement on the measuring scale, handle, or hammer during testing so as not to injure the hands or fingers.

IV. Samples, Test Specimens, Test Locations, etc.

A. The locations of DCP testing shall be selected by the Engineer. In locations where the subgrade is being assessed, DCP testing should be conducted to at least 36 in. (914.4 mm) into the subgrade unless otherwise directed by the Engineer.

V. Procedure

A. Equipment check: Inspect the DCP for damaged or fatigued parts and excessive wear of the drive rod or reusable cone tip if it is being used. Securely tighten or fasten all joints as well as the Type 1 or Type 2 tips on the drive rod. (See Figures 2 and 3)

B. Basic operation:
   1.Operator
      a) Hold the DCP in a vertical\plumb position.
         i. On the pavement surface, take an initial reading.
         ii. In a drilled hole (if applicable), take an additional reference reading.
      b) Raise and release the hammer from the standard drop height.
   2.Recorder
      a) Read the scale at reference points and after each blow.
      b) Record the measurements corresponding to the blow on the DCP data recording sheet included in this document (Appendix 1).

Note B-1: A measurement is recorded for each blow

C. Testing and recording procedure for Case 1 and 2 sections as shown in Table 1
   1.Determine thickness needed to ensure that penetration will be at least 36 inches into the subgrade. Add extensions. The appropriate extensions should be added to the DCP assembly prior to beginning testing to account for the thickness of the Pavement, base course, and subgrade layer.
   2.Initial reading: Begin by placing the DCP and measuring scale vertically plumb on the surface and record the measurement (R1) (cm) on the data recording sheet as shown in Figures 5 and 6, respectively.
   3.Pilot hole: Drill a vertically plumb 1 in. (25.4 mm) diameter hole (minimum) through the pavement layer as shown in Figure 7. Alternatively, the pilot hole may be created by auguring with a core rig. The pilot hole under no circumstance should be created by wet coring.
   4.Record the reading prior to the first DCP blow: Place the DCP through the pilot hole and let the cone tip rest on top of the layer to be tested as shown in Figure 8. Record the reading (R2) (cm) in the location shown in Figure 6. This reading corresponds to blow count 0 as shown in Figure 6.

D. Testing sequence
   1. Dropping the hammer: Hold the DCP assembly vertically plumb. Lift and drop the hammer and from the standard height as shown in Figure 1. The person recording the data records the blow count and reading from the vertical scale corresponding to each blow as the DCP penetrates through the layer as shown in Figure 6. Alternatively, the data may be recorded directly into the excel template as mentioned in Section II.A.10.

Note D-1: A reading must be recorded for each blow.

   2. Depth of penetration: The depth of penetration should be to at least 36 inches into the subgrade as shown in Figure 9 unless otherwise directed by the Engineer. For example, if the total thickness of the pavement, base course, and subgrade layer is 24 in. (609.6 mm) then a 24 in. (609.6 mm) extension should be added to the assembly.
   3. Refusal: In some instances, the DCP may not penetrate the material and this is

referred to as refusal. If after 10 blows, the device has not advanced more than 1 mm, testing shall cease on that layer. When refusal occurs, the DCP is removed from the hole and the rotary drill is used to drill through that layer as shown in Figure 10. The DCP is then carefully placed vertically plumb through the hole and allowed to rest on top of the layer to be tested. Record that reading (R2) (cm) and re-label that blow as 0 as shown in Figures 11 and 12. Testing is resumed as before as outlined in V.D.1.

4. Extraction: Once testing is complete, use the extraction jack to remove the DCP from the testing hole.

Note D-2: Do not reverse impact the handle to extract the DCP. Damage/breakage will occur.

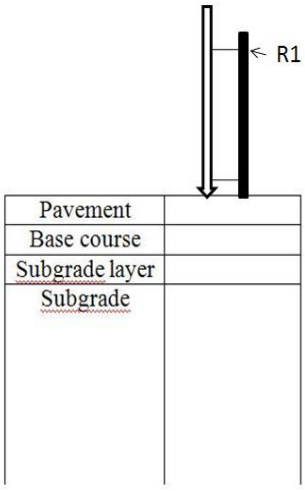

Figure 5

Project	
Date	
Location (CSLM / STA.)	
Location (Lane direction)	
Location (Outside / Inside Lane)	
Location (Distance from centerline)	
Initial reading on Surface	R1 = 42.1
Pilot hole depth	R2-R1 = 56.8-42.1=14.7
Reading after pilot hole	R2 = 56.8
Comments	

Number (A) Of Blows	Rod (B) Reading (cm)	Comments
0	56.8	
1	61.7	
2	62.6	
3	63.1	
4	63.5	
5	64.0	
"	"	

(A) Number of Hammer blows between test reading
(B) Scale reading corresponding to blow in cm

Figure 6

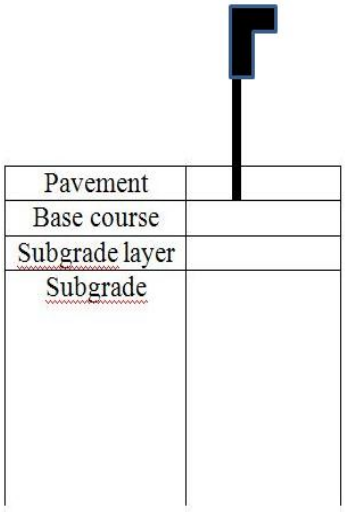

Figure 7

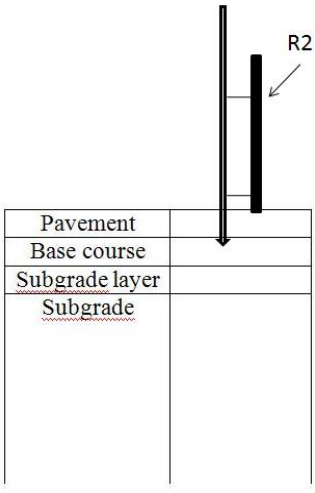

Figure 8

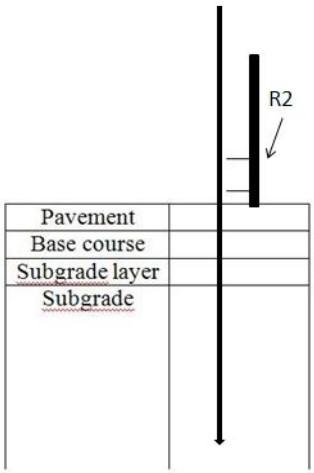

Figure 9

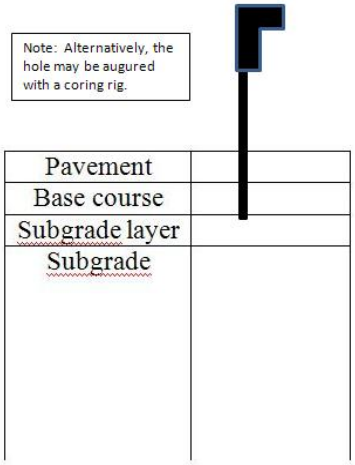

Figure 10

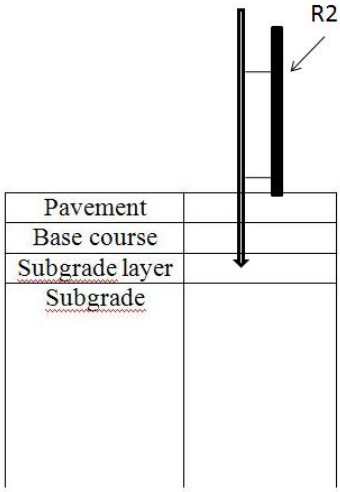

Figure 11

Project	
Date	
Location (CSLM / STA.)	
Location (Lane direction)	
Location (Outside / Inside Lane)	
Location (Distance from centerline)	
Initial reading on Surface	**R1=30.2**
Pilot hole depth	**R2-R1=26.6**
Reading after pilot hole	**R2=56.8**
Comments	

Prior to refusal

Number (A) Of Blows	Rod (B) Reading (cm)	Comments
0	46.3	
1	46.8	
2	49.9	
3	47.0	
4	47.0	
5	47.0	
6	47.0	
7	47.0	
8	47.0	
9	47.0	
10	47.0	
11	47.0	
12	47.0	
13	47.0	
0	56.8	
1	61.7	
2	62.6	
3	63.1	
4	63.5	
5	64.0	
"		

(RF) Refusal occurred from Blows 3 to 13 & drilled through layer
(A) Number of Hammer blows between test reading
(B) Scale reading corresponding to blow in cm

Figure 12

5. **Data recording:** Use the form shown in Appendix 1 to record field data from DCP testing or the Excel template mentioned in A10 to record the data in a lab top computer. Form can be downloaded from http://www.ltrc.lsu.edu/downloads.html.

VI. Calculation and Interpretation of Results

Refer to field measurements

VII. Report

If the field data was recorded on the form in Appendix 1, then it will be transcribed into the Excel template mentioned in Section II.A10 and given to the Engineer. If the field data was recorded into the excel template in the field, that shall be delivered to the Engineer as the report

VIII. Normal Test Reporting Time

DCP testing time varies from 5 to 30 minutes depending upon site conditions.

IX. Illustrations and Tables, etc.

Appendix 1
DCP field measurements

Sheet _____ of _____

Project Number (1)	**456-99-0562**	**Date**	**12-21-2009**
CSLM (1)	**1.356**	**Lane Direction**	**NB**
Lane (Outside/Inside)	**Out**	**Distance from Centerline**	**9**
Reading on Surface (cm)	**10.0**	**Reading after pilot hole (cm)**	**30.0**
Pilot hole depth (cm)	**20.0**		
Comments	**La 1, Avoyelles Parish (DCP tests in right wheel path)**		

(1) Project Number and CSLM required to export into Content Manger

Number of blows	Rod reading	Number of blows	Rod reading	Number of blows	Rod reading
0	30.0	14	39.2	28	55.5
1	31.2	15	39.9	29	59.3
2	33.2	16	40.3	30	62.3
3	34.1	17	40.5	31	64.5
4	34.5	18	42.3	32	68.2
5	34.9	19	43.6	33	70.6
6	35.0	20	44.1		
7	35.3	21	44.9		
8	35.6	22	45.6		
9	35.8	23	45.9		
10	36.2	24	48.3		
11	37.8	25	49.5		
12	38.2	26	50.2		
13	38.9	27	52.3		

Note: Excel template form can be downloaded from http://www.ltrc.lsu.edu/downloads.html.