ALDOT-462
DETERMINING THE IN-PLACE STRENGTH OF SOIL-CEMENT BASE WITH THE DYNAMIC CONE PENETROMETER

1. General

1.1. This procedure provides a method for determining the in-place compressive strength of soil cement base with the Dynamic Cone Penetrometer (DCP).

1.2. Except otherwise noted herein, the test method shall follow all the requirements of ASTM D6951/6951M titled "Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications".

1.3. The use of this procedure consists of the following four steps:
- 1.3.1. Procedure to conduct DCP tests
- 1.3.2. Procedure to analyze DCP test data
- 1.3.3. Determining the compressive strength from DCP test results

2. Referenced Documents

2.1. ASTM D6951/6951M, Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications

3. Apparatus

3.1. The Contractor shall supply all necessary equipment to use this procedure. The equipment will be approved by the Materials and Tests Engineer prior to use.

3.2. All DCP test equipment shall meet all the requirements of ASTM D6951/6951M. The following are also required for all DCP equipment:
- 3.2.1. A standard 17.6 lb hammer with a with a 22.6-inch drop height.
- 3.2.2. A replaceable point tip with a 60° angle. Tips shall be replaced after no more than 100 tests.
- 3.2.3. An extra strong, 37-inch long, 0.75-inch diameter drive rod.
- 3.2.4. An automated method to collect all penetration versus depth data. The automated method shall also make all test data electronically available for transfer to a personal computer. An example of such equipment is the Magnetic Ruler (with Upper Attachment) available from Kessler Soils Engineering Products, Inc. (Leesburg, Virginia).

3.3. The same brand and type of DCP shall be used for all testing performed on a specific project.

4. Procedure to Conduct DCP Tests

4.1. Perform three tests at each DCP testing location in a triangular pattern as shown in Figure 1. The corner of the triangular pattern should be 2 ft ± 0.5 ft apart.

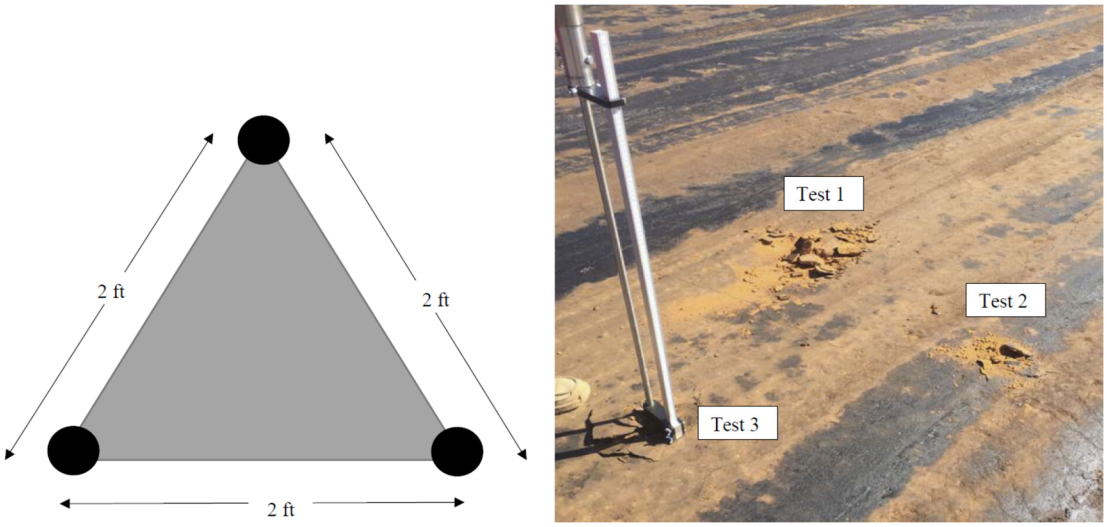

Figure 1: Triangular test pattern required at each DCP testing location

4.2. Due to the small displacements, use the millimeter (mm) scale of the DCP to record all data.

4.3. With the DCP held vertically, seat the DCP tip by driving the tip 25 mm (1 in.) into the soil-cement base, such that the top of the widest part of the tip is flush with the surface of the soil cement.

4.4. While holding the DCP in a vertical plumb position the operator shall raise the hammer until it makes light contact with the top handle and release the hammer to initiate a blow.

4.5. Using the Magnetic Ruler, record penetration readings in mm after every blow of the hammer. This process shall continue until at least 100 mm (4 inch) of total penetration is exceeded, unless refusal occurs as defined in Section 4.6.

4.5.1. Note that the total penetration of at least 100 mm (4 in.) consists of the seating depth of 25 mm (1 in.) plus an additional DCP test depth of at least 75 mm (3 in.).

4.6. In accordance with ASTM D 6951, if the penetration is less than 2 mm after five blows or the DCP handle deflects more than 3 inches from the vertical position, testing shall be stopped. When either of these occur, this is considered refusal and the test is complete.

4.7. Remove the DCP by driving the hammer upwards against the top of the handle.

5. Procedure to Analyze DCP Test Data

5.1. The DCP data can be analyzed by using the DCPAL software available from ALDOT. The DCPAL software will analyze the data and determine the average DCP compressive strength for the soil-cement section as defined herein.

5.2. Download all the DCP test data for each test one at a time and label each file

to clearly define the test location.

5.3. For each individual test, starting at 0 mm, use linear interpolation between the collected values to obtain blow count data at every 5 mm of penetration.

5.4. The data collected over a seating depth of 25 mm will be discarded, and the subsequent 75 mm of data will be used as the DCP analysis depth.

5.5. If refusal was determined to occur in accordance with ASTM D6951, the DCP data collected for this test will be discarded and not included in any subsequent analysis.

5.6. Identification of Potential Outliers

5.6.1. Only consider data collected over the DCP analysis depth (75 mm), i.e. do not include any results collected when seating the DCP.

5.6.2. For each individual test, plot the blow count on the x-axis versus the penetration depth on the y-axis. Use a linear regression analysis with the intercept set to zero, to determine the best-fit slope (in units of mm/blow) of the blow count versus penetration data. An example graph is shown in Figure 2 and in this example the best-fit slope is 2.123 mm/blow.

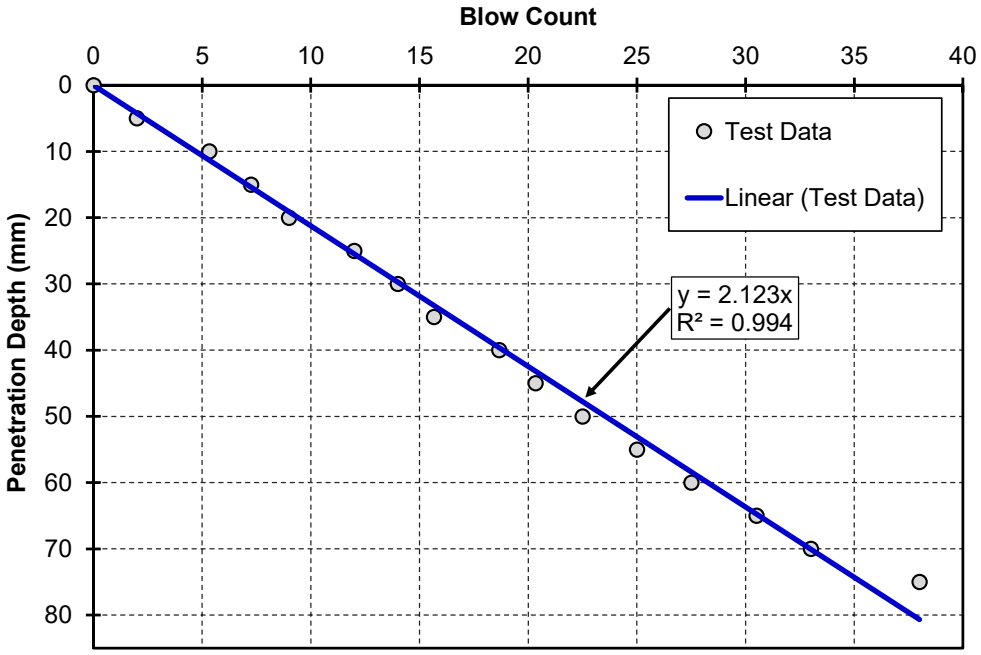

Figure 2: An example graph of blow count versus penetration depth with a linear regression analysis shown for the results.

5.6.3. Repeat the step directly above for all three tests at a location. Once all three slopes of the three tests at a location have been determined, determine the range in percent of these results by taking the maximum slope minus the minimum slope divided by the average of all three slopes and multiplying by 100.

5.6.4. If the range in percent is less than or equal to 50 percent, then no outlier exists at this test location and the analysis can proceed.

5.6.5. If the range in percent exceeds 50 percent, then an outlier exists in the data. The outlier is the test result that has the slope that is the furthest removed (below or above) from the average slope of the data. If an outlier exists, this test results shall be discarded and not included in any subsequent analysis.

5.6.6. If one outlier was found and discarded, then the next step is to determine the range in percent of the remaining two results by taking the maximum slope minus the minimum slope divided by the average of the two slopes and multiplying by 100.

5.6.7. If the range in percent is less than or equal to 50 percent, then no additional outliers exists at this test location and the analysis can proceed.

5.6.8. If the range in percent exceeds 50 percent, then these two results are too statically different to analyze and these two DCP test shall be discarded. Three new DCP tests shall be collected near the location where these tests were performed.

5.7. Determine the average slope (in units of mm/blow) of the tests at a location.

6. Determining the Compressive Strength from DCP Results

6.1. Calculate the compressive strength of the test location by using Equation 1.

$$MCS = 1220e^{-0.559 \times DCP} \quad \text{(Equation 1)}$$

Where,

MCS = Molded cylinder strength (psi), and
DCP = Average DCP slope (mm/blow).

Example:

Assume that DCP = 1.725 mm/blow
From Equation 1, MCS = 465 psi

6.2. Repeat the calculation in Section 6.1 to determine the compressive strength at all three test locations within the test section.

6.3. Determine the average DCP compressive strength to the nearest 10 psi for the three test locations in a test section.

7. Report

7.1. The following minimum data shall be reported:

- DCP technician name,
- Location of the test section,

- Date and time when the test section was constructed,
- Date and time when the DCP tests were performed,
- Any test(s) that met refusal in accordance with ASTM D6951,
- Any test(s) that were identified as outliers,
- The average slope (in units of mm/blow) of the DCP tests performed at each test location,
- The compressive strength (in psi) obtained from the average slope of the DCP tests performed at each test location, and
- Average DCP compressive strength of the section to the nearest 10 psi.