SALEM TOOL COMPANY

CORPS STYLE
DUAL MASS DYNAMIC CONE
PENETROMETER

APPLICATION AND MAINTENANCE
MANUAL

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Description of Dual Mass DCP

The Dual Mass Dynamic Cone Penetrometer (DCP) consists of a steel extension shaft assembly with a 60 degree hardened steel cone tip attached to one end which is driven into the pavement or subgrade by means of a sliding dual mass hammer (figure 1). The diameter of the base of the cone is 20 mm. The diameter of the cone is 8 mm larger than that of the extension shaft assembly to ensure that the resistance to penetration is exerted on the cone. The DCP is driven into the soil by dropping either the 8 kg or 4.6 kg sliding hammer from height of 575 mm. The 8 kg hammer is converted to 4.6 kg hammer by removing the hexagonal set screw and removing the outer steel sleeve from the dual mass hammer. This procedure can be accomplished during a test since the outer sleeve is designed to slide over the DCP handle. The cone penetration caused by one blow of the 8 kg hammer is essentially twice that caused by one blow of the 4.6 kg hammer. The 4.6 kg hammer is more suitable for use and yields better test results in weaker soils having CRB of 10% or less. And can be used for evaluating soils in foundations for residential structures which require a bearing value of 2000 PSF (approximate CRB of 6%). The 8 kg hammer penetrates high strength soils quicker and may be preferred when these types of soil are encountered. However, the 4.6 kg hammer can be used on soils up to CRB 80%.

Depth of Cone Penetration

The depth of cone penetration is measured at selected penetration or hammer drop intervals and the soil sheer strength is reported in terms of the DCP index. The DCP index is based on the average penetration depth resulting from one blow of the 8 kg hammer. The average penetration per hammer blow of the 4.6 kg hammer must be multiplied by 2 in order to obtain the DCP index value. The DCP is designed to penetrate soils to a depth of 1 meter. Individual values are reported for each test depth resulting in a soil-strength-width-depth profile for each test location.
 Longer length extension shafts may be ordered for special applications. Consult our dealer for more information.

Disposable Cone Tips

The disposable cone tip is used in soils where the standard cone is difficult to remove. The disposable cone tip mounts on an extension shaft assembly equipped with an optional cone tip adaptor. At the conclusion of the test, the disposable cone tip easily slides off the cone tip adaptor allowing the operator to easily remove the DCP device from the soil. The disposable cone tip remains in the soil. Use of the disposable cone approximately doubles the number of tests per day that can be run. It also helps to greatly reduce user fatigue. As well as excess wear and tear on the DCP Slide Hammer Assembly.

Go/No-Go Gauge Use

The Go/No-Go gauge is used to ensure that the cone tip base diameter is within proper tolerance. Each new cone tip should be checked before use and at selected usage intervals to ensure the cone tip base diameter is within a proper tolerance of between 19.81 mm and 20.32 mm. The cone tip must be replaced if its base diameter fits into both ends or neither end of the Go/No-Go gauge. The cone tip is within proper tolerance when it fits only into one end if the gauge.
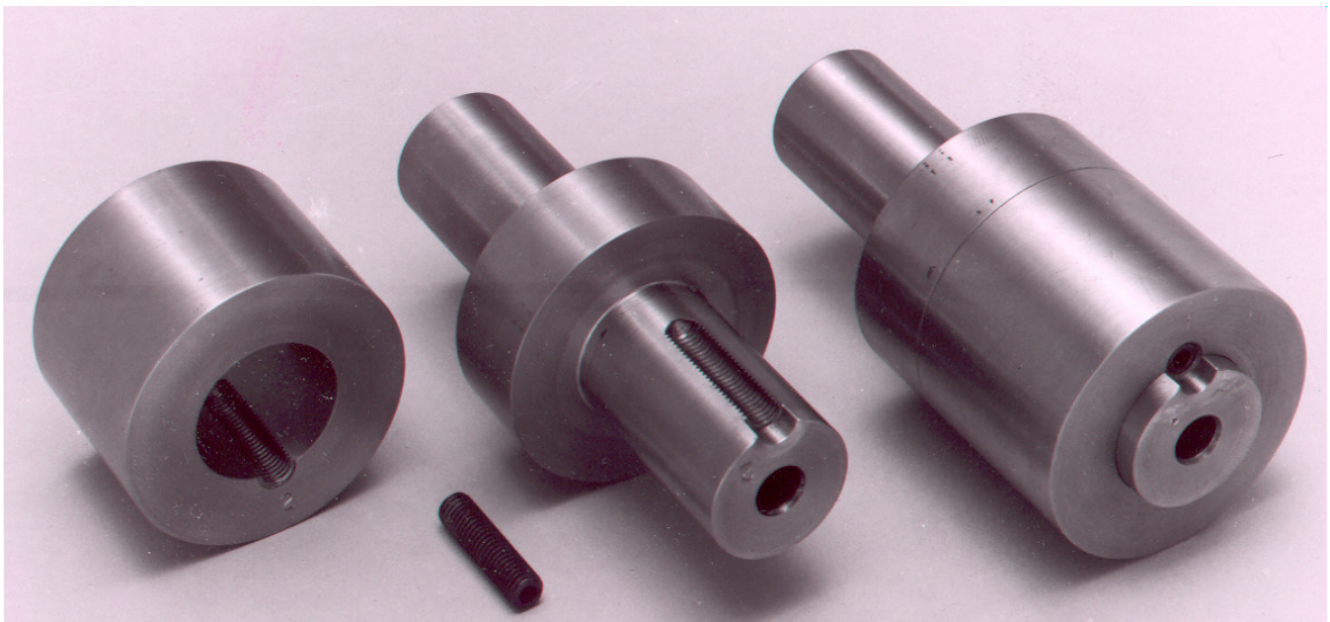
Figure 1. Dual Mass Hammer showing the Removable steel sleeve, Set screw, 4.6 kg Hammer and 8 kg Hammer Configuration

(3)

Operation of the Dual Mass DCP

Two people are required to operate the DCP. One person holds the device by the handle in a vertical position and taps the device using the hammer until the base of the cone is flush with the surface of the soil. The second person then checks the device for a zero reading by holding the vertical scale between the soil surface and bottom of hammer. The bottom of the 4-in.-diameter portion of the hammer should read zero millimeters on the vertical scale. In weak soils, the weight of the DCP device will sink the cone past its zero reading. In this case a zero blow penetration reading is recorded at the actual measured pretest depth to the nearest millimeter. The hammer is then raised to the bottom of the handle and dropped. Care should be exercised when raising the hammer to ensure that the hammer is touching the bottom of the handle but not lifting the cone before it is allowed to drop. The hammer must be allowed to fall freely with its downward movement not influenced by any hand movement. The operator should also be careful not to exert any downward force on the handle after dropping the hammer. Both the operator and the recorder should keep track of the number of hammer drops (blows) between measurements.

The recorder is responsible for recording the number of hammer blows between measurements and measuring and recording the penetration after each set of hammer blows. The penetration measurements are recorded to the nearest millimeter. As an example of how to read the penetration depth, (figure 2) shows a penetration depth of 150 mm.

The cone must penetrate a minimum of 10 mm between recorded measurements. Data taken at less than 10 mm penetration increments are unnecessary and sometimes result in inaccurate strength determinations The number of hammer blows between measurement recordings will generally be 20, 10, 5, 3, 2, or 1 depending on the soil strength and thus cone penetration rate. Both the operator and recorder should be alert to sudden increase in the cone penetration rates during the test. Any noticeable increase in the penetration rate indicates a weaker soil layer. The operator should stop and allow the recorder to record the blow count and penetration depth whenever a weaker soil layer is encountered.

After the cone has been driven to the desired test depth (max. 1 meter), it is extracted from the soil by driving the hammer against the top handle. Caution must be exercised during this operation in order to not damage the DCP device. The hammer must be raised in a vertical direction (rather than in a arcing motion) or the rod may be bent or broken. In soils where great difficulty is encountered in extracting the DCP device, the disposable cone tips should be used. Use of the disposable cone tips will save wear and tear on both the device and the operator. In some soils with large aggregate the DCP may try to penetrate the soil at a slant rather than from a vertical direction. The operator should not apply force to the handle of the DCP on an attempt to force it to penetrate the soil vertically. Lateral force will cause the upper handle rod to fatigue and possibly break. Instead, the test should be stopped when the handle deviates laterally 6 in. or more from the vertical position and a new test attempted at another location.
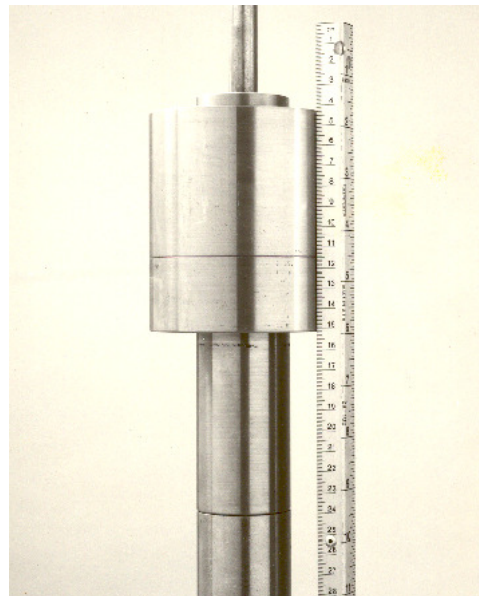

Figure 2. Example of penetration measurement showing a penetration of 150 mm

Soil Strength Evaluations With DCP

Correlation Of DCP With Index CBR

Correlation of **DCP** index with **CBR** is the soil strength value often used for designing and evaluating unsurfaced, aggregate surfaced, and flexible pavements for roads. A data base of field **CBR** versus **DCP** values was collected by Waterways Experiment Station technicians from many sites and different soil types. In addition, correlation test results by Harrison (1987), Kleyn (1975), Livneh and Ishai (1987), and Van Vuuren (1969) were compared with the data base test values. General agreement was found between the various sources of information. The equation Log **CBR** - 2.46-1.12 (Log **DCP**) was selected as the best correlation. In this equation, **DCP** is the penetration ratio in millimeters per blow for the 8 kg hammer. Figure 3 shows a plot of the correlation of **CBR** versus **DCP** index. Figure 4 shows a tabulated correlation of **DCP** index with **CBR**. Figure 5 shows the correlation between the **CBR** values and the bearing value in **PSF**. This correlation is helpful when the bearing value **PSF** is needed.

Data Tabulation

A suggested format for DCP data collection is shown in Figure 6. The data can be tabulated in spreadsheet format with the only data input values required being those of the number of hammer blows, hammer weight, and cone penetration record to the nearest 5 mm after each set hammer blows. A blank copy of the data collection sheet is shown in Figure 7.

Data Analysis

The user should group test data for locations having similar type soil conditions. For each location group, an individual should make a combined data plot showing CBR, interpreted from Figure 3, versus depth in inches as shown in Figure 4. From this data an average data plot of CBR versus depth in inches should be developed.

(6)

DCP Index mm/blow	CBR %	DCP Index mm/blow	CBR %
<3	100	51	3.6
3	80	52	3.5
4	60	53-54	3.4
5	50	55	3.3
6	40	56-57	3.2
7	35	58	3.1
8	30	59-60	3.0
9	25	61-62	2.9
10-11	20	63-64	2.8
12	18	65-66	2.7
13	16	67-68	2.6
14	15	69-71	2.5
15	14	72-74	2.4
16	13	75-77	2.3
17	12	78-80	2.2
18-19	11	81-83	2.1
20-21	10	84-87	2.0
22-23	9	88-91	1.9
24-26	8	92-96	1.8
27-29	7	97-101	1.7
30-34	6	102-107	1.6
35-38	5	108-114	1.5
39	4.8	115-121	1.4
40	4.7	122-130	1.3
41	4.6	131-140	1.2
42	4.4	141-152	1.1
43	4.3	153-166	1.0
44	4.2	166-183	0.9
45	4.1	184-205	0.8
46	4.0	206-233	0.7
47	3.9	234-271	0.6
48	3.8	272-324	0.5
49-50	3.7	>324	<0.5

Figure 4: Tabulated Correlation of CBR versus DCP Index
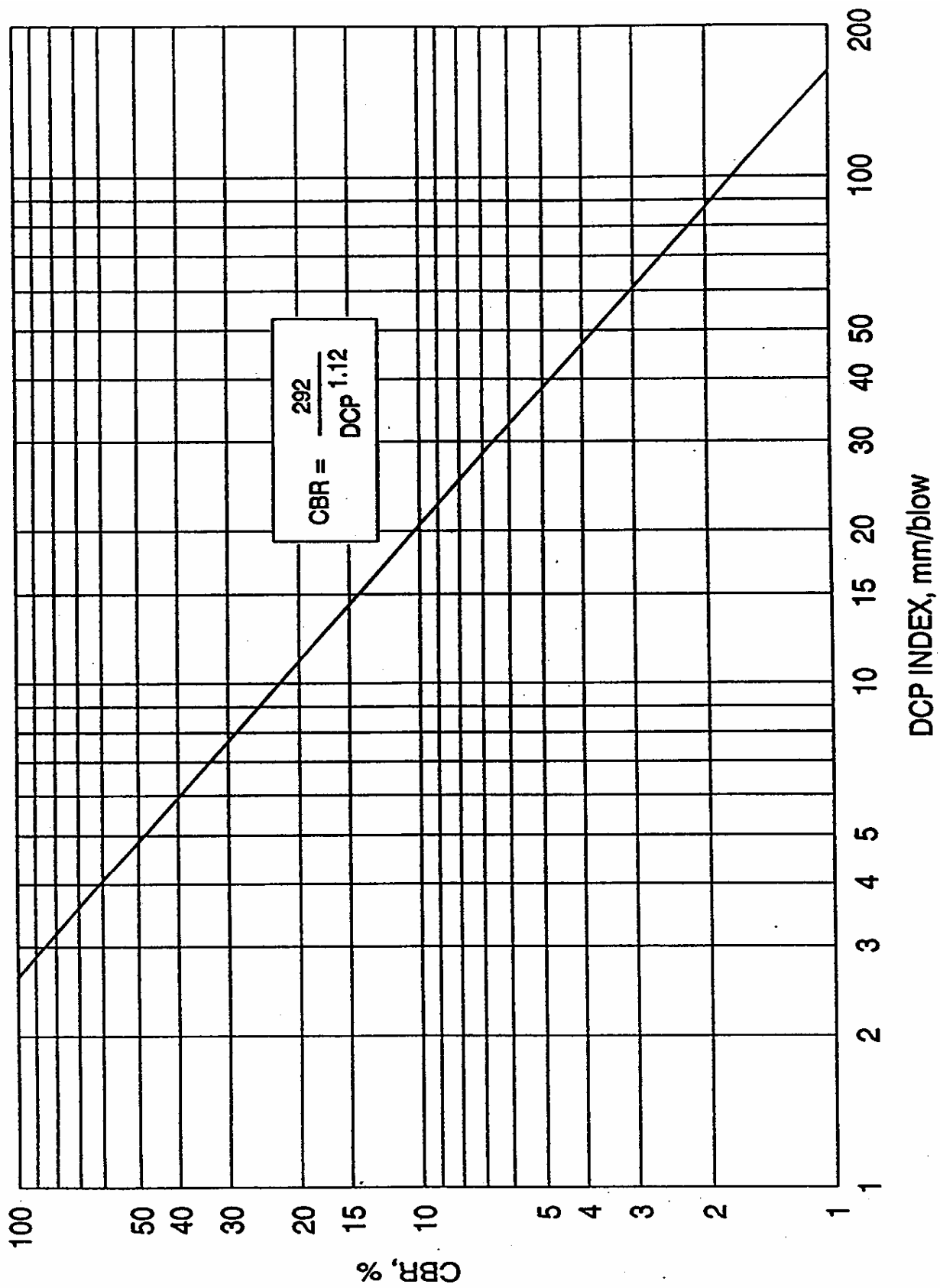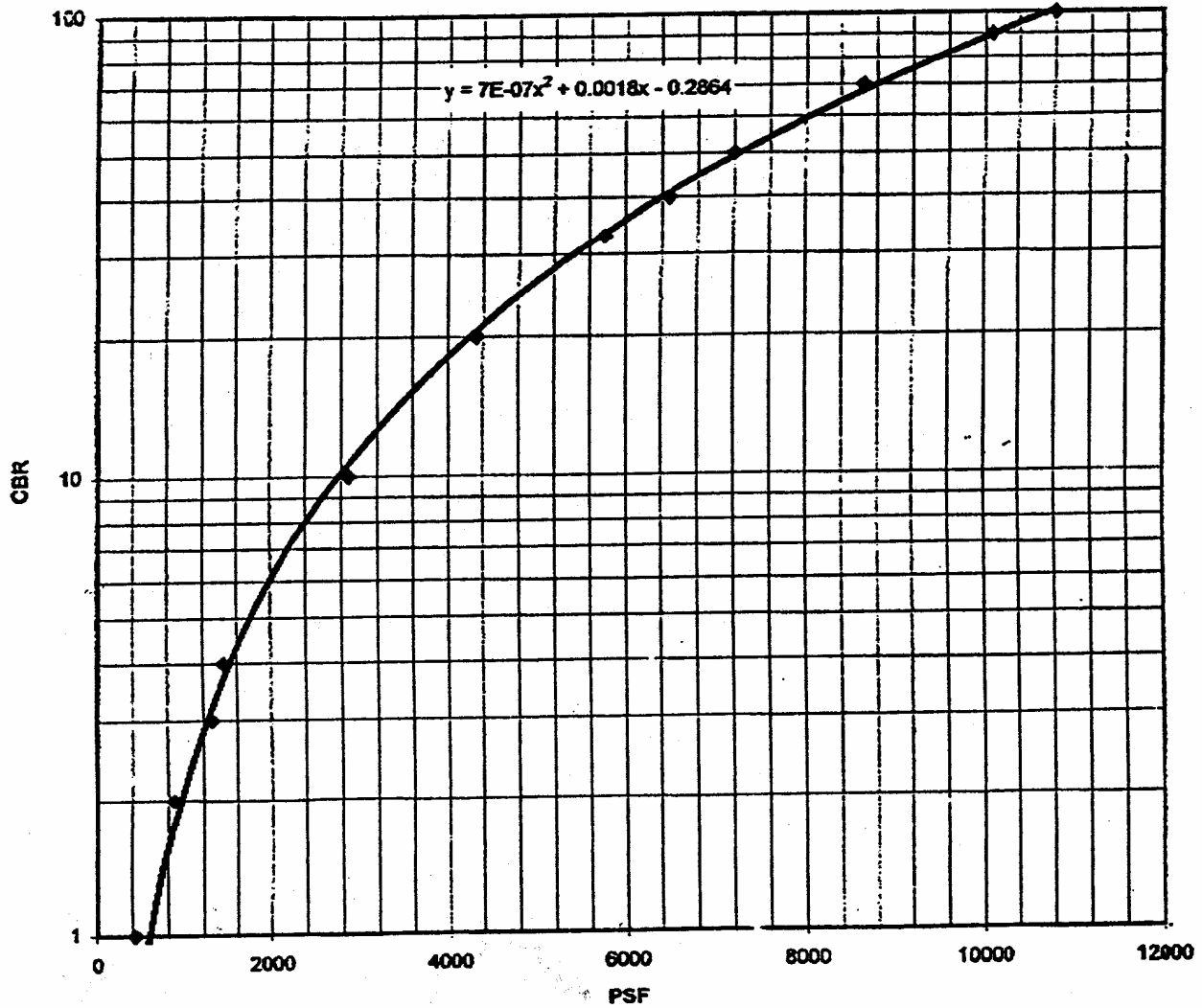
CBR, %

DCP INDEX, mm/blow

$$CBR = \frac{292}{DCP^{1.12}}$$

(8)

Figure 5: CBR Versus Bearing Value

| Project: Forest Service Road | | | Date: 24 SEPT 2001 | | | |
| Location: STA 30 + 50, 4 ft rt of C/L | | | Soil Type(s): GW/CL | | | |

No. Of Blows (1)	Accumulative Penetration/ mm (2)	Penetration per Blow Set/ mm (3)	Penetration per Blow/mm (4)	Hammer Blow Factor (5)	CBR % (7)	DCP Index (6)
0	0	-	-	-	-	-
5	25	25	5.0	1	50	6.0
5	55	30	6.0	1	40	6.0
15	125	70	4.7	1	50	5.0
10	175	50	5.0	1	50	5.0
5	205	30	6.0	1	40	6.0
5	230	25	5.0	1	50	5.0
10	280	50	5.0	1	50	5.0
5	310	30	6.0	1	40	6.0
5	340	30	6.0	1	40	6.0
5	375	35	7.0	1	35	7.0
5	435	60	12.0	1	18	12.0
2	495	60	30.0	1	6	30.0
2	530	35	17.5	1	12	17.5
3	555	25	8.3	1	30	8.3
6	605	50	12.5	1	18	12.5
3	640	35	11.7	1	18	11.7
3	680	40	13.3	1	16	13.3
3	705	25	8.3	1	30	8.3
3	745	40	13.3	1	16	13.3
3	775	30	10.0	1	20	10.0
3	810	35	11.7	1	18	11.7
3	840	30	10.0	1	20	10.0
3	865	25	8.3	1	30	8.3
4	890	25	6.3	1	40	6.3
4	920	30	7.5	1	35	7.5

1. Number of hammer blows between test readings.
2. Accumulative cone penetration after each set of hammer blows.
3. Difference in accumulative penetration (2) at start and end of hammer blow set.
4. (3) divided by (1).
5. Enter 1 for 8 kg hammer. Enter 2 for 4.6 kg hammer.
6. (4) X (6).
7. From CBR versus DCP correlation.

Figure 6: Example of Completed DCP Data Sheet(10)

Project:			Date:			
Location:			Soil Type(s):			

No. Of Blows (1)	Accumulative Penetration/ mm (2)	Penetration per Blow Set/ mm (3)	Penetration per Blow/mm (4)	Hammer Blow Factor (5)	DCP Index (6)	CBR % (7)

1.   Number of hammer blows between test readings.
2.   Accumulative cone penetration after each set of hammer blows.
3.   Difference in accumulative penetration (2) at start and end of hammer blow set.
4.   (3) divided by (1).
5.   Enter 1 for 8 kg hammer. Enter 2 for 4.6 kg hammer.
6.   (4) X (6).
7.   From CBR versus DCP correlation.

THE U.S. ARMY CORPS OF ENGINEERS OFFERS

Pavement-Transportation Computer Assisted
Structural Engineering (PCASE)

The PCASE program was established to develop and provide computer programs for use in the design and evaluation of transportation systems. The latest versions of all PCASE programs are available to user 24 hours a day via the PCASE Bulletin Board, Internet and, of course, WWW. PCASE software is free of charge (FREEWARE) to all private individuals, companies and government affiliates.

Phone Number: (800) 522-6937
Fax Number: (601) 634-3020
WWW Address: http://www.pcase.com/

All of the PCASE programs may be accessed by BBS or anonymous ftp using the information above or by clicking on the appropriate file name below.

DCP Evaluation: This program is specifically designed for the Dual Mass Dynamic Cone Penetrometer as it is produced under license by the US Army Corps of Engineers.

INSTRUCTIONS FOR USING
THE DCP EXCEL SPREADSHEET

1.   Open the file **DCP.XLT** in Excel version 5 or later

2.   Click on cell **C4** and type the **PROJECT NAME,** then hit enter key.

3.   Type **TEST LOCATION** in cell **C5**, then hit enter key.

4.   Click on cell **G4** and type the data **Day-Month-Year**, then hit enter key.

5.   Click on the soil type **CH, CL**, or **All other soils button**. If soil type is not known click the **All other soils button** and describe the soil in cell **G5**

6.   Select the **10.1 lb**, or **both** hammer button.

7.   Type in test data in cells **A13-55** and **B13-55.**
        Also, if cells **C13-55** are blank, enter **1** when using the 17.6 lb hammer or **2**   when using the 10.1 lb hammer.

8.   **CBR vs Depth** will plot automatically.

9.   **Save** button can be used to save that test data. When the file is saved, the name is printed on the data sheet below ADCP TEST DATA≅

10.   **DELETE** button will delete current DCP test data and prepare the spreadsheet for entering new test data. **PROJECT, LOCATION, DATA, SOIL, TYPE,** and **HAMMER** information will have to be updated.

11.   **PROFILE BUTTON** is still under development. Layer and CBR information must be hand typed on the profile drawing.

To use the PROFILE BUTTON

a. Save current file and then print a copy of the spreadsheet.

b. Use the CBR vs Depth plot to determine the thickness and CBR of the various soil layers tested. This requires some judgement on your part.

c. Click **PLOT PROFILE** button and a **Soil Profile** box asks Ado you want a profile of your data?≅ Click Yes

d. A **Layer** box asks for the number of layers in the profile Type in the number of layers and hit the enter key.

e. A profile box is then automatically drawn below the CBR vs Depth plot. A **box labeled 1** then asks for the first layer depth (in inches). Enter the layer depth and hit the enter key.

f. A line is automatically drawn for layer depth 1 and **box 2** asks for the depth of layer 2. Enter the depth and hit the enter key. Repeat the box instructions until all layers have been drawn.

g. **Double click on the profile drawing**. The border of the profile drawing will be highlighted. Next, type **A__CBR**≅ for the firsts layer and hit the enter key. The **A__CBR**≅ will print on the profile drawing. Click on the **A__CBR**≅ box and move it where you want. Repeat typing and moving word information until the profile drawing is complete. You can click on other parts of the drawing and edit as desired.

h. Remember, **Plot Profile** is under development. If an error message appears, close the file without saving and reopen the file and try again.

11.   **PRINT** will print the DCP data sheet including the CBR vs Depth graph and profile drawing.

13.   You can click on the graph or profile drawing and cut and paste them into other window programs or change them to suit your needs.