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 extension shaft is 16 mm diameter 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. It can also 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. 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 requiring a greater test depth. ***Consult with your distributor for more information regarding in stock lengths that are available as well as special order lengths and lead times.***

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. This can be ordered through your distributor.

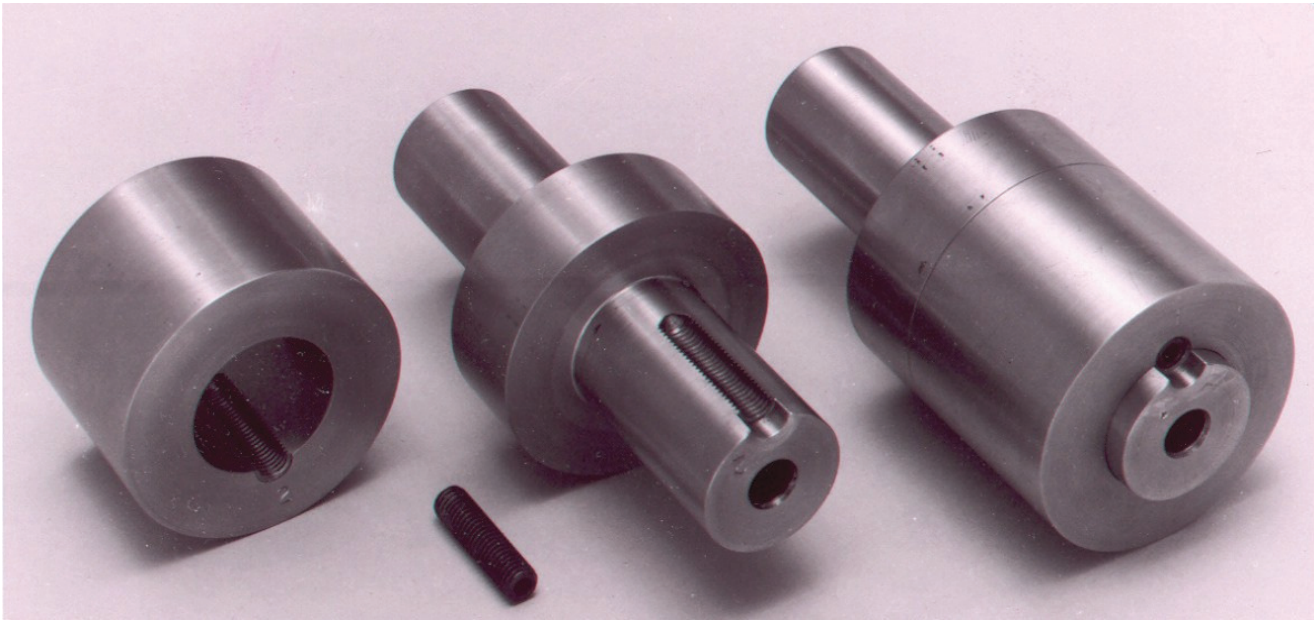


Figure 1. Dual Mass Hammer showing the Removable steel sleeve, Set screw, 4.6 kg Hammer and 8 kg Hammer Configuration

Operation of the Dual Mass DCP

Hold the device by the handle in a vertical position and tap the hammer until the base of the cone is flush with the surface of the soil. Get a zero reading using the vertical scale (S-4219.10) and the upper vertical scale attachment guide (S-4219.11). 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. The operator should keep track of the number of hammer drops (blows) between measurements. Measurement recordings will generally be 20, 10, 5, 3, 2, or 1 depending on the soil strength and thus cone penetration rate. The operator 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 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 unless other rods are attached to achieve a greater depth), 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. We also have an extractor that we manufacture that makes extraction a breeze. This can be ordered through your distributor and is a real time saver. (S-4219.14)

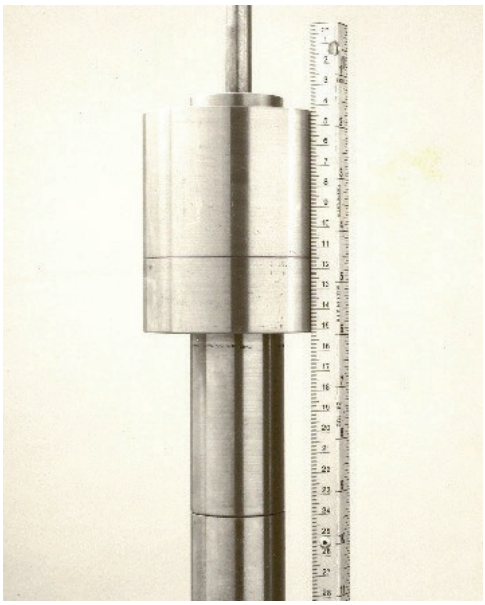


Figure 2. Example of penetration measurement showing a penetration of 150 mm

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.

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

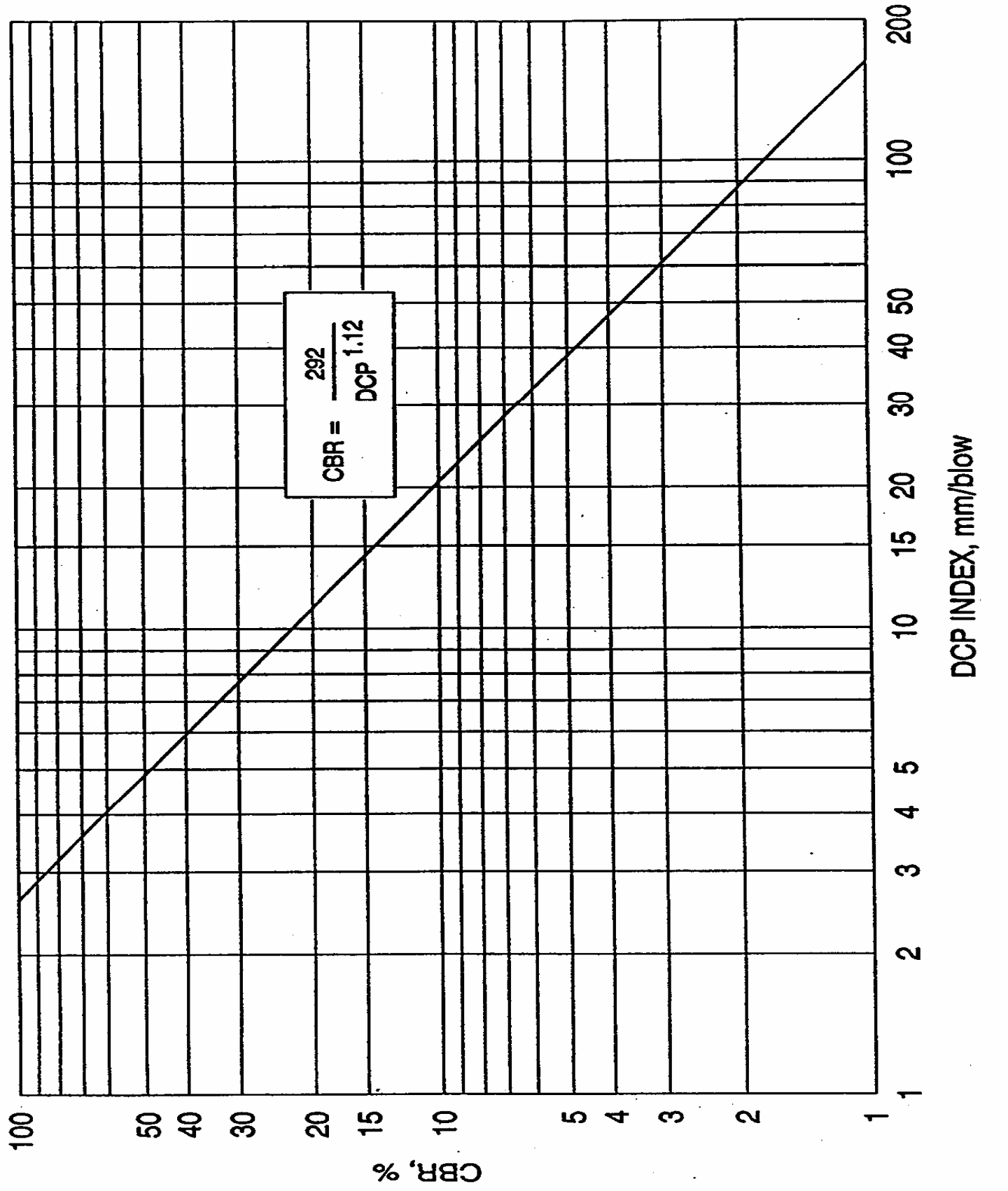
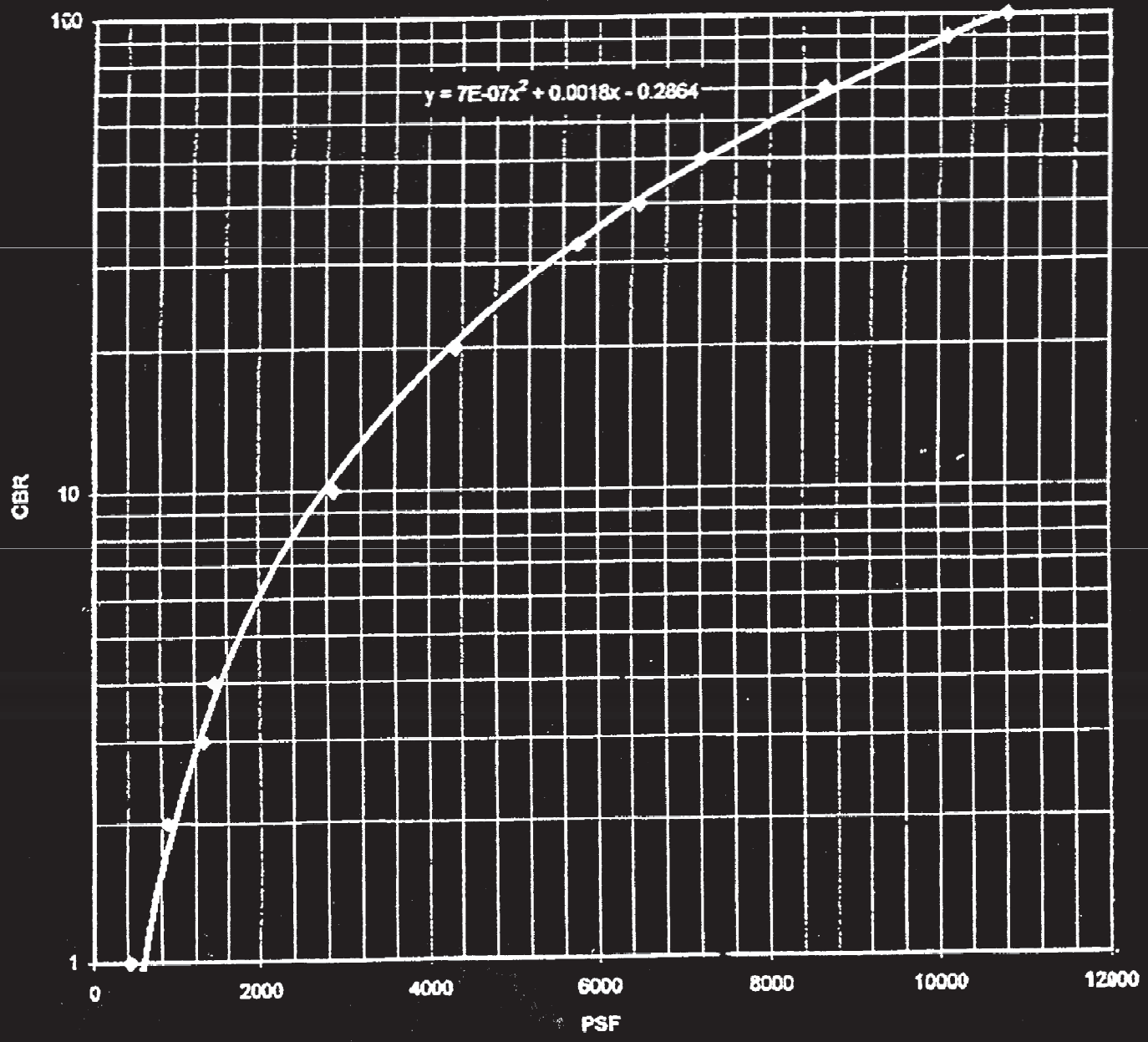


Figure 5: CBR Versus Bearing Value



Plotted from Table XVII
Interrelationships of Soil Classifications,
California Bearing Ratio,
Bearing Values and "K" Values
Design of Concrete Airport Pavment
Portland Cement Assoc., Page 8, 1955

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 % (6)	DCP Index (7)
0	0	-	-	-	-	-
5	25	25	5.0	1	50	5.0
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) Divided by (1).
(5) Enter 1 for 8 kg hammer. Enter 2 for 4.6 kg hammer.
(6) (4) X (5).
(7) From CBR versus DCP correlation.

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

Blows (1)	Accumulative Penetration/ (2)	Penetration per Blow Set/ mm (3)	Penetration per Blow/mm (4)	Hammer Blow Factor (5)	DCP Index (6)	CBR % (7)

United States Army Corps of Engineers Designed Dual Mass Dynamic Cone Penetrometer Program Download Instructions

Below are the instructions to download a program that was designed specifically for the Dual Mass DCP by the Army Corps of Engineers. It is much better than the Excel template that comes with your DCP.

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. **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.

INSTRUCTIONS FOR USING THE DCP WITHOUT THE VERTICAL SCALE

The following three tables are derived from the these equations below that where researched and recommended by the US Army Corps of Engineers.

PR is the DCP penetration rate in mm per blow using the 17.6-lb hammer.

This formula is used to assess the in place strength of undisturbed soil or compacted material.

$$CBR = 292/PR^{1.12}$$

Tabulated Correlations of Blows per 2" Penetration verses CBR and PSF

Hammer	Hammer		CBR			PSF	
8.0 Kg.	4.6 Kg.		Soil Type			Soil Type	
Blows / 2"	Blows / 2"	Other	CL	CH	Other	CL	CH
	1	2	0	3	760	260	1240
1	2	4	1	7	1270	660	1960
	3	6	3	10	1720	1130	2560
2	4	8	5	14	2130	1660	3100
	5	10	8	17	2520	2230	3600
3	6	12	12	21	2280	2840	4060
	7	15	15	24	3240	3240	4500
4	8	17	17	27	3570	3570	4920
	9	19	19	31	3900	3900	5320
5	10	22	22	34	4220	4220	5700
	11	24	24	38	4530	4530	6070
6	12	27	27	41	4830	4830	6430
	13	29	29	45	5130	5130	6790
7	14	32	32	48	5420	5420	7130
	15	34	34	51	5700	5700	7460
8	16	37	37	55	5980	5980	7790
	17	39	39	58	6260	6260	8110
9	18	42	42	62	6530	6530	8420
	19	45	45	65	6800	6800	8730
10	20	47	47	69	7060	7060	9030
	21	50	50	72	7320	7320	9330
11	22	53	53	75	7580	7580	9620
	23	55	55	79	7840	7840	9910
12	24	58	58	82	8090	8090	10200
	25	61	61	86	8340	8340	10480
13	26	63	63	89	8580	8580	10750
	27	66	66	92	8830	8830	11020
14	28	69	69	96	9070	9070	11290
	29	72	72	99	9310	9310	11560
15	30	74	74	100	9550	9550	11820
	31	77	77		9780	9780	
16	32	80	80		10020	10020	
	33	83	83		10250	10250	
17	34	86	86		10480	10480	
	35	89	89		10710	10710	
18	36	91	91		10930	10930	
	37	94	94		11160	11160	
19	38	97	97		11380	11380	
	39	100	100		11600	11600	
20	40	100	100		11820	11820	

Tabulated Correlations of Blows per 4" Penetration verses CBR and PSF

Hammer	Hammer		CBR			PSF	
8.0 Kg.	4.6 Kg.		Soil Type			Soil Type	
Blows / 4"	Blows / 4"	Other	CL	CH	Other	CL	CH
	1	1	0	2	460	110	780
1	2	2	0	3	760	260	1240
	3	3	1	5	1030	450	1620
2	4	4	1	7	1280	660	1960
	5	5	2	9	1510	890	2270
3	6	6	3	10	1730	1140	2570
	7	7	4	12	1940	1390	2840
4	8	8	5	14	2140	1660	3110
	9	9	7	15	2330	1950	3360
5	10	10	8	17	2520	2240	3600
	11	11	11	19	2710	2710	3840
6	12	12	12	21	2890	2890	4070
	13	13	13	22	3070	3070	4290
7	14	15	15	24	3240	3240	4500
	15	16	16	26	3410	3410	4720
8	16	17	17	27	3580	3580	4920
	17	18	18	29	3740	3740	5120
9	18	19	19	31	3910	3910	5320
	19	21	21	33	4070	4070	5520
10	20	22	22	34	4220	4220	5710
	21	23	23	36	4380	4380	5900
11	22	24	24	38	4530	4530	6080
	23	25	25	39	4690	4690	6260
12	24	27	27	41	4840	4840	6440
	25	28	28	43	4990	4990	6620
13	26	29	29	45	5130	5130	6790
	27	30	30	46	5280	5280	6970
14	28	32	32	48	5420	5420	7140
	29	33	33	50	5570	5570	7310
15	30	34	34	51	5710	5710	7470
	31	36	36	53	5850	5850	7640
16	32	37	37	55	5990	5990	7800
	33	38	38	57	6130	6130	7960
17	34	39	39	58	6270	6270	8120
	35	41	41	60	6400	6400	8280
18	36	42	42	62	6540	6540	8430
	37	43	43	63	6670	6670	8590
19	38	45	45	65	6810	6810	8740
	39	46	46	67	6940	6940	8890
20	40	47	47	69	7070	7070	9040

Tabulated Correlations of Blows per 6" Penetration verses CBR and PSF

Hammer	Hammer		CBR			PSF	
8.0 Kg.	4.6 Kg.		Soil Type			Soil Type	
Blows / 6"	Blows / 6"	Other	CL	CH	Other	CL	CH
	1	0	0	1	340	60	600
1	2	1	0	2	560	150	950
	3	2	0	3	760	260	1240
2	4	2	1	5	940	390	1500
	5	3	1	6	1110	520	1740
3	6	4	1	7	1280	660	1960
	7	4	2	8	1430	810	2170
4	8	5	2	9	1580	970	2370
	9	6	3	10	1730	1140	2570
5	10	6	4	11	1870	1310	2750
	11	7	4	13	2000	1480	2930
6	12	8	5	14	2140	1660	3110
	13	9	6	15	2270	1850	3280
7	14	9	7	16	2400	2040	3440
	15	10	8	17	2520	2240	3600
8	16	11	11	18	2650	2650	3760
	17	12	18	19	2770	2770	3920
9	18	12	19	21	2890	2890	4070
	19	13	21	22	3010	3010	4220
10	20	14	22	23	3120	3120	4360
	21	15	23	24	3240	3240	4500
11	22	15	24	25	3350	3350	4650
	23	16	25	29	3470	3470	4790
12	24	17	27	27	3580	3580	4820
	25	18	28	29	3690	3690	5060
13	26	19	29	30	3800	3800	5190
	27	19	30	31	3910	3910	5320
14	28	20	32	32	4010	4010	5450
	29	21	33	33	4120	4120	5580
15	30	22	34	34	4220	4220	5710
	31	23	36	35	4330	4330	5830
16	32	23	37	37	4430	4430	5960
	33	24	38	38	4530	4530	6080
17	34	25	39	39	4640	4640	6200
	35	26	41	40	4740	4740	6320
18	36	27	42	41	4840	4840	6440
	37	28	43	42	4940	4940	6560
19	38	28	45	43	5040	5040	6680
	39	29	46	45	5130	5130	6790
20	40	30	47	46	5230	5230	6910