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USER'S GUIDE TO THE VSDC TERRAIN DATA ANALYSIS SOFTWARE (TDAS)

S.T. Chen and Dr. J.Y. Wong

Vehicle Systems Development Corporation

Ottawa, Canada

November 1990

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VSDC

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TERRAIN DATA ANALYSIS SOFTWARE (TDAS)

BY

S. T. CHEN AND DR. J. Y. WONG

NOVEMBER 1990

VEHICLE SYSTEMS DEVELOPMENT CORPORATION
OTTAWA, CANADA

USER'S GUIDE TO THE VSDC

TERRAIN DATA ANALYSIS SOFTWARE (TDAS)

prepared for

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under Contract

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November 1990

FOREWORD

This report describes the VSDC Terrain Data Analysis Software (TDAS) for processing experimental data obtained using the Rammsonde, the bevameter and the hand-held shear device.

The work was performed by Vehicle Systems Development Corporation, under contract (Serial No. W7702-9-R127/01-XSG) to the Canadian Department of National Defence through the Department of Supply and Services. The Principal Investigator was Dr. J.Y. Wong. The field data were collected by Messrs. J. Preston-Thomas and C. Smith. The Terrain Data Analysis Software was developed by Mr. S.T. Chen with initial assistance provided by Mr. J. Preston-Thomas and under the direction of Dr. J.Y. Wong. The Scientific Authority for the contract was Dr. G.J. Irwin, Vehicle Mobility Section, Defence Research Establishment Suffield.

The Rammsonde, the bevameter and the hand-held shear device used in field testing were provided by Vehicle Mobility Section, Defence Research Establishment Suffield.

SUMMARY

To examine the feasibility of using the pressure-sinkage data obtained using a Rammsonde as input to the computer simulation model NTVPM-85, developed by Vehicle Systems Development Corporation (VSDC), for predicting tracked vehicle performance over snow, a series of measurements of the pressure-sinkage relationships of fresh and preconditioned snow was made using a Rammsonde and a bevameter. In addition, the shear strength of the snow was also measured using a bevameter shear device and a hand-held shear device. This report describes the Terrain Data Analysis Software (TDAS) developed by VSDC for processing experimental data obtained using the Rammsonde, the bevameter and the hand-held shear device. The instructions for the operation of the TDAS and for the preparation of input data files are given. Sample output from the TDAS is also presented.

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1. INTRODUCTION

This report describes the Terrain Data Analysis Software (TDAS) for processing the experimental data obtained using the Rammsonde, the bevameter and the hand-held shear device, and the preparation of the input data files for these analyses. Sample output from the TDAS is also presented.

The TDAS is designed for performing the following:

A. Processing the data obtained using the Rammsonde

i) calculating the Rammsonde hardness;

ii) calculating the Rammsonde pressure;

iii) fitting Bekker's pressure-sinkage equation to the Rammsonde pressure-sinkage data taking into account size effect;

iv) fitting Bekker's pressure-sinkage equation to the Rammsonde pressure-sinkage data without taking into account size effect;

B. Processing the data obtained using a bevameter including both pressure-sinkage data and shear data

i) fitting Bekker's pressure-sinkage equation to the pressure-sinkage data taking into account size effect.

ii) fitting Bekker's pressure-sinkage equation to the pressure-sinkage data without taking into account size effect.

iii) fitting an exponential equation to the shear stress-

shear displacement data.

C. Processing the data obtained using a hand-held shear device

Fitting the Mohr-Coulomb equation to both the maximum and residual shear strength data.

For the above analyses, a number of options regarding plotting and printing are available. A description of the options is given in Section 2.

To perform analysis using the TDAS, experimental data obtained in the field should be properly organized. Requirements on the preparation of the input data files are presented in Section 3.

In Section 4, sample output from the analysis is presented.

The TDAS is written in FORTRAN (including Microsoft FORTRAN Version 4.1 [1] and MetaWINDOW-Fortran [2]) and implemented on an IBM PC-compatible microcomputer with Hercules Monochrome Graphics Adaptor under MS-DOS Version 3.3 [3]. An assumption is made that the user has a basic familiarity with IBM PC-compatible microcomputers and MS-DOS. This should allow the user to create and delete directories, display the contents of directories, copy and print files, and perform other similar tasks. The details of these operations can be found in the "Microsoft MS-DOS User's

Guide and User's Reference" [3] published by Microsoft Corporation and in many similar publications.

2. OPERATION OF THE TERRAIN DATA ANALYSIS SOFTWARE (TDAS)

The Terrain Data Analysis Software (TDAS) is, to a certain extent, a self-explanatory, user-friendly software package. All character inputs are not case-sensitive, i.e., the TDAS accepts both lowercase and uppercase characters. For clarity, all character inputs are in uppercase in this report.

When the TDAS is executed (assuming everything is ready for running the program), the following should appear on the screen (main menu).

D>TDAS

TERRAIN DATA ANALYSIS SOFTWARE

Developed by
Vehicle Systems Development Corp.
Nepean, Ontario, Canada
1990

Select the type of Experiment (R, B or H)		
Rammsonde (R)	Bevameter (B)	Hand-Held Shear (H)

*** Enter Q to quit running.

The user may select the type of experimental data to be processed by entering the corresponding letter, R or B or H. These three letters, R, B and H, represent the Rammsonde, the

bevameter and the hand-held shear device, respectively.

If the letter R in the main menu is selected, the following should appear on the screen (analysis menu).

*** Enter Q to quit running.
R

Select the type of analysis (H, P, 1 or 2)			
Rammsonde Hardness (H)	Rammsonde Pressure (P)	Fit Pressure-Sinkage Data Using the Bekker Equation	
		n & k (1)	n, k_c & k_phi (2)

*** Enter G to go back.

The user may then select the type of analysis desired by entering the corresponding letter, H or P, or number 1 or 2. The two letters, H and P, represent the calculation of the Rammsonde hardness and of the Rammsonde pressure, respectively, while the two numbers 1 and 2 represent the fitting of Bekker's pressure-sinkage equation to the data without taking into account size effect and taking into account size effect, respectively.

If the letter B in the main menu is selected, the following should appear on the screen (analysis menu).

*** Enter Q to quit running.
B

Select the type of Analysis (E, 1 or 2)		
Shear Analysis Using Exponential Equation	Pressure - Sinkage Analysis Using The Bekker Equation	
	n & k (1)	n, k_c & k_phi (2)
(E)		

*** Enter G to go back.

The user may then select the type of analysis desired by entering the corresponding letter, E, or number 1 or 2. The letter E and the two numbers, 1 and 2, represent the fitting of the exponential shear stress-shear displacement equation to the shear data, the fitting of Bekker's pressure-sinkage equation to the pressure-sinkage data without taking into account size effect, and the fitting of Bekker's equation to the pressure-sinkage data taking into account size effect, respectively.

On the other hand, if the letter H in the main menu is selected, the following should appear on the screen (plotting menu, NOTE: no analysis menu for this selection).

*** Enter Q to quit running.
H

INPUT DATA FILES (F)	FITTING RANGE (cm) (R)
HS1204	.00- .00

	(S) CURRENT FITTING AND PLOTTING STATUS		
	STATUS	DESCRIPTION	OPTION
1		NOT USED	
2	Y	Plot individual curves ?	(Y,N)
3		NOT USED	
4		NOT USED	
5		NOT USED	
6	P	Pause or run Continuously ?	(P,C)
7	N	Dump graphs ?	(Y,N)

PLOTTING RANGE (A for auto-scaling)			
Xmin= .01	Xmax= 79.99	Ymin= .01	Ymax= 9.99
X in kPa		Y in N-m	

*** ENTER to continue, or enter G to go back, or enter H for help.

It should also be noted that the letter Q may be entered to quit running the program when the main menu is on.

If a letter or number other than letters R, B, H and Q is entered when the main menu is on, an error message, "Improper choice. Please try it again", will appear on the top of the screen, and the main menu remains at the lower part of the screen.

The letter G may be entered on the subsequent menus in order to go back to the previous menu for re-selection.

After the type of analysis has been selected, the plotting menu will appear as follows,

*** Enter G to go back.
E

INPUT DATA FILES (F)	FITTING RANGE (cm) (R)
SD1413	.00- 5.00
SD1414	.00- 5.00
SD1415	.00- 5.00
SD1416	.00- 5.00

(S) CURRENT FITTING AND PLOTTING STATUS

	STATUS	DESCRIPTION	OPTION
1	B	fit Individual, Combined, or Both ?	(I,C,B)
2	Y	Plot individual curves ?	(Y,N)
3	Y	Plot combined curves ?	(Y,N)
4	D	Point, Symbol, Line, Dot or S&L ?	(P,S,L,D,B)
5	T	shear summary in Torque or Stress ?	(T,S)
6	C	Pause or run Continuously ?	(P,C)
7	Y	Dump graphs ?	(Y,N)

PLOTTING RANGE (A for auto-scaling)

Xmin= .00	Xmax= .00	Ymin= .00	Ymax= .00
X in cm		Y in N-m	

*** ENTER to continue, or enter G to go back, or enter H for help.

The plotting menu is divided into two blocks and one string. The left block contains two sections: the input data files, Section F, on the left of the block; the fitting range, Section R, on the right. The right block also contains two sections: the current fitting and plotting status, Section S, at the top of the block; the PLOTTING RANGE section at the bottom. One string is on the lower part of the screen. It should also be noted that there is a column of numbers beside the left side of the right block. This column of numbers serves as row numbers.

In Section F, the input data files can be changed, deleted or inserted (the TDAS always assumes that all data files have extension ".DAT" in their names, therefore it is unnecessary to specify the extension).

To change an input data file, enter F#, then enter the new name. Here # represents row number. It should correspond to the file to be changed.

To delete an input data file, enter F#, then hit Enter key (enter a blank line).

To insert an input data file, enter F#I, then enter the new file name.

In section R, the fitting range for each data file can be changed by entering R#, then enter two numbers separated by comma, for example, " 0,100 ".

In Section S, the status of fitting and plotting can be changed. There are seven lines under DESCRIPTION. The current status is shown under STATUS. The options are listed under OPTION in brackets.

The first line asks whether to fit the individual data set or the combined data set or both, since there may be a

group of data sets for a particular test. Options I, C and B stand for individual data set, combined data set, and both individual and combined data sets, respectively.

The second line asks whether to plot the individual curves. Y means to plot the individual curves, and N means not to plot. If the option C in the first line has been selected, then the letter N should be selected for this line.

The third line asks whether to plot the combined curves. Y means to plot the combined curves, and N means not to plot. If the option I in the first line has been selected, then the letter N should be selected for this line.

The fourth line asks whether points, symbols, lines, dots or the combination of symbols and lines (S&L) are to be used when plotting the measured data. Options P, S, L, D and B stand for using points, symbols, lines, dots, and the combination of symbols and lines, respectively.

The fifth line asks whether to plot the shear summary curves in torques or shear stresses. Options T and S stand for plotting in torques and in shear stresses, respectively.

The sixth line asks whether to run the analysis continuously or pause after the completion of plotting each diagram (either on the screen or on the printer). If pause is selected, pressing the Enter key is required to continue (NOTE: if N is selected on the seventh line, more options will appear after a diagram is displayed on the screen). Options P and C stand for running the analysis continuously and pause after the completion of plotting each diagram, respectively.

The seventh line asks whether to plot the diagrams and print the results of the analysis on a printer. Y means to plot and print, N means not to. In either case, an output file named "TDAS.OUT", which contains the results of the analysis, will be saved on the disk, but no diagrams will be saved. If N is selected, the diagrams, if any, will not be printed, but they will be displayed on the screen.

To make any changes of the fitting and plotting status, enter S#, then enter the appropriate letter from the options. Here # represents row number.

In the PLOTTING RANGE section, the plotting range defined by four numbers, under which their units are shown, can also be changed by entering XMIN, XMAX, YMIN or YMAX, then enter an appropriate number. To use automatic scaling, enter A.

The string provides three options. The first one is pressing the Enter key for the program to continue. The second one is to enter the letter G for going back to the previous menu. The third one is to enter the letter H for on-line help, which gives brief instructions for how to make changes. Once the Help is on, pressing the Enter key will bring the plotting menu back.

In certain cases, some lines in Section 3 will not be shown, instead a message "NOT USED" will appear on those lines. This is because those lines are not relevant to the type of analysis that has been selected.

If there are a lot of data files and they can not be displayed on one screen, then the data files will be shown screen by screen upon each pressing of the Enter key. This means the left block will keep changing while the right block remains unchanged.

After all changes have been made, pressing the Enter key will let the program perform the analysis, plot and print the diagrams, etc.

After the plotting and printing are done, the program will ask the user whether or not to do more analysis. If yes, the whole procedure will be repeated (CAUTION: the "TDAS.OUT" will be

replaced). If not, the program will be terminated.

It is required that all data files to be used should be stored on disk in the same directory as that where the TDAS is stored before running the program (see Appendix A).

3. PREPARATION OF INPUT DATA FILES

The formats of input data files in this section are shown on a "text editor", which is formed by one horizontal line and one vertical line. Above the horizontal line are the column numbers. On the left side of the vertical line are the row (line) numbers. These numbers and the two lines are not part of the input file.

3.1 Input Data Files for Rammsonde Analysis

The input data files for Rammsonde analysis should have the following form:

```
          1         2         3         4
  12345678901234567890123456789012345678901
 ---------------------------------------------
 1|FILE #: RAM01
 2|LOCATION: Fernie, B.C.
 3|DATE: 13/2/90
 4|TIME: 09:55h
 5|TERRAIN DESCRIPTION: FRESH SNOW
 6|CONE DIAMETER (cm): 4.
 7|WEIGHT OF PENETROMETER (kg): .89101
 8|HAMMER WEIGHT (kg): 1.0069
 9|DROP HEIGHT (cm): 40.
10|
11| DROPS (#)   SINKAGE (cm)
12|     1          34.7
13|     1          68.2
14|     1          78.3
15|     1          94.5
16|     1          106.8
17|     1          110.1
18|     1          116.0
19|
```

From lines 1 to 9, the colon is necessary to separate the description from the input. Special requirements and explanations

are specified as follows:

Line 1:

The Rammsonde test file number. The letter R must be provided as the first letter after colon to indicate this is a set of Rammsonde data.

Line 10:

A blank line must be provided here.

Line 12 - end

The Rammsonde data. The first data column is the number of hammer drops (#) needed to achieve a particular sinkage. The second data column is the observed sinkage in cm.

3.2 Input Data Files for Bevameter Analysis

3.2.1 Pressure-Sinkage Date Files

The input data files for the bevameter pressure-sinkage analysis should have the following form:

```
          1         2         3         4
  12345678901234567890123456789012345678901234
 ---------------------------------------------
 1|FILE #: PS1414
 2|LOCATION: Fernie, B.C.
 3|DATE: 14/2/90
 4|SAMPLE RATE (s/sec/channel): 200
 5|POINTS/CHANNEL: 2000
 6|RANGE OF DATA POINTS TO BE USED: 30 1250
 7|PENETRATION RATE (cm/sec): 2.5
 8|TERRAIN DESCRIPTION: PRECONDITIONED SNOW
 9|PLATE DIAMETER (cm): 10.
10|INITIAL OFFSET (mm): 10.
11|PRESSURE(kPa)  SINKAGE(mm)
12|   59.1502        .796802
13|   64.0342        3.18721
14|   67.8328        5.57761
15|   118.843        7.17122
16|   103.106        7.96802
17|   106.362        8.76482
18|   111.246        9.56162
19|   109.618        10.3584
20|   113.959        11.1552
21|    ......        .......
22|    ......        .......
```

From lines 1 to 9, the colon is necessary to separate the description from the input. Special requirements and explanations are specified as follows:

Line 1:

Bevameter pressure-sinkage test file number. The letter P must be provided as the first letter after colon to indicate it is a set of bevameter pressure-sinkage data.

Line 6:

The first number is the beginning data number (not line number) and second number is the ending data number.

Line 9:

Either letter P or C must be provided in the first column to indicate whether a bevameter plate or Rammsonde cone was used for collecting this set of data. P is for plate, C is for Rammsonde cone.

Lines 12 - end

Bevameter pressure-sinkage data. The first data column is the normal pressure in kPa. The second data column is the sinkage in mm.

3.2.2 Torque-Shear Displacement Date Files

The input data files for the bevameter shear stress-shear displacement analysis should have the following form:

```
          1         2         3         4         5
 12345678901234567890123456789012345678901235678901
 ---------------------------------------------------
 1|FILE #: SD1413
 2|LOCATION: Fernie, B.C.
 3|DATE: 14/2/90
 4|SAMPLE RATE (s/sec/channel): 200
 5|POINTS/CHANNEL: 2000
 6|RANGE OF DATA POINTS TO BE USED: 380  2000
 7|SHEAR RATE (at average radius, cm/sec): .975917
 8|TERRAIN DESCRIPTION: Preconditioned Snow and New
 9|SHEAR TYPE: Rubber-Snow
10|NUMBER OF GROUSERS (#): 0
11|GROUSER HEIGHT (cm): 0.
12|SHEAR RING INNER and OUTER DIAMETERS (cm): 14.5 18.25
13|ADDITIONAL NORMAL LOAD (kg): 28.1232
14|DEAD WEIGHT (kg): 30.8448
15|TORQUE(N.m) POSITION(deg)  SINKAGE(mm)
16|   .526741      .341463       .754278
17|   10.5348      .341463      -.0502852
18|   10.5348      .682927      -.0502852
19|   8.42786      1.02439      -.0502852
20|   5.26741      1.36585      -.0502852
21|   14.222       1.70732      -.0502852
22|   23.7034      2.04878      -.0502852
23|   11.0616      2.39024      -.0502852
24|   13.6953      2.73171      -.0502852
25|   10.0081      3.07317      -.0502852
26|   7.90112      3.41463      -.0502852
27|    .....        .....         ......
28|    .....        .....         ......
```

From lines 1 to 14, the colon is necessary to separate the description from the input. Special requirements and explanations are specified as follows:

Line 1:

Bevameter torque-shear displacement test file number. The letter S must be provided as the first letter after colon to indicate it is a set of bevameter shear data.

Line 6:

The first number is the beginning data number (not line number) and second number is the ending data number.

Lines 16 - end

Bevameter shear data. The first data column is the torque in N*m. The second data column is the angle of rotation of the shear ring in degrees. The third data column is the slip-sinkage in mm.

3.3 Input Data Files for Hand-Held Shear Analysis

The input data files for the hand-held shear analysis should have the following form:

```
          1         2         3         4         5         6
123456789012345678901234567898012345678901234567890123456789012345678901
 ----------------------------------------------------------------------
 1|FILE #: HS1204
 2|LOCATION: Fernie, B.C.
 3|DATE: 12/2/90
 4|TIME: 11:00h - 11:40h
 5|TERRAIN DESCRIPTION: FRESH SNOW
 6|SHEAR TYPE: Rubber-Snow
 7|GROUSER HEIGHT (cm): 0.
 8|SHEAR RING INNER and OUTER DIAMETERS (cm): 12.  15.
 9|DEAD WEIGHT (kg): 6.097
10|SPRING SCALE STIFFNESS (kg/m): 104.47761
11|SPRING SCALE UNSTRETCHED LENGTH (cm): 18.
12|DISTANCE FROM THE AXIS TO THE FIRST HOOK (cm): 23.
13|HOOK LENGTH (cm): 2.5
14|HOOK SPACING (cm): 10.
15|NORMAL LOAD GAUGE CALIBRATION (slope, kg/div): 0.1345748
16|
17|NORMAL LOAD  HOOK   MAXIMUM  RESIDUAL   INITIAL      FINAL
18|           POSITION SPRING    SPRING
19|   (div)     (#)   FORCE(kg) FORCE(kg) SINKAGE(cm) SINKAGE(cm)
20|     0        1      0.35      0.30       1.27         1.27
21|    60        1      0.60      0.30       1.27         1.27
22|    55        1      0.70      0.30       2.54         2.54
23|   105        1      1.15      0.80       1.91         1.91
24|   100        1      1.40      0.90       2.54         2.54
25|   150        1      1.60      0.80      19.69        19.69
26|   150        1      2.20      0.90      17.78        17.78
27|   150        1      2.20      0.90      21.59        21.59
28|   200        1      2.10      1.20      20.32        20.32
29|   200        1      2.00      1.00       6.35         6.35
30|   250        1      2.75      1.00      23.50        23.50
31|   250        1      1.70      1.00      53.34        53.34
31|   250        1      2.40      1.00      27.94        27.94
32|
```

From lines 1 to 15, the colon is necessary to separate the description from the input. Special requirements and explanations

are specified as follows:

Line 1:

Hand-held shear test number. The letter H must be provided as the first letter after colon to indicate this is a set of hand-held shear data.

Line 16:

A blank line must be provided here.

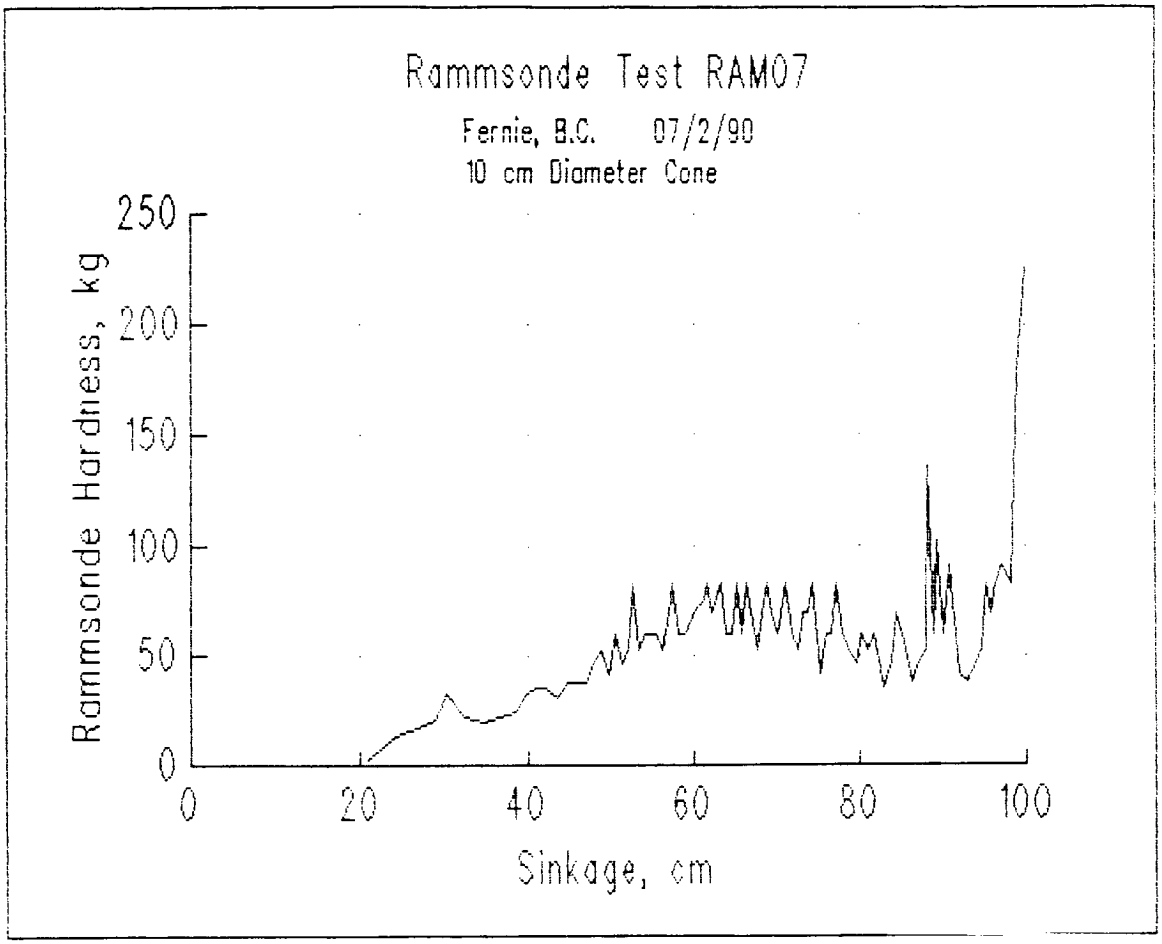
Line 20 - end

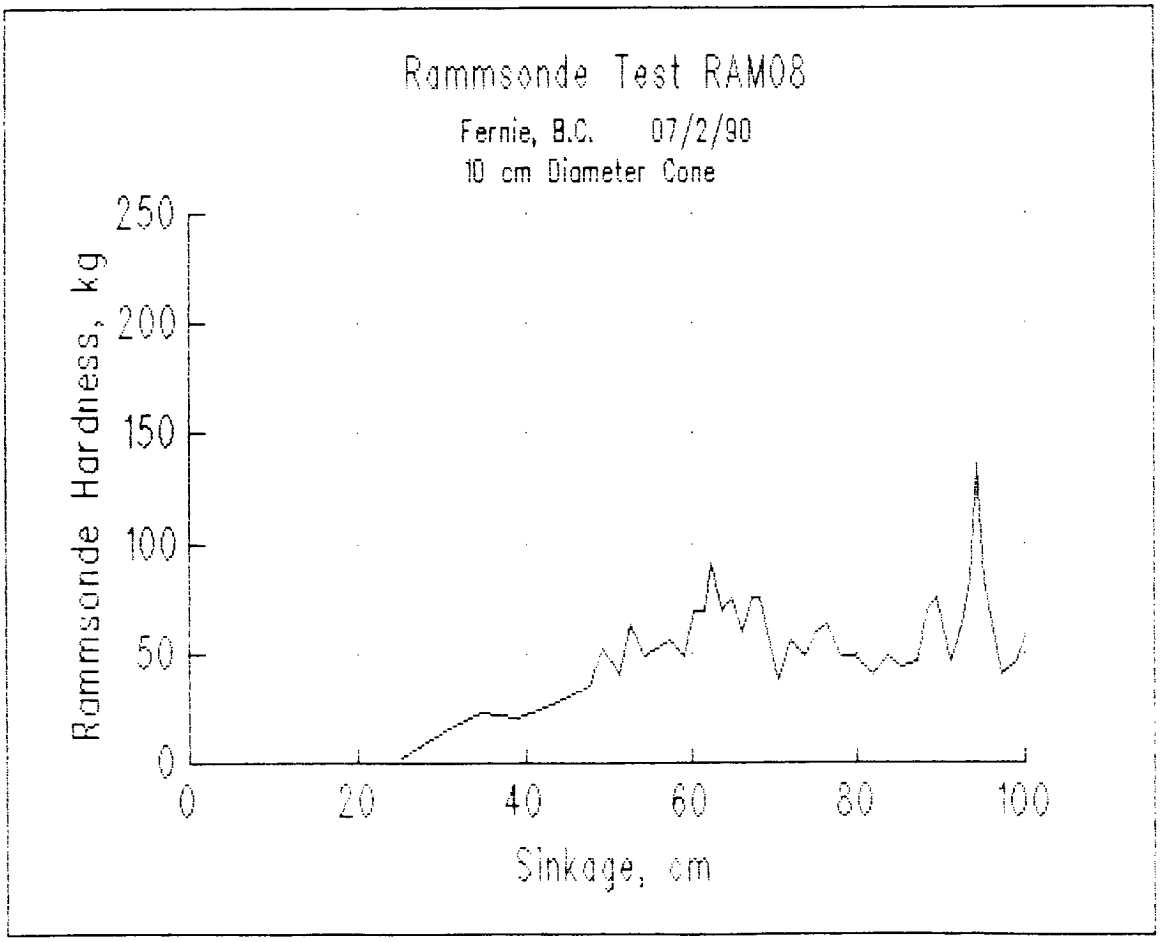
The hand-held shear test data. The first data column is the normal load applied in gauge divisions. The second data column is the hook position where the spring scale is attached. The third data column is the maximum spring force in kg. The fourth data column is the residual spring force in kg. The fifth data column is the slip-sinkage (initial) in cm for the maximum spring force. The sixth data column is the slip-sinkage (final) in cm for the residual spring force.

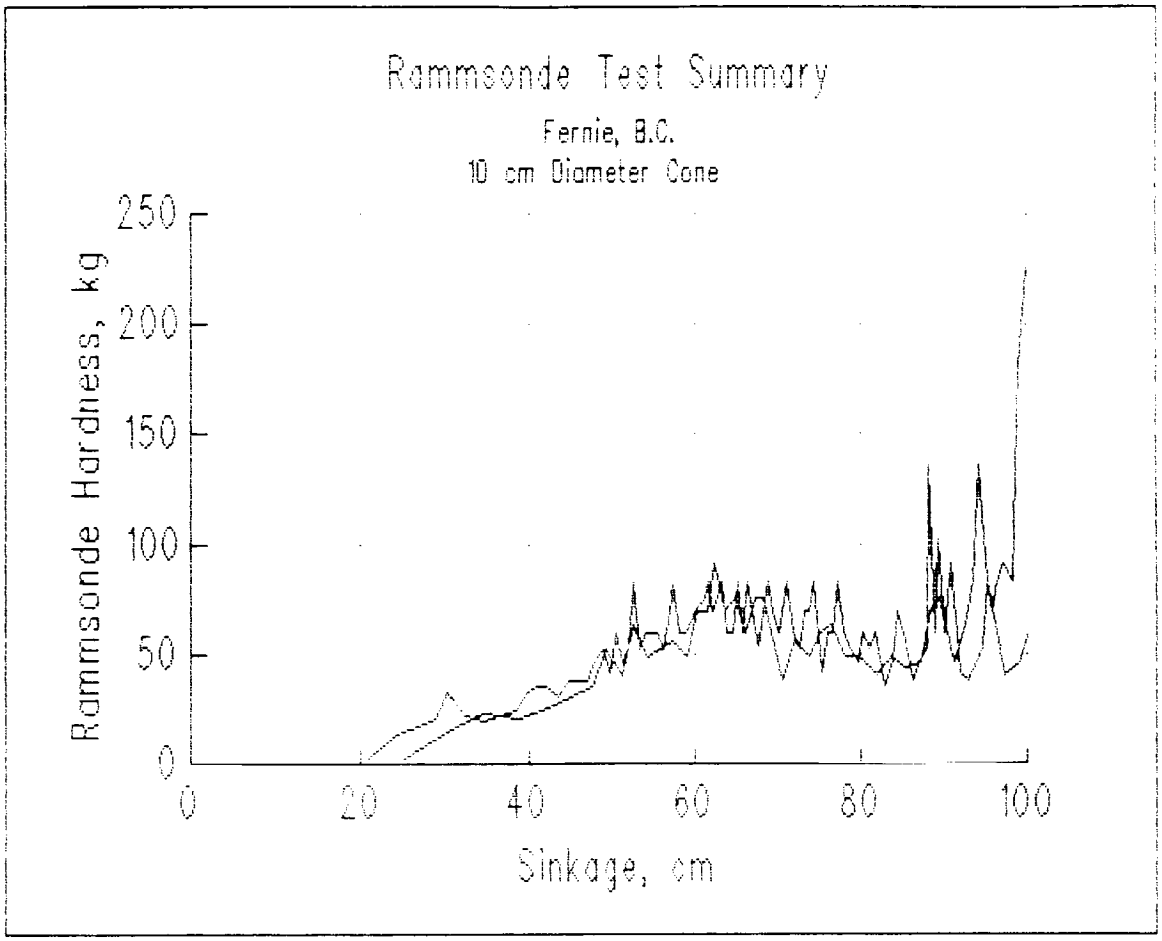
4. Sample Output

4.1 Output from Rammsonde Analysis

4.1.1 Rammsonde Hardness


Rammsonde Test RAM07
Fernie, B.C. 07/2/90
10 cm Diameter Cone
Rammsonde Hardness, kg
250
200
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test RAM08
Fernie, B.C. 07/2/90
10 cm Diameter Cone
Rammsonde Hardness, kg
250
200
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test Summary
Fernie, B.C.
10 cm Diameter Cone
Rammsonde Hardness, kg
250
200
150
100
50
0
0
20
40
60
80
100
Sinkage, cm

FILE #: RAM07
LOCATION: Fernie, B.C.
DATE: 07/2/90
TIME: 11:00h
TERRAIN DESCRIPTION: FRESH SNOW
CONE DIAMETER (cm): 10.
WEIGHT OF PENETROMETER (kg): 1.53218
HAMMER WEIGHT (kg): 1.0069
DROP HEIGHT (cm): 40.

SINKAGE (cm)	RAMMSONDE HARDNESS (kg)
20.90	2.539
24.30	13.378
27.00	16.449
29.10	20.711
30.40	32.514
32.40	21.670
34.70	19.043
36.70	21.670
38.50	23.908
39.80	32.514
41.00	35.095
42.20	35.095
43.60	30.301
44.70	38.147
45.80	38.147
46.90	38.147
47.80	46.283
48.60	51.877
49.60	41.808
50.30	59.069
51.20	46.283
52.00	51.877
52.50	82.084
53.30	51.877
54.00	59.069
54.70	59.069
55.40	59.069
56.20	51.877
56.80	68.659
57.30	82.084
58.00	59.069
58.70	59.069
59.90	68.659
61.00	74.761
61.50	82.084
62.10	68.659
63.10	82.084

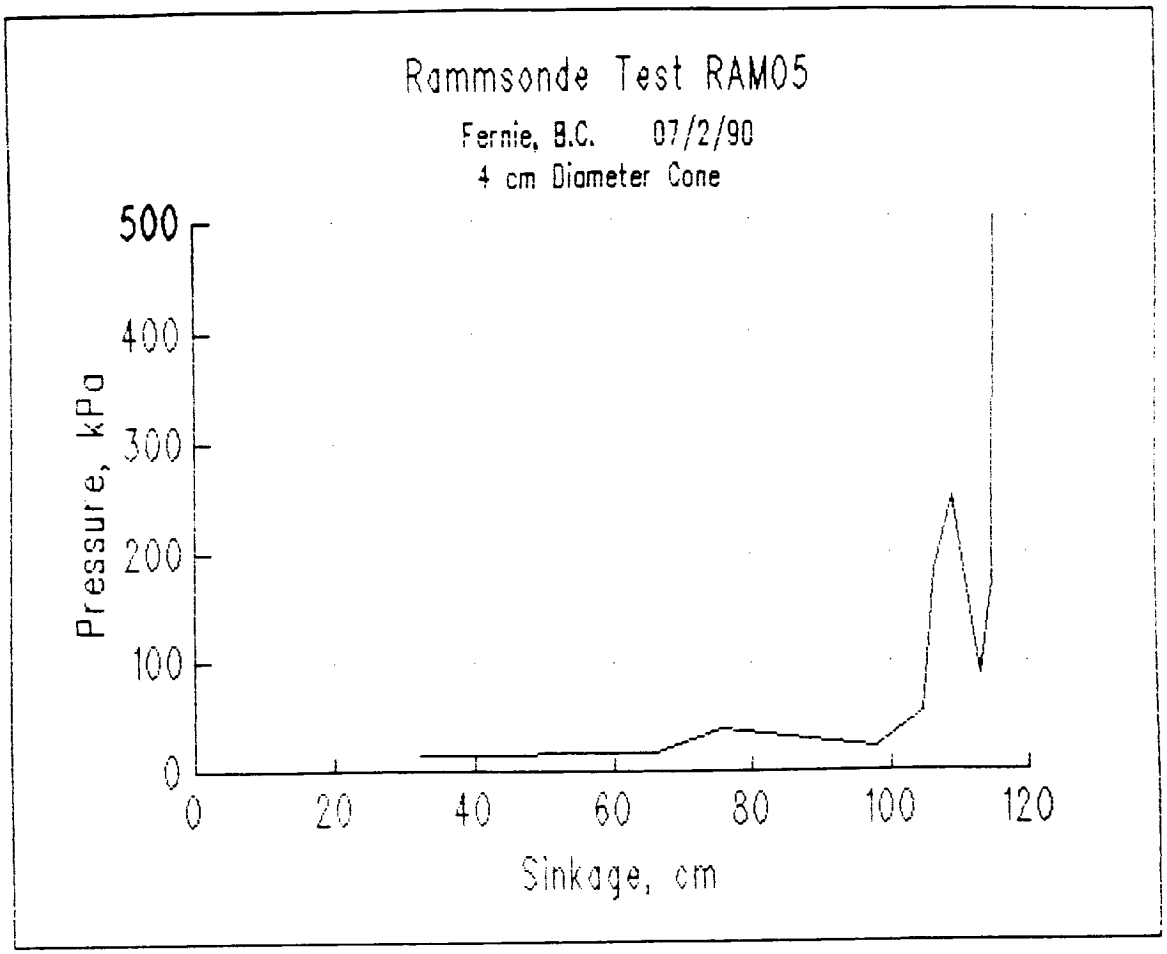
63.80	59.069
64.50	59.069
65.00	82.084
65.70	59.070
66.20	82.084
66.80	68.658
67.60	51.877
68.20	68.659
68.70	82.084
69.30	68.658
70.00	59.070
71.00	82.084
71.70	59.070
72.50	51.877
73.10	68.659
73.70	68.659
74.20	82.084
75.20	41.808
75.90	59.069
76.60	59.070
77.10	82.084
77.80	59.069
78.60	51.877
79.50	46.283
80.20	59.070
81.00	51.877
81.70	59.070
82.90	35.095
83.80	46.283
84.40	68.659
85.10	59.070
86.20	38.147
87.10	46.283
87.90	51.877
88.20	135.788
88.90	59.069
89.30	102.222
90.00	59.070
90.90	91.034
91.90	41.808
93.00	38.147
93.90	46.283
94.70	51.877
95.20	82.084
95.80	68.658
96.30	82.084
97.20	91.035
98.20	82.084
99.10	180.536
100.00	225.287

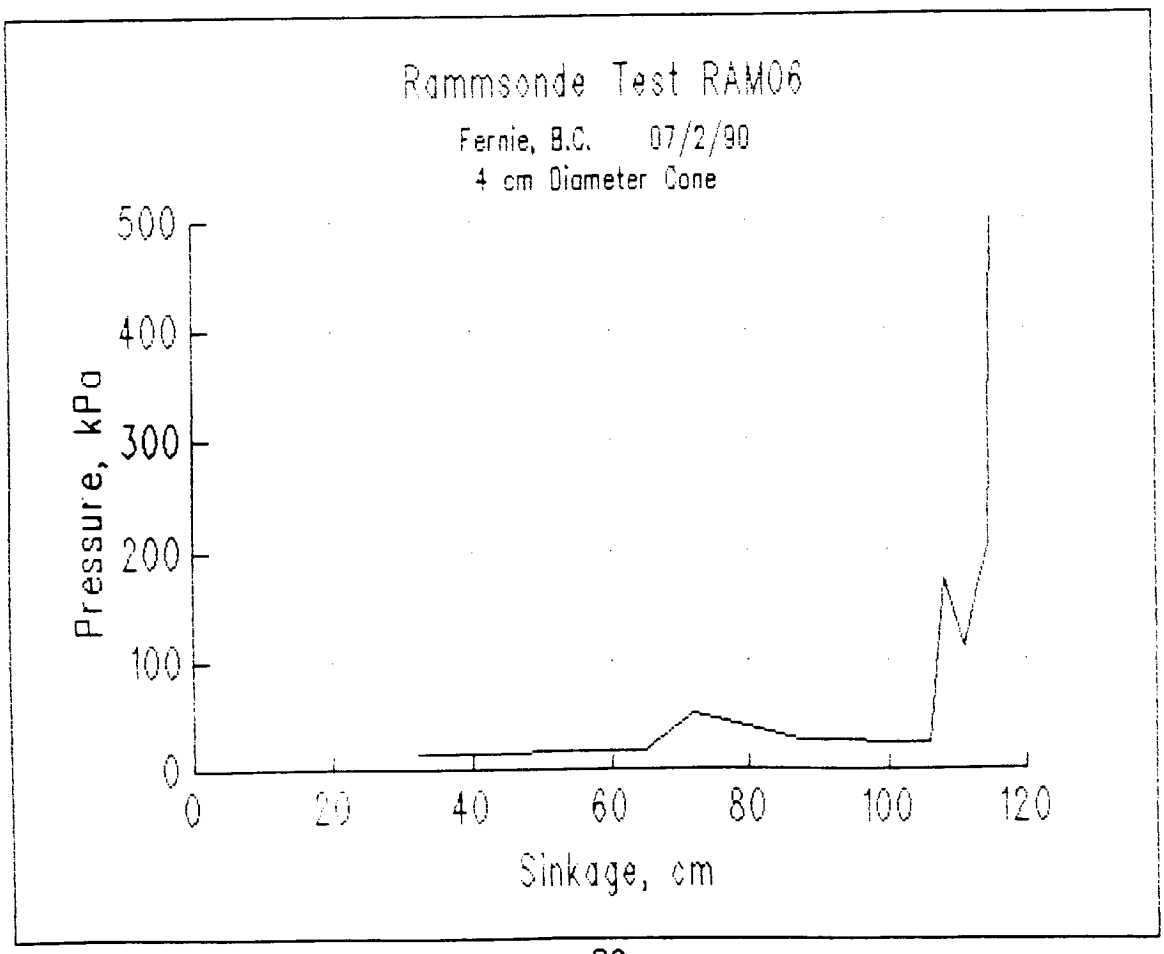
FILE #: RAM08
LOCATION: Fernie, B.C.
DATE: 07/2/90
TIME: 11:20h
TERRAIN DESCRIPTION: FRESH SNOW
CONE DIAMETER (cm): 10.
WEIGHT OF PENETROMETER (kg): 1.53218
HAMMER WEIGHT (kg): 1.0069
DROP HEIGHT (cm): 40.

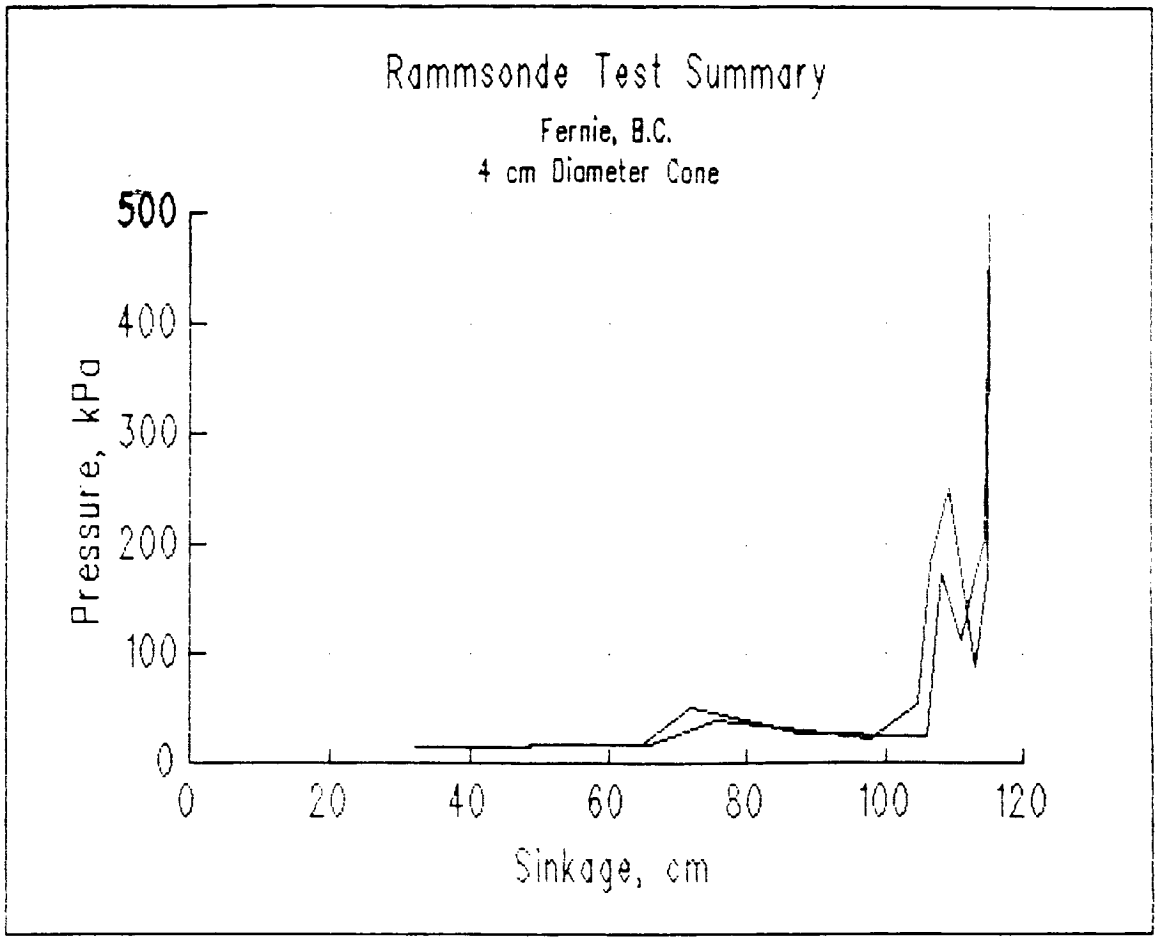
SINKAGE (cm)	RAMMSONDE HARDNESS (kg)
25.20	2.539
31.00	15.420
34.80	22.730
39.00	20.711
42.30	25.942
45.10	30.301
47.50	35.095
49.10	51.877
51.20	39.890
52.50	63.495
54.20	48.916
55.80	51.877
57.30	55.234
59.00	48.916
60.20	68.659
61.40	68.659
62.30	91.035
63.50	68.659
64.60	74.761
66.00	59.069
67.10	74.761
68.20	74.761
70.40	38.147
71.90	55.234
73.60	48.916
75.00	59.069
76.30	63.495
78.00	48.916
79.70	48.916
81.80	39.890
83.50	48.916
85.40	43.928
87.20	46.283
88.40	68.659
89.50	74.761
91.30	46.283
92.60	63.495

93.60	82.084
94.20	135.786
95.20	82.084
97.30	39.890
99.10	46.283
100.40	63.495
101.60	68.659
102.60	82.084
104.00	116.606
105.20	135.786
106.00	102.222
107.20	202.913

4.1.2 Rammsonde Pressure


Rammsonde Test RAM05
Fernie, B.C. 07/2/90
4 cm Diameter Cone
Pressure, kPa
500
400
300
200
100
0
0
20
40
60
80
100
120
Sinkage, cm


Rammsonde Test RAM06
Fernie, B.C. 07/2/90
4 cm Diameter Cone
Pressure, kPa
500
400
300
200
100
0
0
20
40
60
80
100
120
Sinkage, cm


Rammsonde Test Summary
Fernie, B.C.
4 cm Diameter Cone
Pressure, kPa
500
400
300
200
100
0
0
20
40
60
80
100
120
Sinkage, cm

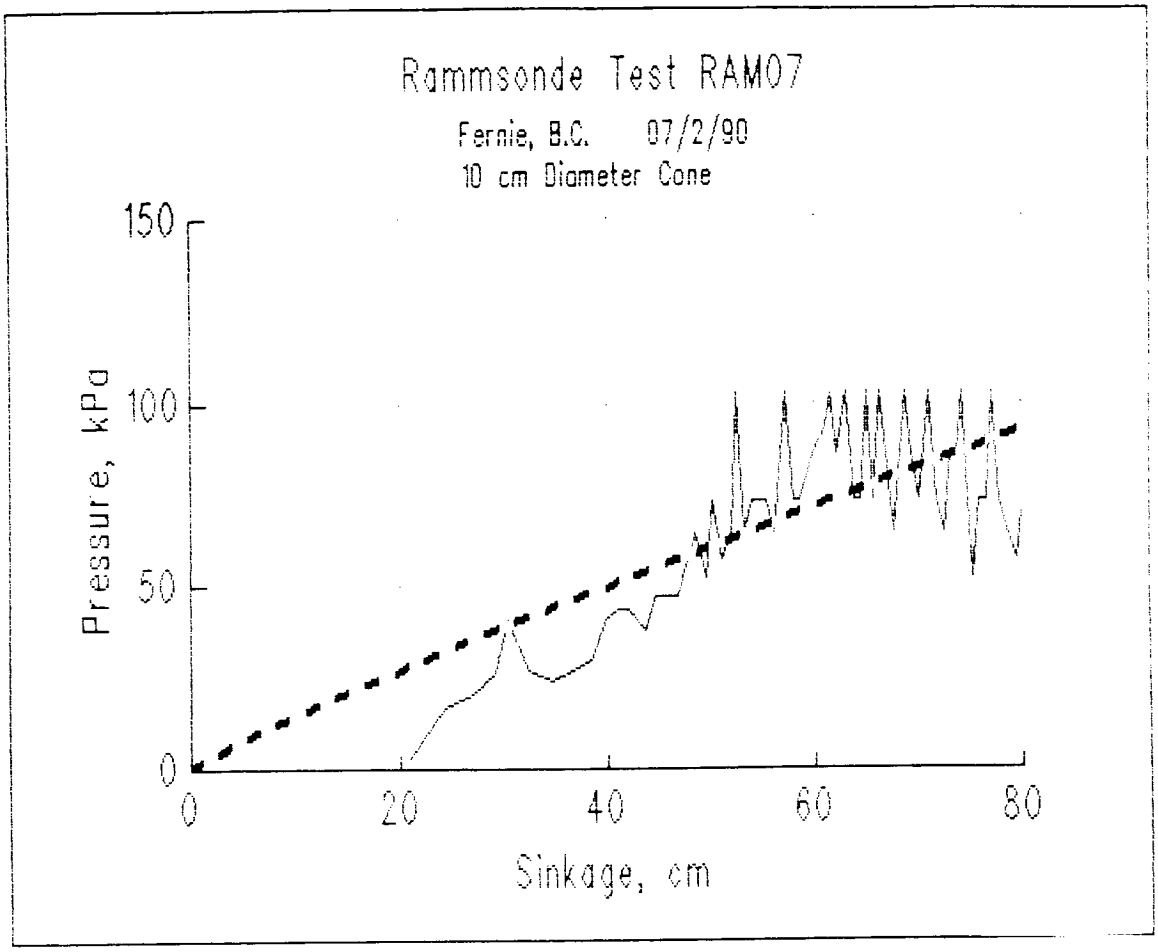
FILE #: RAM05
LOCATION: Fernie, B.C.
DATE: 07/2/90
TIME: 10:45h
TERRAIN DESCRIPTION: FRESH SNOW
CONE DIAMETER (cm): 4.
WEIGHT OF PENETROMETER (kg): .89101
HAMMER WEIGHT (kg): 1.0069
DROP HEIGHT (cm): 40.

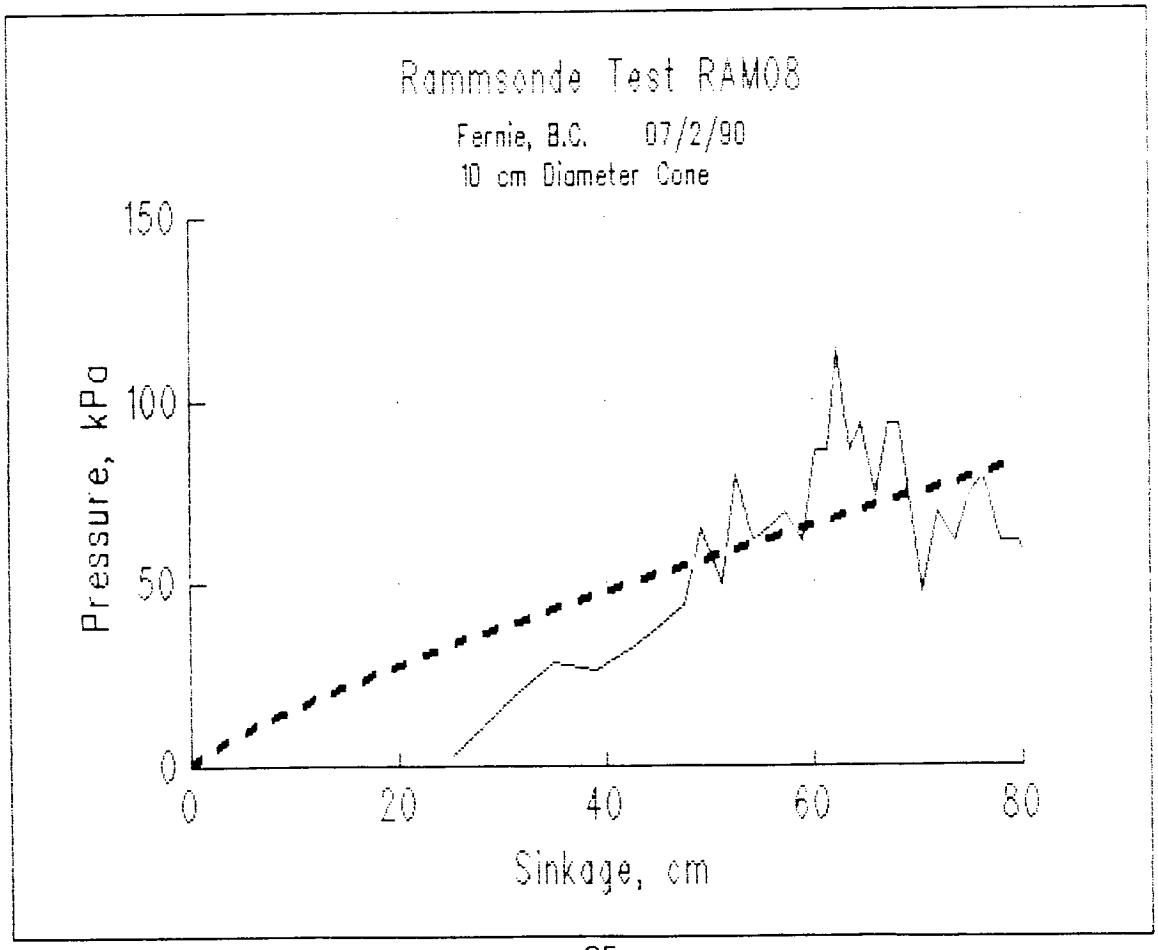
SINKAGE (cm)	RAMMSONDE PRESSURE (kPa)
32.00	14.816
65.90	16.231
75.60	39.370
97.80	21.119
104.60	53.193
106.40	181.631
107.90	216.567
109.20	248.816
113.10	87.575
115.00	172.438
115.30	1055.000

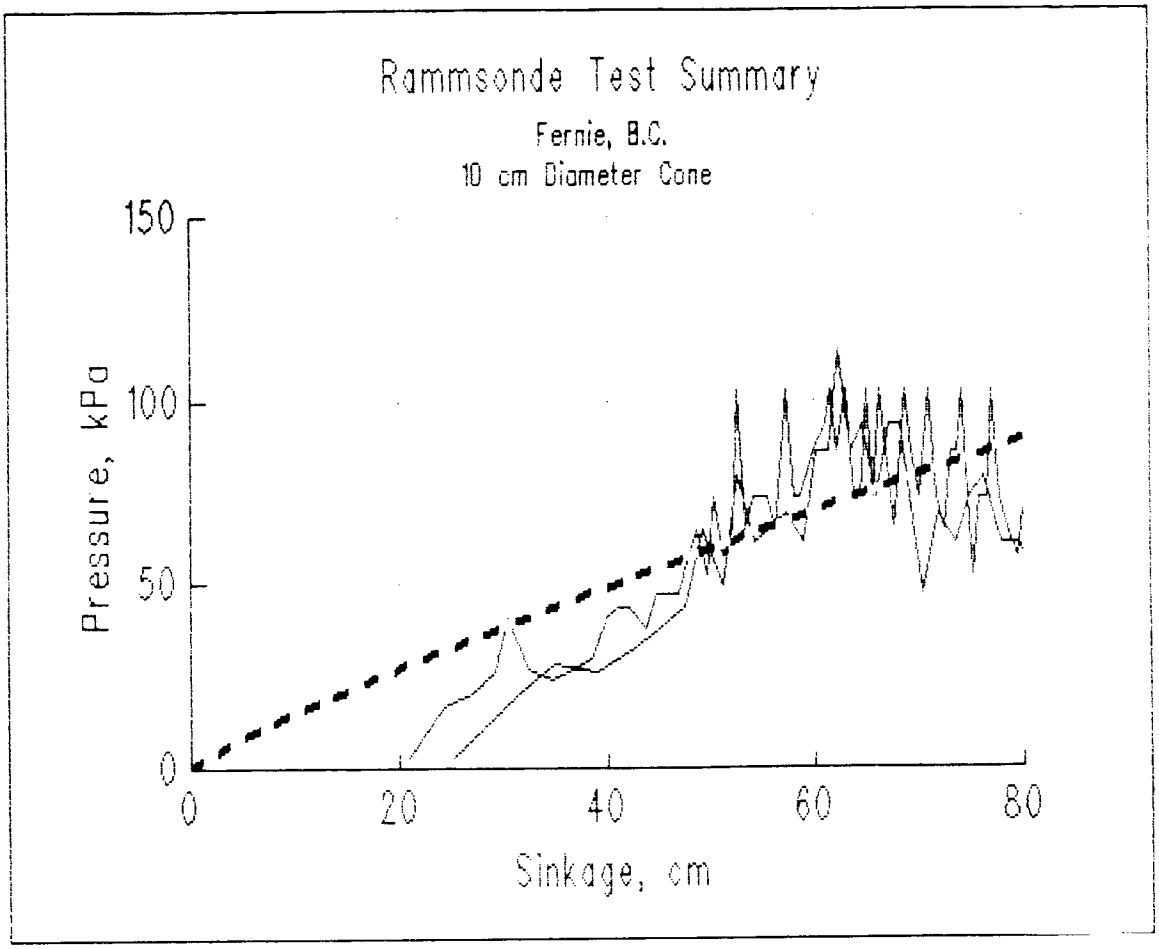
FILE #: RAM06
LOCATION: Fernie, B.C.
DATE: 07/2/90
TIME: 10:55h
TERRAIN DESCRIPTION: FRESH SNOW
CONE DIAMETER (cm): 4.
WEIGHT OF PENETROMETER (kg): .89101
HAMMER WEIGHT (kg): 1.0069
DROP HEIGHT (cm): 40.

SINKAGE (cm)	RAMMSONDE PRESSURE (kPa)
32.00	14.816
64.70	16.571
72.00	50.026
87.50	27.241
106.10	23.860
108.00	172.438
111.00	111.761
113.00	164.164
114.60	203.466
115.20	530.985

4.1.3 Fitting Bekker's Pressure-Sinkage Equation without Taking into Account Size Effect


Rammsonde Test RAM07
Fernie, B.C. 07/2/90
10 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
Sinkage, cm


Rammsonde Test RAM08
Fernie, B.C. 07/2/90
10 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
Sinkage, cm


Rammsonde Test Summary
Fernie, B.C.
10 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
Sinkage, cm

DATA INPUT

EXPT NUMBER	FILE NAME	PLATE RADIUS (CM)	CURVE FITTING BEGINS (CM)	CURVE FITTING ENDS (CM)
1	RAM07	5.00	20.90	80.00
2	RAM08	5.00	25.20	80.00
COMBINED CURVE 1		5.00	00.00	80.00

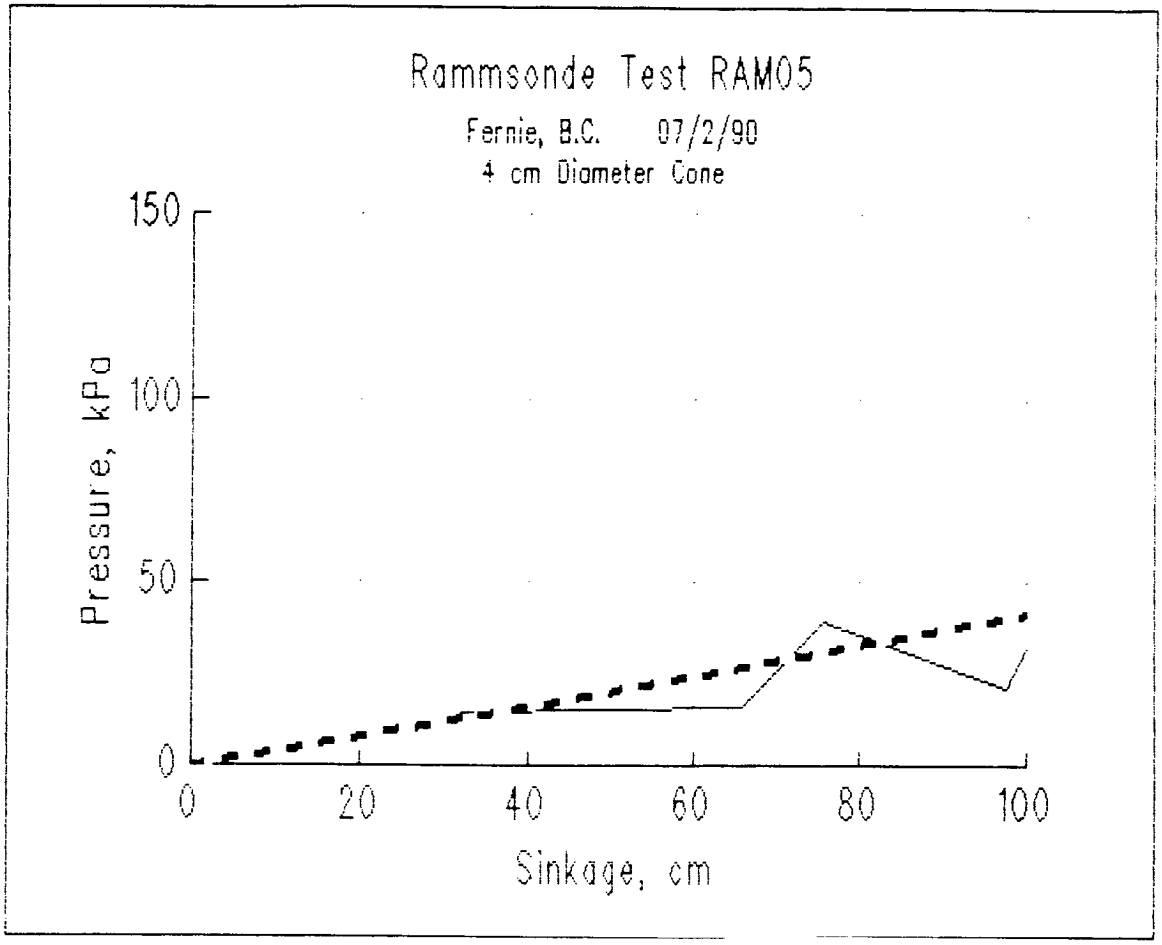
PRESSURE-SINKAGE PARAMETERS (FOR THE INDIVIDUAL CURVES)

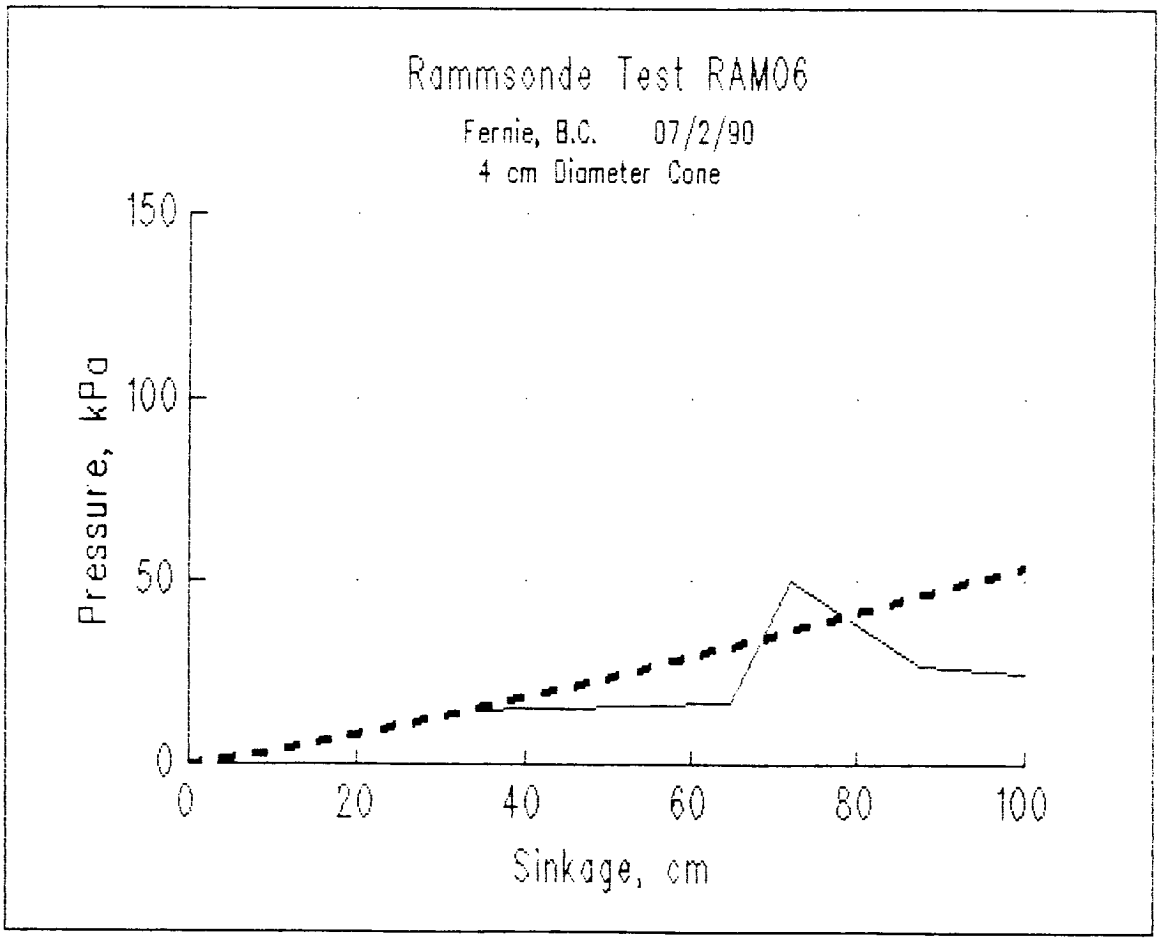
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	.88783	.00000	112.85	75.192
2	.78922	.00000	98.533	69.809
MEAN	.83852	.00000	105.69	
STD. DEV.	.69732E-01	.00000	10.121	

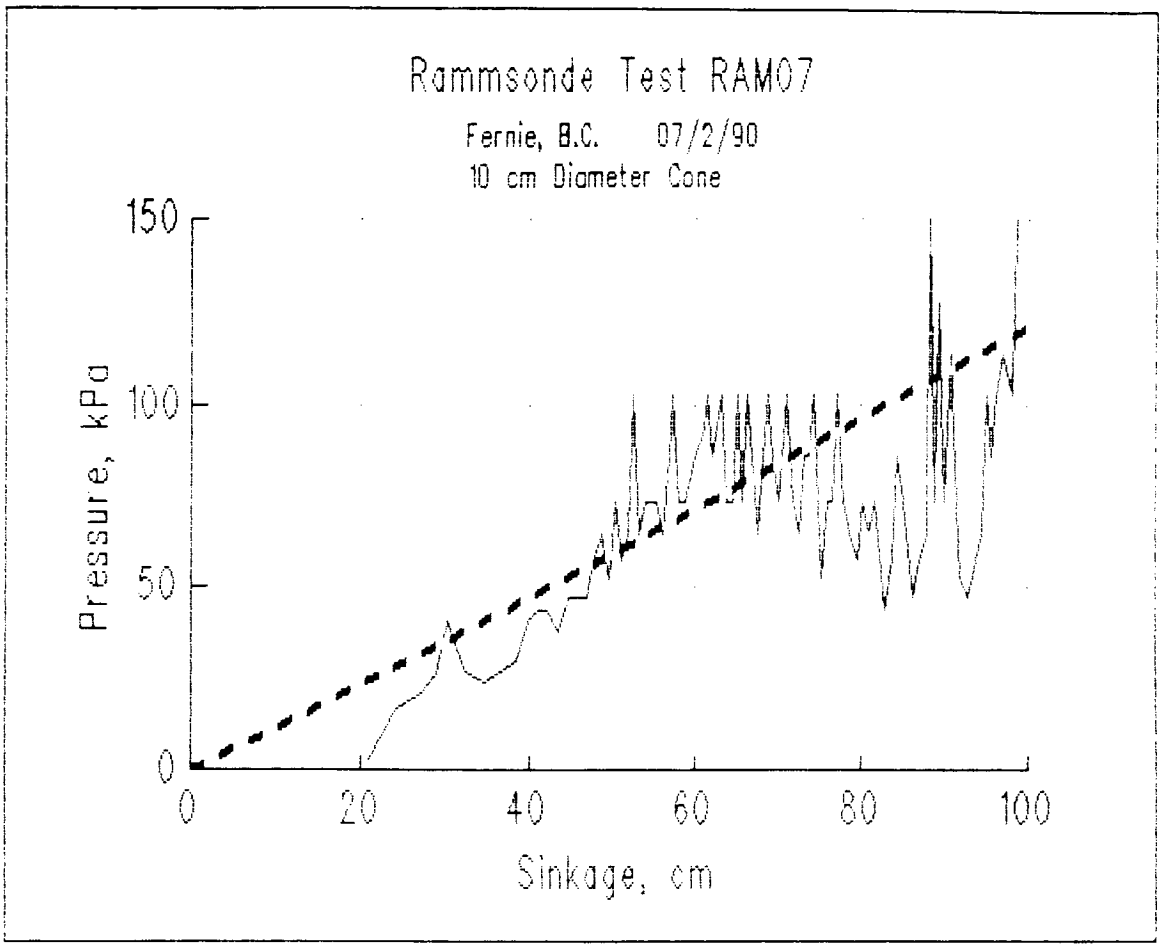
PRESSURE-SINKAGE PARAMETERS (FOR THE COMBINED CURVES)

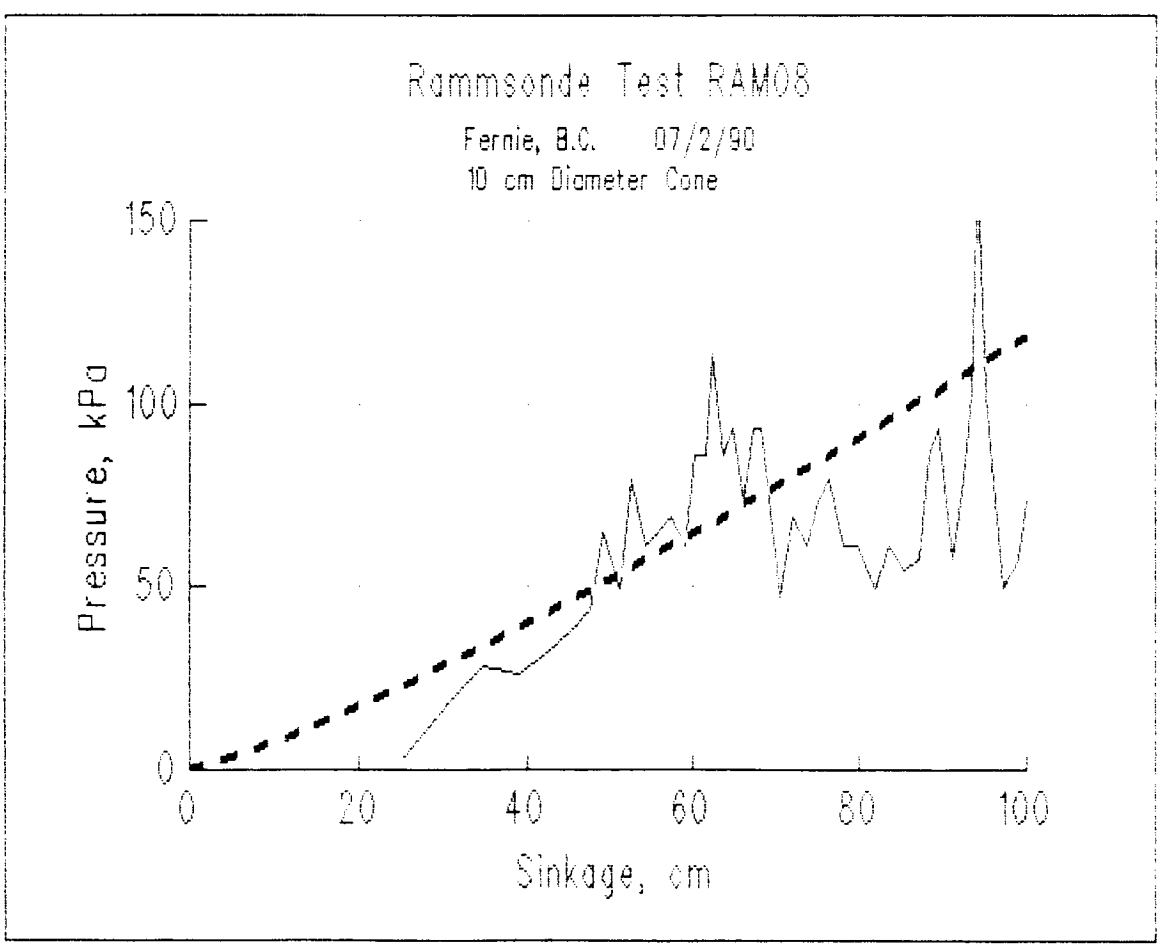
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	.86053	.00000	108.27	73.517
2	-	-	-	-

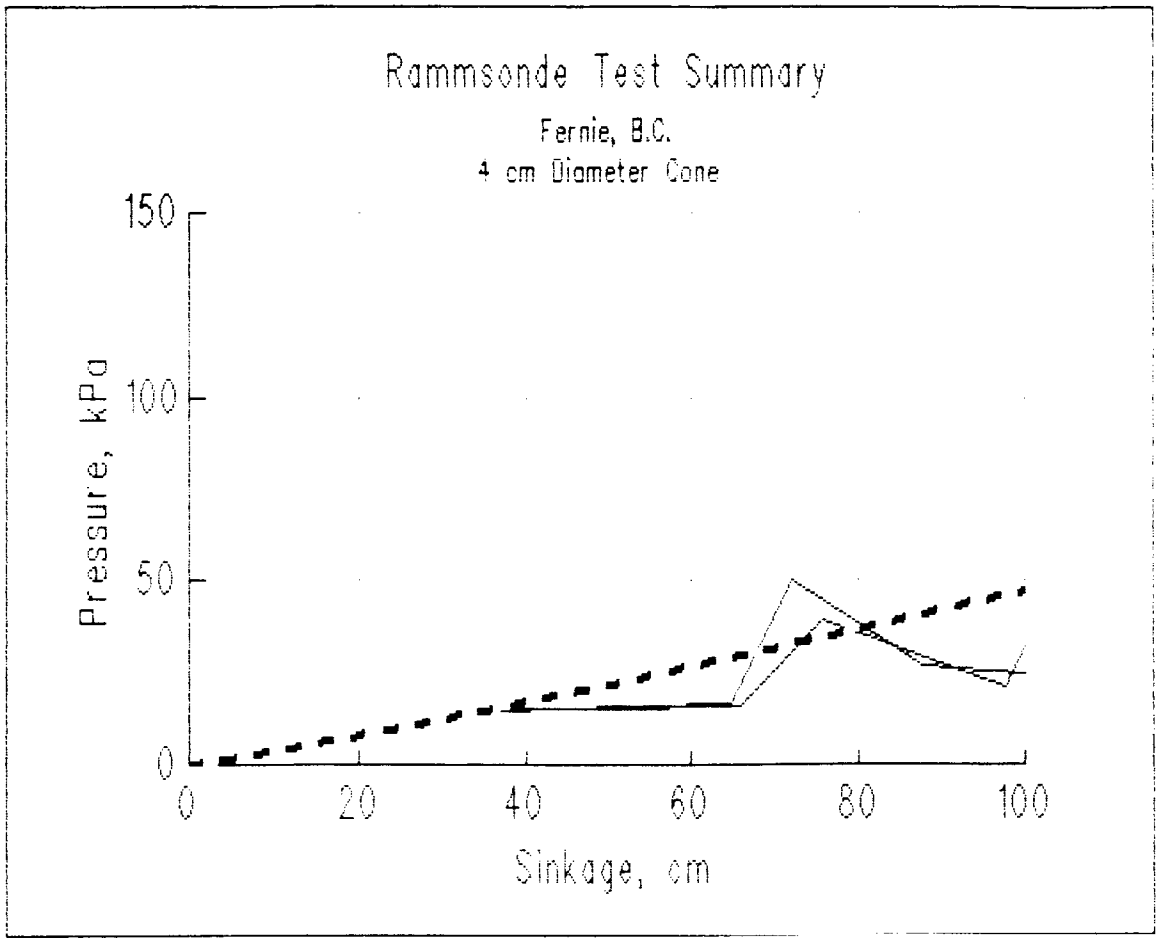
4.1.4 Fitting Bekker's Pressure-Sinkage Equation Taking into Account Size Effect

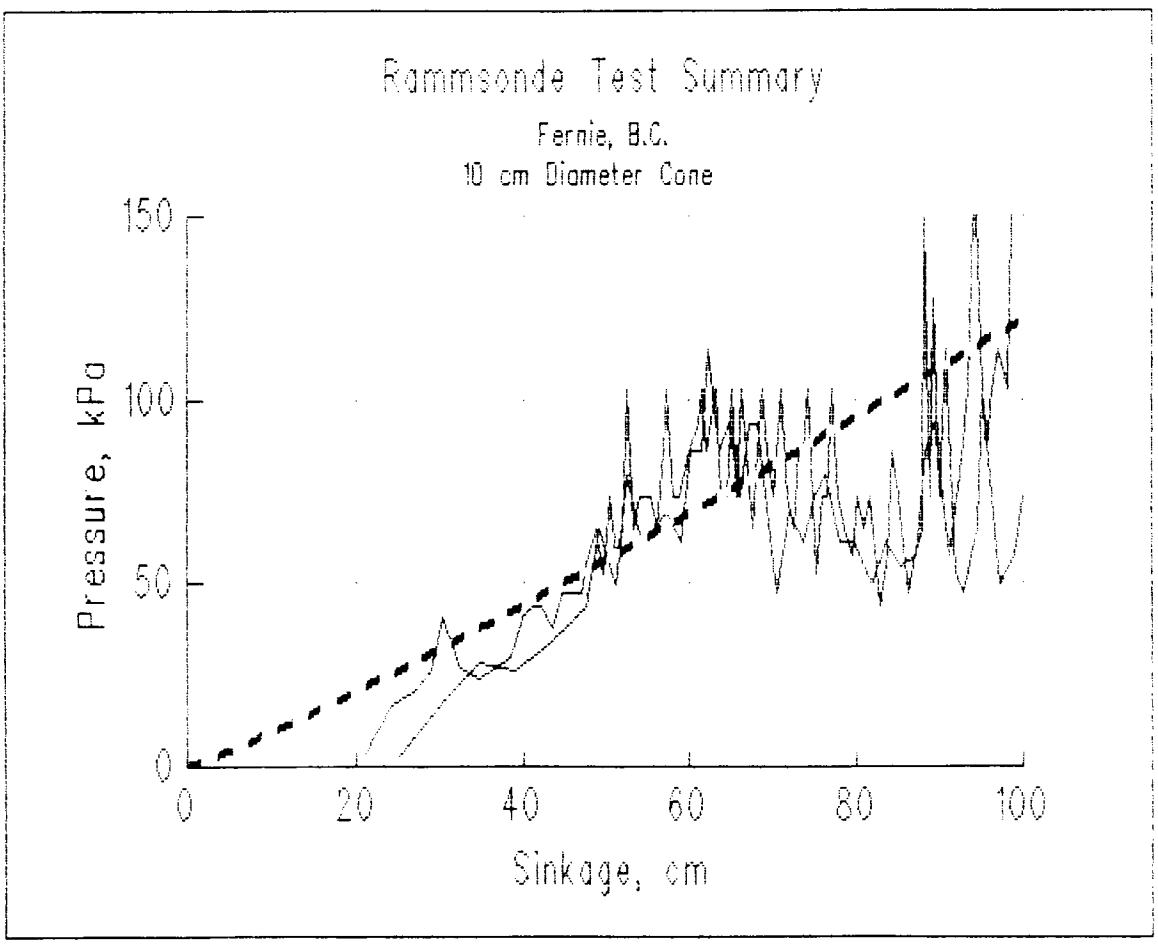

Rammsonde Test RAM05
Fernie, B.C. 07/2/90
4 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test RAM06
Fernie, B.C. 07/2/90
4 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test RAM07
Fernie, B.C. 07/2/90
10 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test RAM08
Fernie, B.C. 07/2/90
10 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test Summary
Fernie, B.C.
4 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
100
Sinkage, cm


Rammsonde Test Summary
Fernie, B.C.
10 cm Diameter Cone
Pressure, kPa
150
100
50
0
0
20
40
60
80
100
Sinkage, cm

DATA INPUT

EXPT NUMBER	FILE NAME	PLATE RADIUS (CM)	CURVE FITTING BEGINS (CM)	CURVE FITTING ENDS (CM)
1	RAM05	2.00	32.00	80.00
2	RAM06	2.00	32.00	80.00
COMBINED CURVE 1		2.00	00.00	80.00
3	RAM07	5.00	20.90	80.00
4	RAM08	5.00	25.20	80.00
COMBINED CURVE 2		5.00	00.00	80.00

PRESSURE-SINKAGE PARAMETERS (FOR THE INDIVIDUAL CURVES)

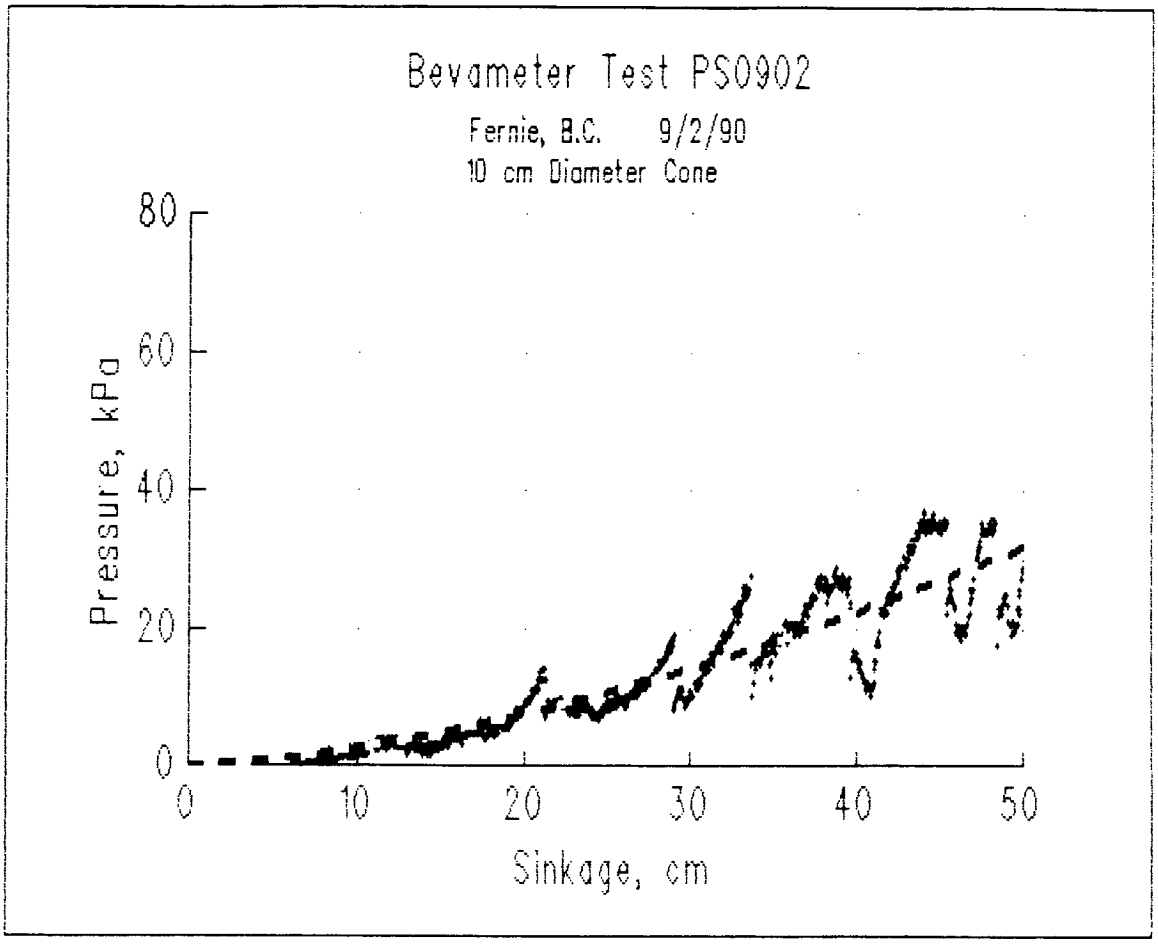
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	1.0303	-2.6501	173.82	41.548
2	1.1816	-2.1480	161.28	23.863
3	1.0303	-2.6501	173.82	75.304
4	1.1816	-2.1480	161.28	70.094
MEAN	1.1060	-2.3991	167.55	
STD. DEV.	.10698	.35503	8.8621	

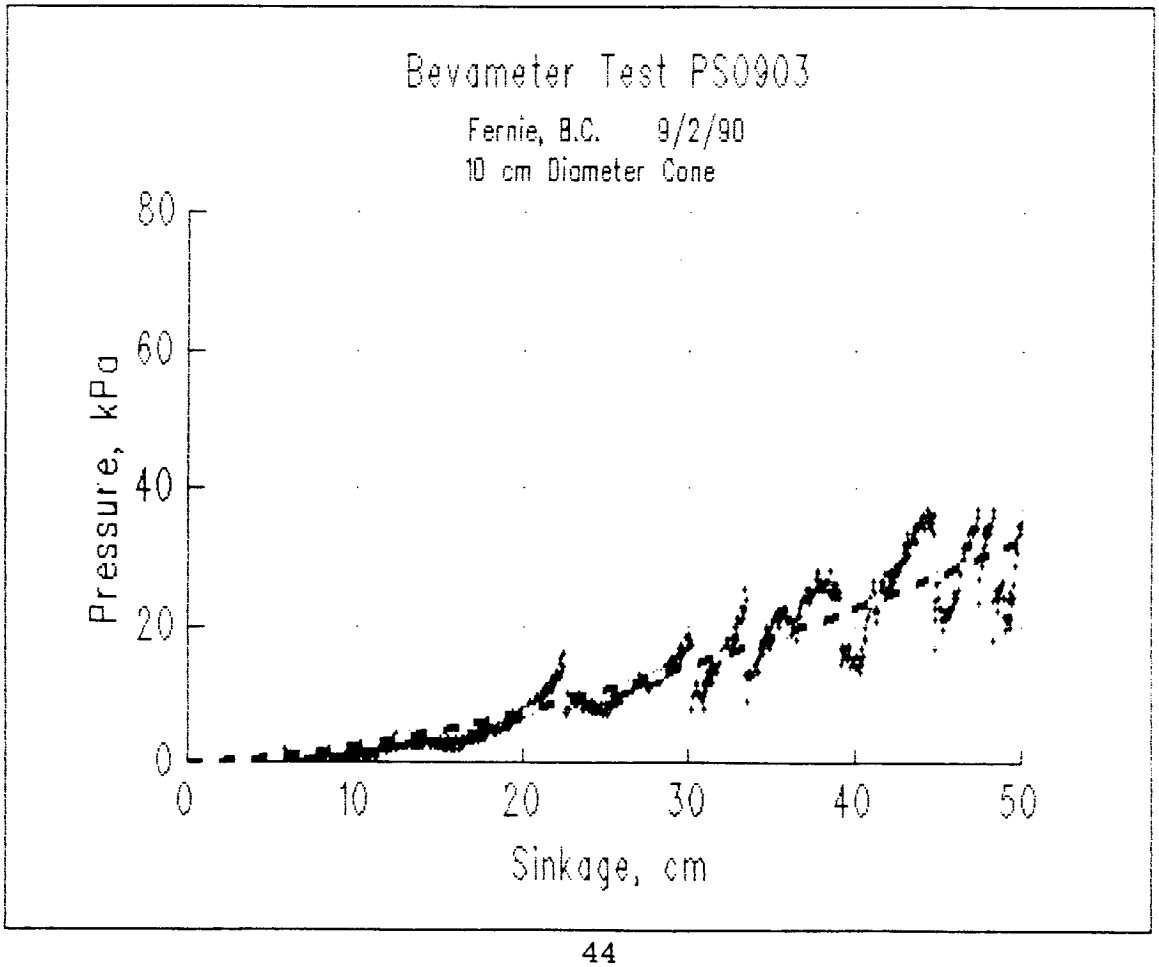
PRESSURE-SINKAGE PARAMETERS (FOR THE COMBINED CURVES)

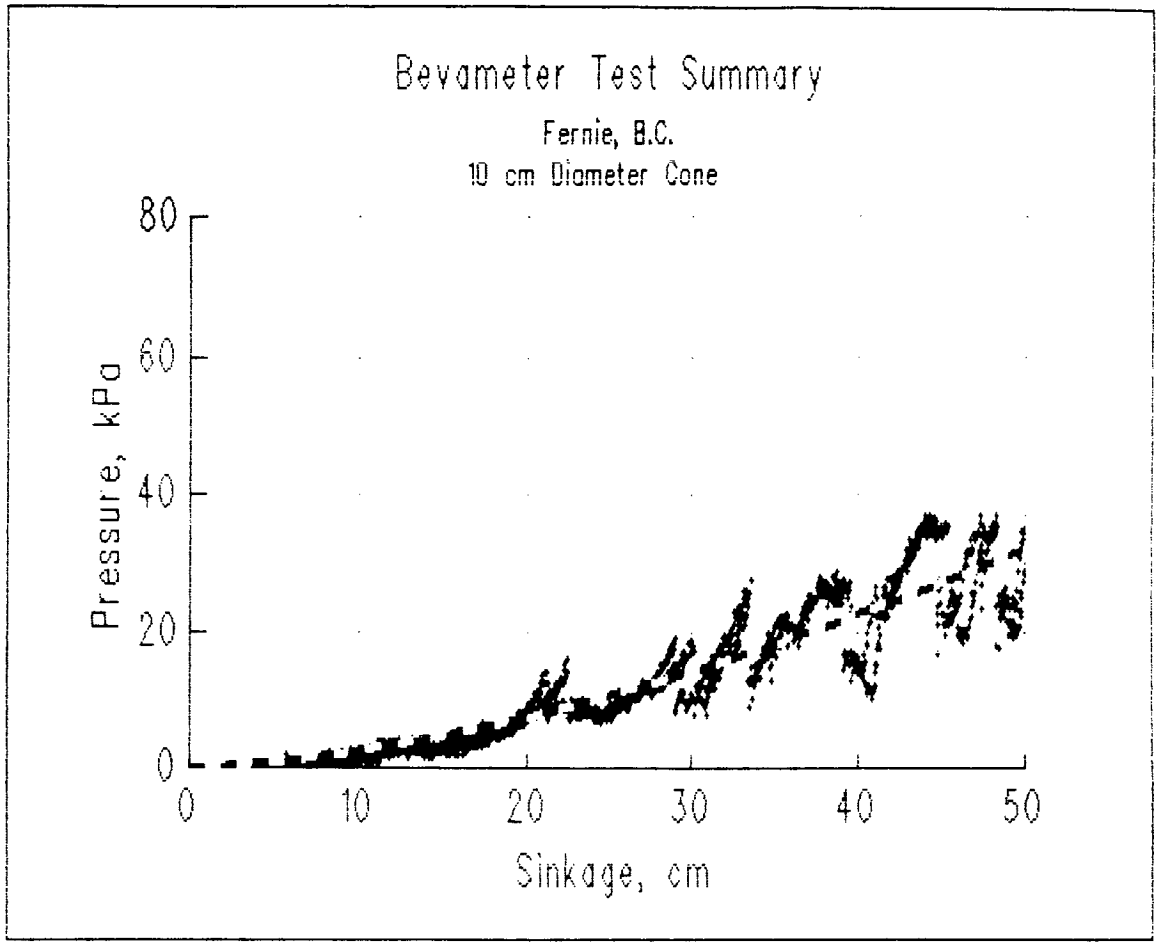
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	1.1091	-2.4837	171.42	49.096
2	-	-	-	-
3	1.1091	-2.4837	171.42	73.574
4	-	-	-	-

4.2 Output from Bevameter Analysis

4.2.1 Fitting Bekker's Pressure-Sinkage Equation without Taking into Account Size Effect


Bevameter Test PS0902
Fernie, B.C. 9/2/90
10 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test PS0903
Fernie, B.C. 9/2/90
10 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test Summary
Fernie, B.C.
10 cm Diameter Cone
Pressure, kPa
80
60
40
20
0
0
10
20
30
40
50
Sinkage, cm

DATA INPUT

EXPT NUMBER	FILE NAME	PLATE RADIUS (CM)	CURVE FITTING BEGINS (CM)	CURVE FITTING ENDS (CM)
1	PS0902	5.00	6.18	50.00
2	PS0903	5.00	5.70	50.00
COMBINED CURVE 1		5.00	00.00	50.00

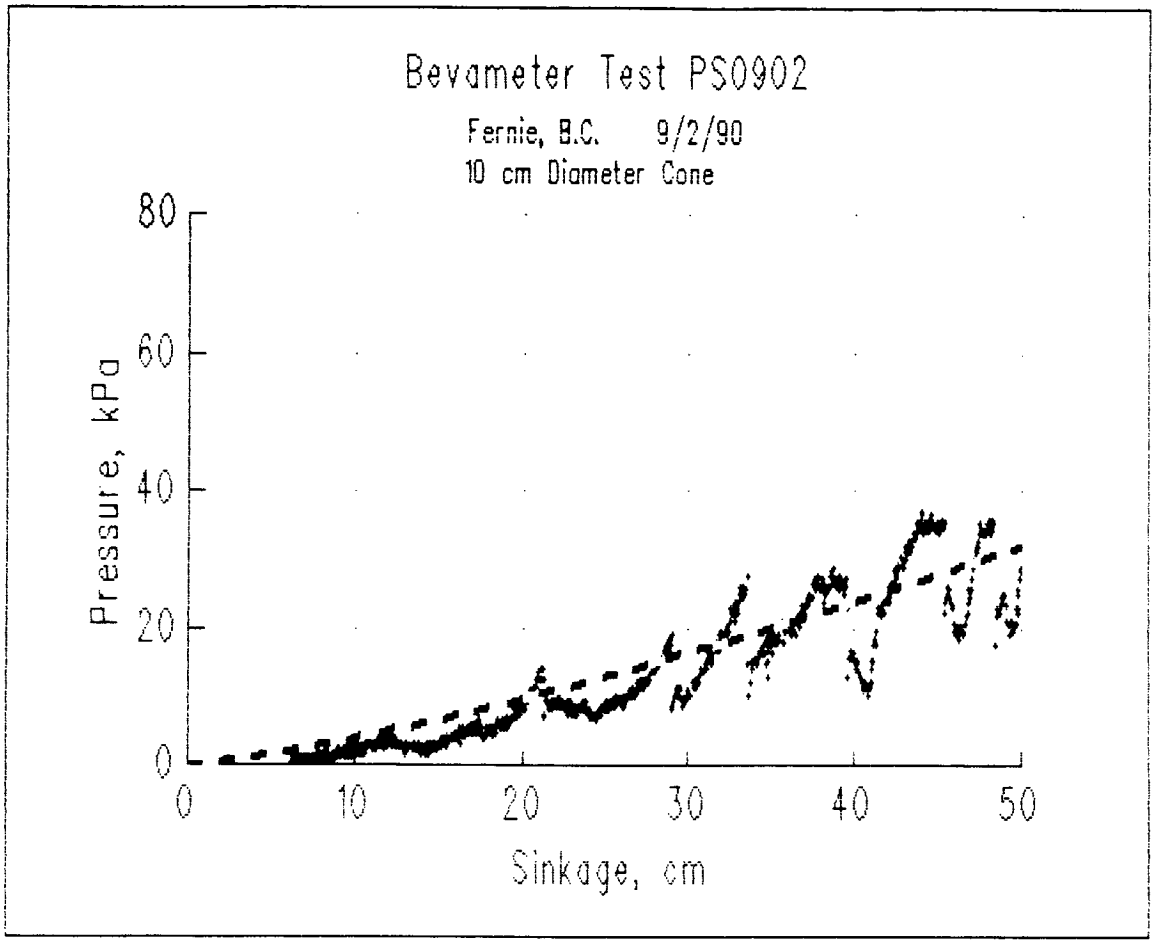
PRESSURE-SINKAGE PARAMETERS (FOR THE INDIVIDUAL CURVES)

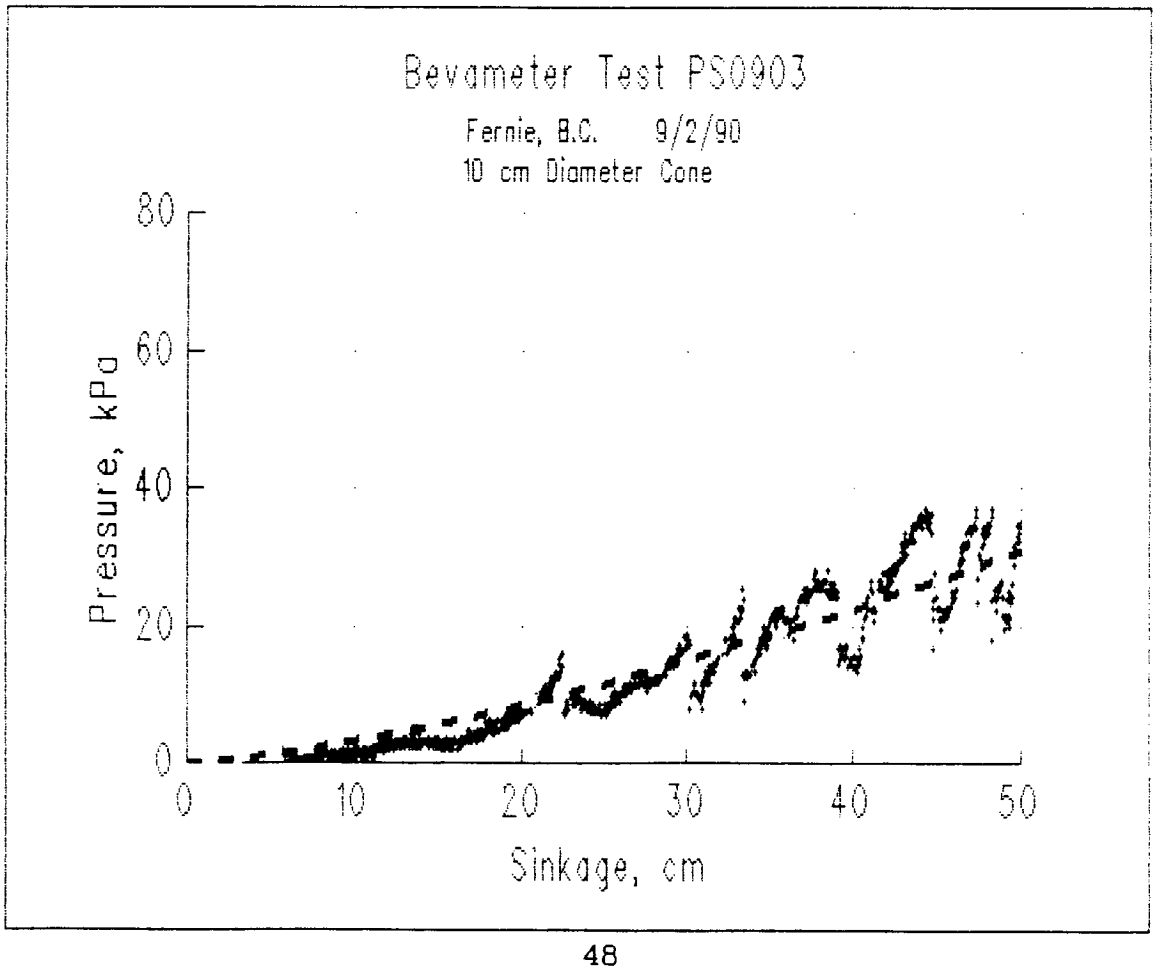
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	1.5676	.00000	93.965	69.797
2	1.6200	.00000	99.488	74.350
MEAN	1.5938	.00000	96.727	
STD. DEV.	.37022E-01	.00000	3.9054	

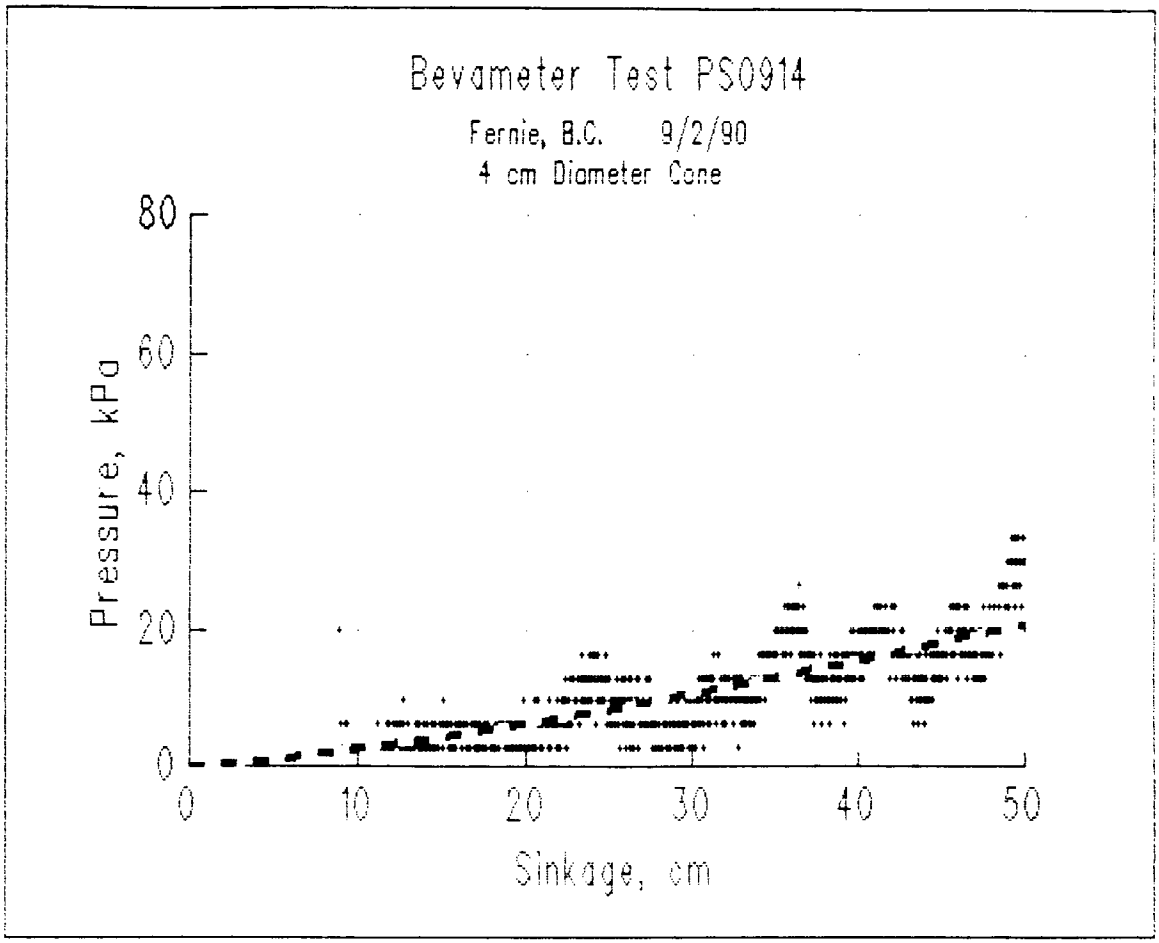
PRESSURE-SINKAGE PARAMETERS (FOR THE COMBINED CURVES)

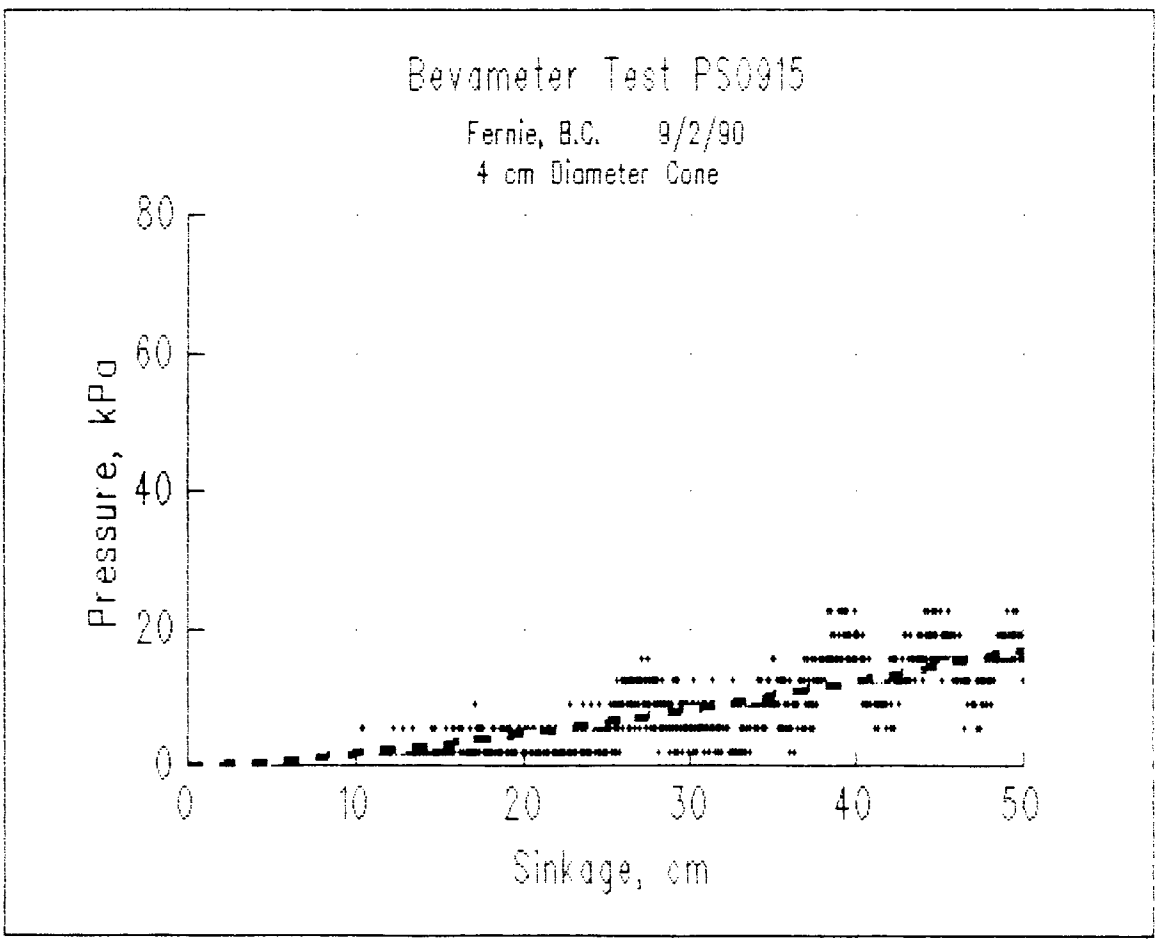
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	1.5928	.00000	96.600	71.996
2	-	-	-	-

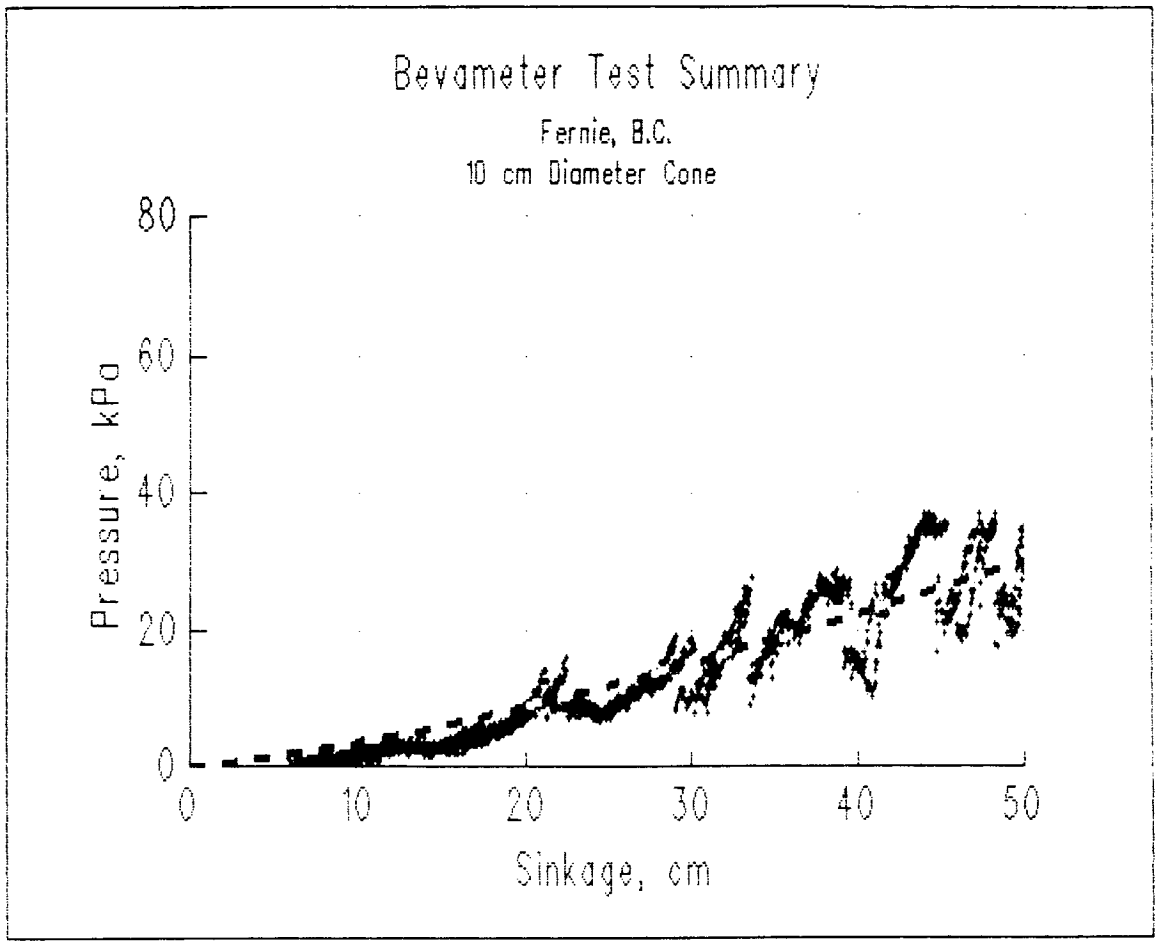
4.2.2 Fitting Bekker's Pressure-Sinkage Equation Taking into Account Size Effect

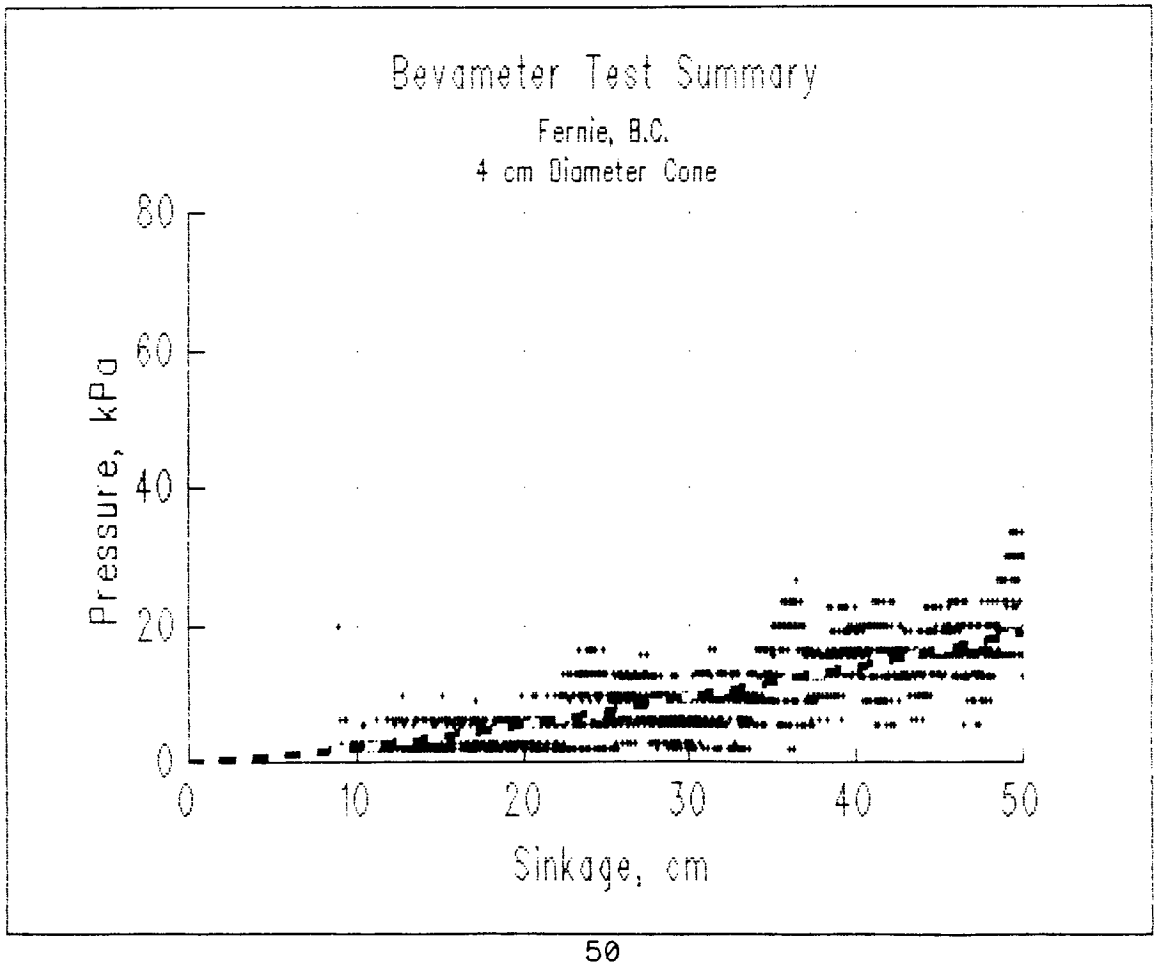

Bevameter Test PS0902
Fernie, B.C. 9/2/90
10 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test PS0903
Fernie, B.C. 9/2/90
10 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test PS0914
Fernie, B.C. 9/2/90
4 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test PS0915
Fernie, B.C. 9/2/90
4 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test Summary
Fernie, B.C.
10 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm


Bevameter Test Summary
Fernie, B.C.
4 cm Diameter Cone
Pressure, kPa
0
20
40
60
80
0
10
20
30
40
50
Sinkage, cm

DATA INPUT

EXPT NUMBER	FILE NAME	PLATE RADIUS (CM)	CURVE FITTING BEGINS (CM)	CURVE FITTING ENDS (CM)
1	PS0902	5.00	6.18	60.00
2	PS0903	5.00	5.70	50.00
COMBINED CURVE 1		5.00	00.00	50.00
3	PS0914	2.00	8.90	50.00
4	PS0915	2.00	10.20	50.00
COMBINED CURVE 2		2.00	00.00	50.00

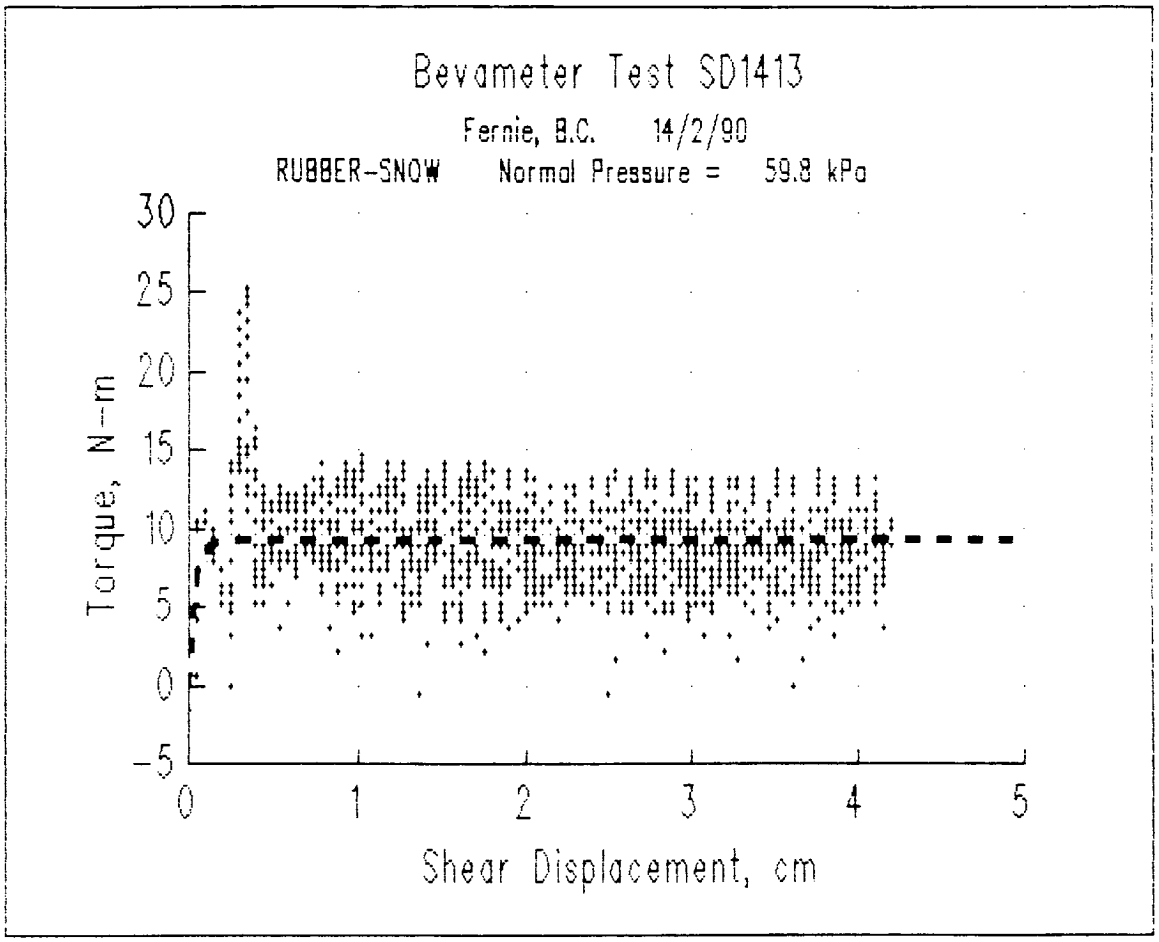
PRESSURE-SINKAGE PARAMETERS (FOR THE INDIVIDUAL CURVES)

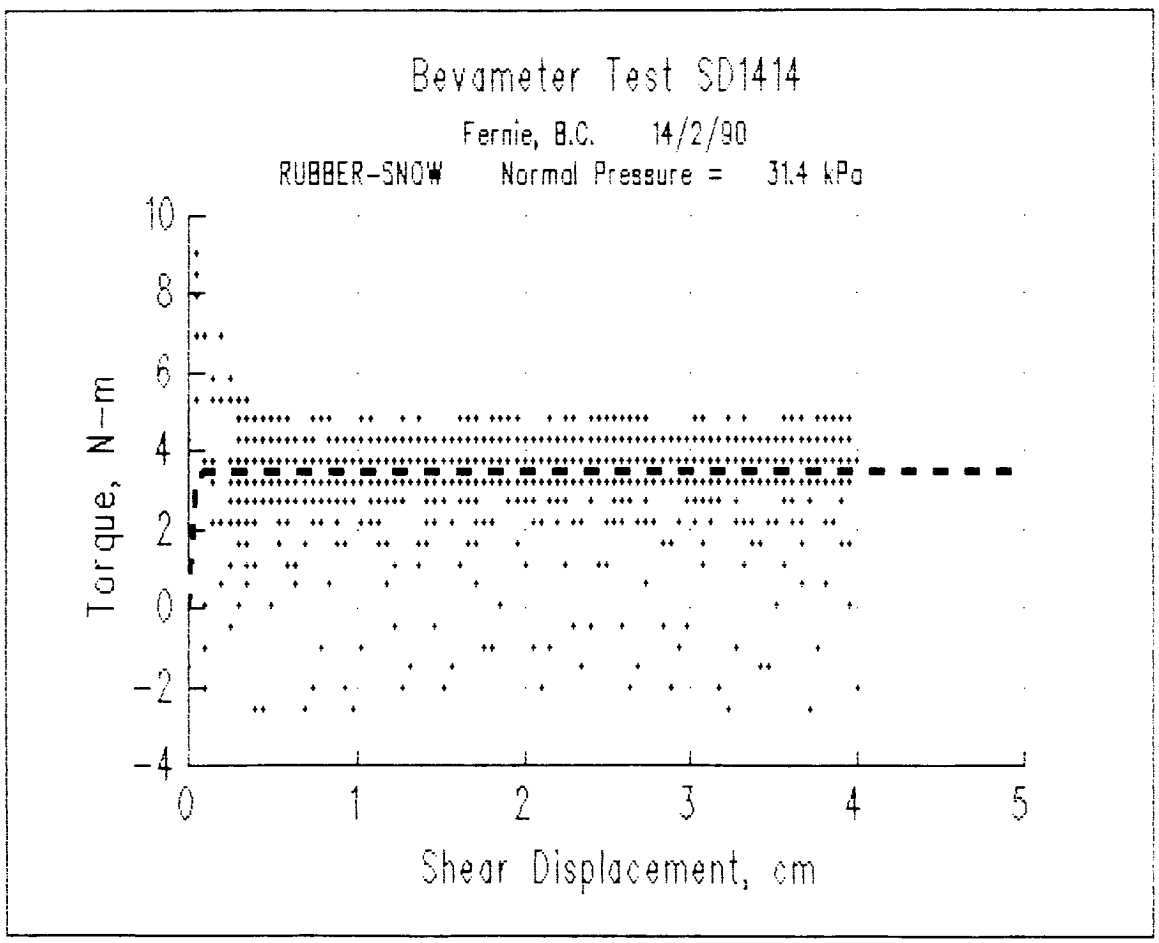
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	1.3085	-.91616	97.211	75.179
2	1.4147	-1.2318	106.50	73.298
3	1.3085	-.91616	97.211	59.035
4	1.4147	-1.2318	106.50	49.283
MEAN	1.3616	-1.0740	101.86	
STD. DEV.	.75107E-01	.22318	6.5705	

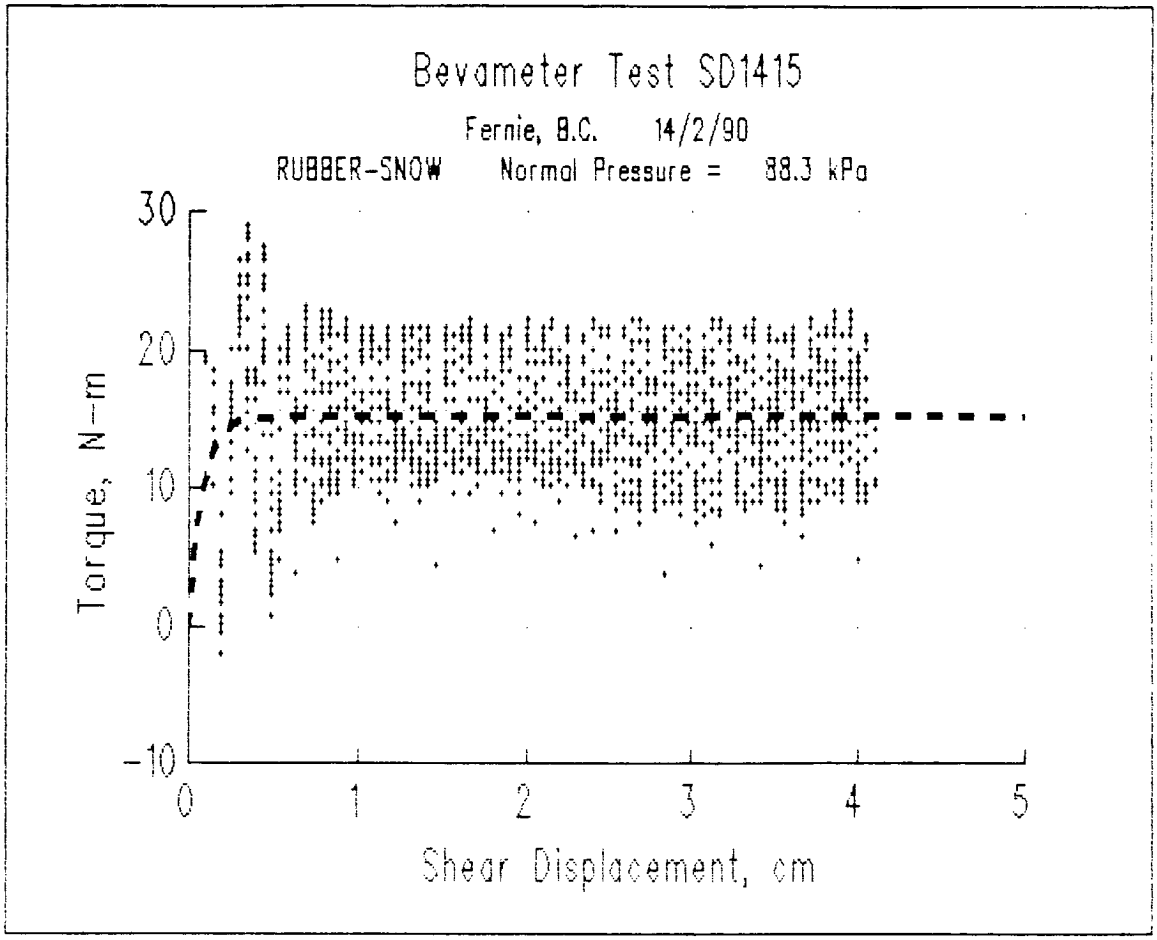
PRESSURE-SINKAGE PARAMETERS (FOR THE COMBINED CURVES)

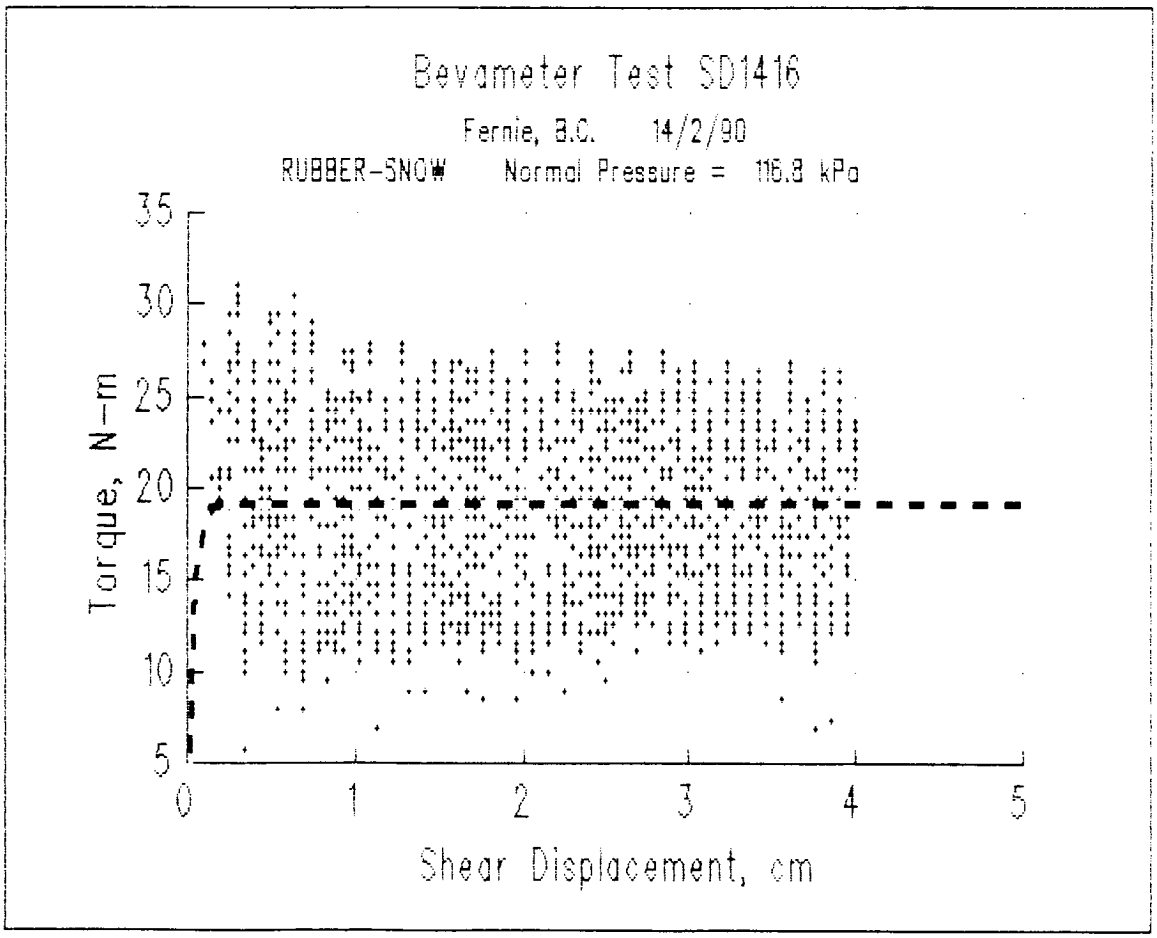
CURVE	N	KC KN/M^(N+1)	KPHI KN/M^(N+2)	GOODNESS OF FIT %
1	1.3444	-.94909	95.154	70.788
2	-	-	-	-
3	1.3444	-.94909	95.154	52.443
4	-	-	-	-

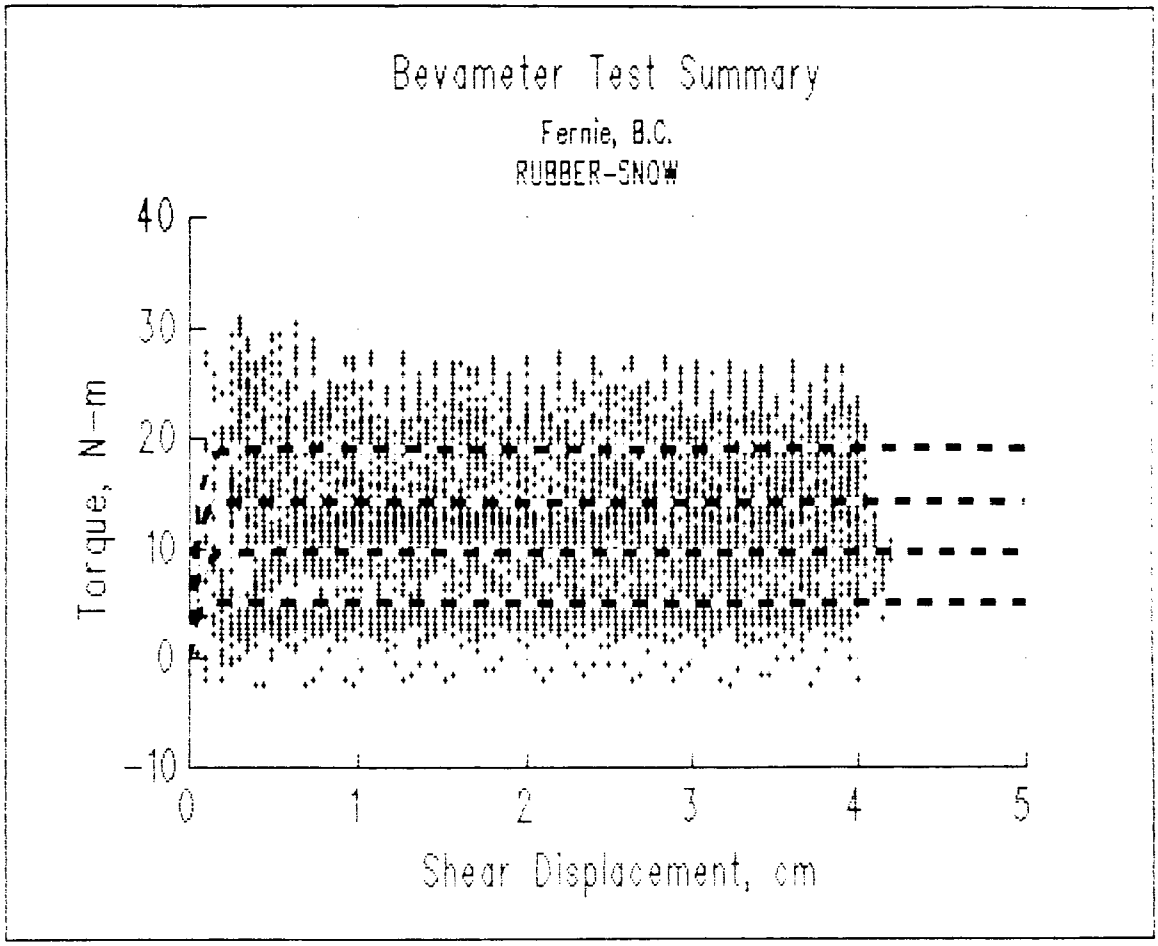
4.2.3 Fitting Torque-Shear Displacement Equation


Bevameter Test SD1413
Fernie, B.C. 14/2/90
RUBBER-SNOW Normal Pressure = 59.8 kPa
Torque, N-m
30
25
20
15
10
5
0
-5
0
1
2
3
4
5
Shear Displacement, cm


Bevameter Test SD1414
Fernie, B.C. 14/2/90
RUBBER-SNOW Normal Pressure = 31.4 kPa
Torque, N-m
10
8
6
4
2
0
-2
-4
0
1
2
3
4
5
Shear Displacement, cm


Bevameter Test SD1415
Fernie, B.C. 14/2/90
RUBBER-SNOW Normal Pressure = 88.3 kPa
Torque, N-m
30
20
10
0
-10
0
1
2
3
4
5
Shear Displacement, cm


Bevameter Test SD1416
Fernie, B.C. 14/2/90
RUBBER-SNOW Normal Pressure = 116.8 kPa
Torque, N-m
35
30
25
20
15
10
5
0
1
2
3
4
5
Shear Displacement, cm


Bevameter Test Summary
Fernie, B.C.
RUBBER-SNOW
Torque, N-m
40
30
20
10
0
-10
0
1
2
3
4
5
Shear Displacement, cm

DATA INPUT

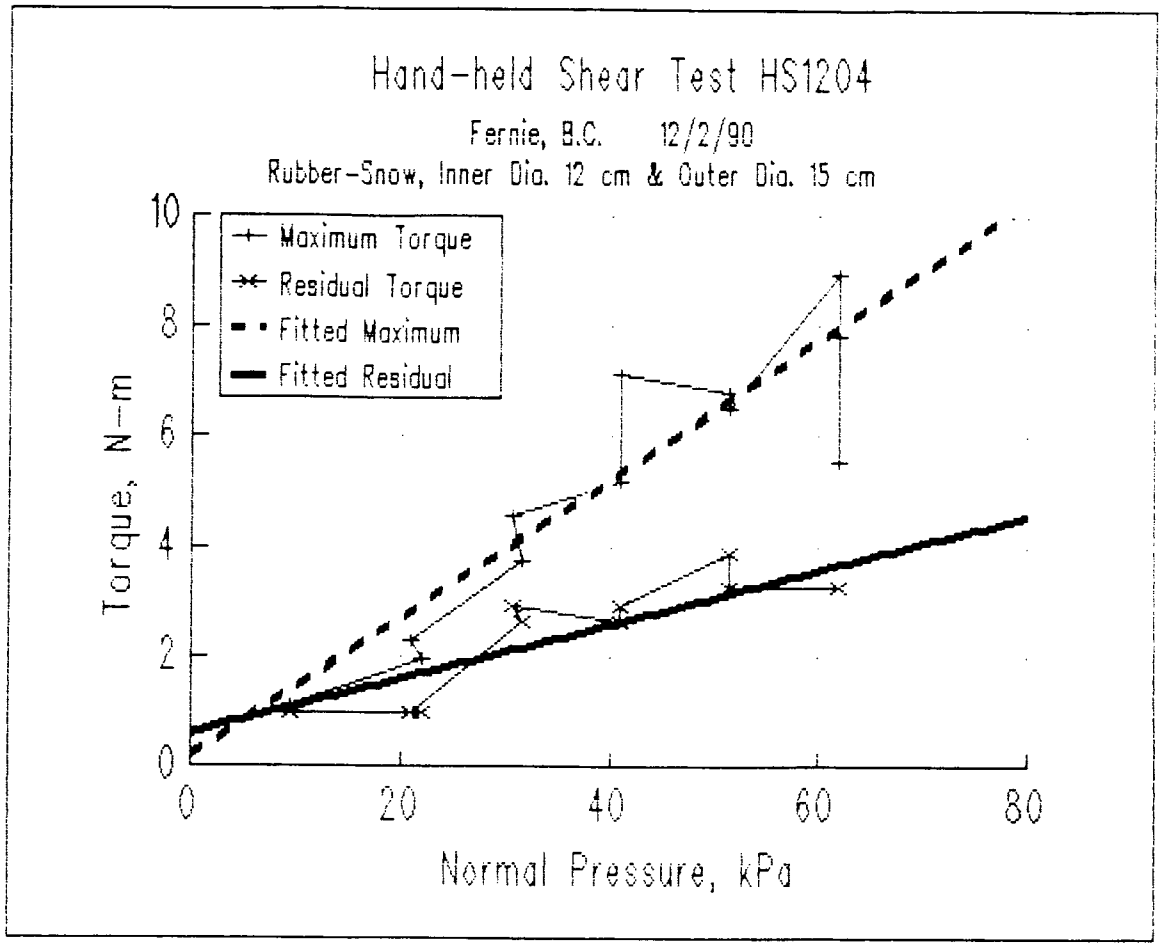
EXPT NUMBER	FILE NAME	INNER RADIUS (CM)	OUTER RADIUS (CM)	GROUSER HEIGHT (CM)	GROUSER SPACING (DEG)	NORMAL PRESSURE (KPA)	CURVE FITTING BEGINS (CM)	CURVE FITTING ENDS (CM)
1	SD1413	7.25	9.13	00.00	30.0	59.8	00.00	4.20
2	SD1414	7.25	9.13	00.00	30.0	31.4	00.00	4.00
3	SD1415	7.25	9.13	00.00	30.0	88.3	.10	4.10
4	SD1416	7.25	9.13	00.00	30.0	116.8	.10	4.00

SHEAR PARAMETERS

EXPT NUMBER	TMAX (N-M)	K (CM)	GOODNESS OF FIT (%)
1	9.2027	.37208E-01	69.174
2	3.4424	.10842E-01	66.375
3	15.168	.80492E-01	68.673
4	19.161	.34171E-01	72.643
MEAN		.40678E-01	
STD. DEV.		.29039E-01	

C (KPA)	PHI (DEG)	GOODNESS OF FIT (%)
.00000	11.604	88.408

4.3 Output from Hand-Held Shear Analysis


Hand-held Shear Test HS1204
Fernie, B.C. 12/2/90
Rubber-Snow, Inner Dia. 12 cm & Outer Dia. 15 cm
Maximum Torque
Residual Torque
Fitted Maximum
Fitted Residual
Torque, N-m
Normal Pressure, kPa
0
2
4
6
8
10
0
20
40
60
80

FILE #: HS1204
LOCATION: Fernie, B.C.
DATE: 12/2/90
TIME: 11:00h - 11:40h
TERRAIN DESCRIPTION: FRESH SNOW
SHEAR TYPE: Rubber-Snow
GROUSER HEIGHT (cm): 0.
SHEAR RING INNER AND OUTER DIAMETERS (cm): 12.0 15.0
DEAD WEIGHT (kg): 6.097
SPRING SCALE STIFFNESS (kg/m): 104.47761
SPRING SCALE UNSTRETCHED LENGTH (cm): 18.0
DISTANCE FROM THE AXIS TO THE FIRST HOOK (cm): 23.0
HOOK LENGTH (cm): 2.5
HOOK SPACING (cm): 10.0
NORMAL LOAD GAUGE CALIBRATION (slope, kg/div): 0.1365748

NORMAL PRESSURE (kPa)	MAXIMUM TORQUE (N-m)	RESIDUAL TORQUE (N-m)	FITTED MAXIMUM (N-m)	FITTED RESIDUAL (N-m)
0			.20	.60
9.40	1.14	.97		
22.04	1.95	.97		
20.98	2.27	.97		
31.52	3.73	2.60		
30.46	4.55	2.92		
40.99	5.19	2.60		
40.99	7.14	2.92		
40.99	7.14	2.92		
51.52	6.82	3.90		
51.52	6.49	3.25		
62.05	8.93	3.25		
62.05	5.52	3.25		
62.05	7.79	3.25		
62.05			7.99	3.66

MAXIMUM:

C = .46 kPa
Phi = 16.23 degrees
Goodness of Fit = 77.59 %

T0 = .20 N-m
tan(Theta) = .126 N-m / kPa

RESIDUAL:

C = 1.40 kPa
Phi = 6.51 degrees
Goodness of Fit = 79.57 %

T0 = .60 N-m
tan(Theta) = .492E-01 N-m / kPa

References

[1] Microsoft FORTRAN 4.1, Microsoft Corporation, 1987.

[2] MetaWINDOW Reference Manual - Fortran, Metagraphics Software Corporation, 1986.

[3] Microsoft MS-DOS User's Guide and User's Reference, Microsoft Corporation, 1987.

Appendix A: Directories of the TDAS Diskette

There is only one diskette for this software package. There are three directories in the diskette. They are:

TDAS.RUN, TDAS.SRC and DATA.

Directory TDAS.RUN contains the following files:

TDAS.EXE, ROMANSYM.FNT, DATFIL.E, DATFIL.H,
DATFIL.R, DATFIL.R1, DATFIL.R2, DATFIL.B1, DATFIL.B2 .

Directory TDAS.SRC contains the following files:

START.FOR, UPCASE.FOR, RAMHP.FOR, PRINTR.FOR,
HNDHLD.FOR, BEVAN01.FOR, BEVAN02.FOR, BEVAN03B.FOR,
BEVAN03C.FOR, BEVAN04.FOR, BEVAN05.FOR, BEVAN06.FOR,
BEVAN07.FOR, BEVAN08.FOR, BEVAN09.FOR, BEVAN10.FOR,
BEVAN11.FOR, TDAS, TDAS.LNK .

Directory DATA contains the following files:

RAM05.DAT, RAM06.DAT, RAM07.DAT, RAM08.DAT .
SD1413.DAT, SD1414.DAT, SD1415.DAT, SD1416.DAT .
PS0902.DAT, PS0903.DAT, PS0914.DAT, PS0915.DAT .
HS1204.DAT .

To run the TDAS, copy all the files in directory TDAS.RUN into user's directory, and store all the input data files to be used in the same directory. To start the program, enter TDAS.

Appendix B. Diskettes Containing the Data Files

There are ten diskettes containing the selected test data collected at Fernie, British Columbia, Canada, in February, 1990.

Four diskettes are for bevameter pressure-sinkage test data. Another five diskettes are for bevameter shear test data. The remaining one contains the Rammsonde test data in directory RAMSONDE.DAT and the hand-held shear test data in directory HANDHELD.DAT .

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