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The PC-SLIN Family of Software for Slope Inclinometer Data Reduction

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SYNOPSIS

PC-SLIN is a family of computer programs designed to assist the engineer in reducing slope inclinometer data. The paper describes the various programs involved which are categorized as PREPROCESSOR, MAIN PROCESSOR, and POST-PROCESSOR programs. The adjustments which can be applied to the data are described along with procedures for handling the voluminous data involved.

INTRODUCTION

'INCLINOMETER' is the general term given to a wide variety of instruments that can be lowered into a casing to measure deviations from the vertical. Inclinometers are widely used to monitor lateral movements of cut slopes, dams, embankments, and landslide areas (Fig. 1). Readings taken at different times allows a monitoring of the total magnitude of movement and the rate of movement. In case of a landslide, the results can also be used to define the location of the slip surface or the zone of major movement.

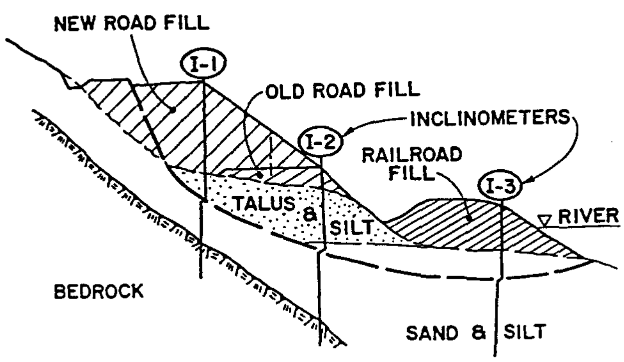

Fig. 1 Typical slide cross-section demonstrating the use of slope indicators

Considerable time is involved in obtaining each set of slope inclinometer readings. Subsequent data reduction is time consuming but greatly enhanced through the use of computers. The PC-SLIN family of software was developed to i) assist the engineer in the input of data, ii) perform the basic calculations for total deflection and change in slope, iii) perform various types of adjustment analysis on the data, iv) catalogue all input and output files, and v) provide graphic output of all plots of interest to the engineer.

HISTORY OF PC-SLIN

THE PC-SLIN family of programs was developed through a cooperative program between Slope Indicator Company, Seattle, WA, U.S.A. and GEO-SLOPE Programming Ltd., Calgary, Canada. A mainframe version of the data reduction program was made available to GEO-SLOPE in January, 1985. The program was re-organized and made suitable for use in the microcomputer environment. Numerous other complimentary programs were also written.

LAYOUT AND FEATURES OF THE PC-SLIN FAMILY OF SOFTWARE

The overall system of programs in the PC-SLIN family of software can be subdivided into PREPROCESSOR programs, MAIN PROCESSOR programs, and POST PROCESSOR programs as shown in Fig. 2.

The PREPROCESSOR programs are: i) PC-PROMID and ii) QMODEM. PC-PROMID is an interactive, user-friendly program which provides free-format, data file creation, and editing. Data can also be downline loaded from the RPP type inclinometers through communications software. QMODEM is a FREEWARE communications software package. The program can be used for downline loading data from the Model 50368 RPP Slope Indicator.

PREPROCESSING

PC-PROMID	QMODEM
Creation of input data file. Transfer of data from coding forms.	Communications software for downline loading data from the Model 50368 RPP Indicator.

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MAIN PROCESSORS

PC-SLIN (Imperial Units)
PC-SLINM (SI or Metric Units)

Computation of Change in Slope casing and Total Displacement of the casing

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POST PROCESSORS

PC-DOT8	PC-DOT9	PC-DOT11
Plots the variables from PC-SLIN or PC-SLINM versus depth.	Plots movement and change in slope versus time. Data from numerous files.	Plots up to 5 movement or or change in slope files versus depth.

REDUCE	PC-HP
Reduces the volume of output from PC-SLIN or PC-SLINM.	Plots any of the .PLT files from PC-DOT8, PC-DOT9 and PC-DOT11 on a flatbed plotter.

Fig. 2 Overall system of programs constituting the PC-SLIN family

The MAIN PROCESSOR programs are PC-SLIN and PC-SLINM. The PC-SLIN program reads a file containing data in Imperial units and calculates the change in slope and total displacement (i.e., relative to the base) for the inclinometer casing. The PC-SLINM program is similar to PC-SLIN except that the inclinometer readings are in the SI or metric system. The PC-SLIN and PC-SLINM programs can also perform the calculations necessary for two types of adjustments to the data. These are: i) the zero shift analysis, and ii) the Error Angle correction. PC-SLIN and PC-SLINM also have a cataloging of files feature. When the data reduction is complete, the user is asked if the files should be catalogued. If the response is 'NO', the PC-SLIN or PC-SLINM programs are terminated. If the response is 'YES', the elapsed time between the 'PRESENT' and the 'PAST' datafiles is computed and catalogued along with the file names. A restriction on the date data is that it must be in the form of MONTH-DAY-YEAR. This means that one or more files exist which contain a summary of the input and output file names associated with various inclinometer casings read on different dates. The catalogue of file names can later be used in conjunction with the PC-DOT9 plotting program.

The POST PROCESSOR programs are designed to assist in handling the output data which accumulates when conducting readings on many inclinometer casings. There are five POST PROCESSOR programs, namely; i) PC-DOT8, ii) PC-DOT9, iii) PC-DOT11, iv) REDUCE, and v) PC-HP.

PC-DOT8 is a dot matrix graphics program which reads an output file of computations and plots various variables versus depth. These plots are of primary value when assessing the reliability or accuracy of the input data.

The PC-DOT9 program produces dot matrix plots of total displacement and change in slope versus time. The output files are selected by reading the catalogue file produced by the PC-SLIN and PC-SLINM programs. A particular casing or hole number can be selected and all relevant output files will be read. Up to five depths can be selected for plotting. The graphs produced are: i) total displacement versus time for the A-A plane or the B-B plane and, ii) change of slope versus time for the A-A plane or the B-B plane.

PC-DOT11 is a high resolution, dot matrix graphics program which plots the 'Change in Slope' and the 'Total Displacement' versus depth for up to five data files on one graph. The plots can be produced for both the A-A and B-B planes. This provides a visualization of the amount of movement on various dates.

The REDUCE program reduces the size of an output file to about 1/5 of its original size. The "change in slope" and "deflection" calculations maintain the original format and can be read by the PC-DOT9 program. The PC-HP program allows the output of any of the dot matrix plots to be directed to a pen plotter (e.g., Hewlett-Packard plotter).

EXAMPLE PROBLEM

The execution of PC-SLIN or PC-SLINM compares two sets of slope indicator readings. The program is designed to optimize and expedite the detection of changes in the data, whether it be due to actual lateral casing movement or erroneous data. An example problem uses two datafiles: one forming the PAST set of data and the other forming the PRESENT set of data.

In addition to the input data, the computer printout consists of seven primary sections:

i) Listing of the eight variables (four readings at each depth increment at two different dates), intermediate computations, and computed deflections,
ii) Plot of the A-A component deflections versus depth,
iii) Plot of the A-A component of changes in reading at each interval versus depth,
iv) Plot of the B-B component deflections versus depth,
v) Plot of the B-B component of changes in reading versus depth,
vi) Performance checks consisting of a listing of check sums of the two sets of A-A and B-B readings and the difference in check sums between sets.
vii) Summary statistics of the instrument performance which lists the mean and standard deviation of the check sums for selected sections of the casing, both for each set of readings and the differences.

Figure 3 shows the input data file for the example problem created through the use of the PC-PROMID program. Shown is the PAST or reference datafile. A total of 38 depth readings were taken and the Imperial (or English) system of units are used.

QUESTIONS	
SI1.SN	= DATA FILE NAME
W-2553-01	= PROJECT NO
BENCHMARK EXAMPLE	NO. 1
B-1	= HOLE NO.
7	= READING SET NO.
SEPT 20/73	= DATE
13:10	= TIME
20.,	= STATISTICS INTERVAL
039	= INSTRUMENT NO.
0,	= HALF OR COMPLETE SET OF DATA
.000,	= A-ROTATION ERROR CORRECTION
.000,	= B-ROTATION ERROR CORRECTION
20000.,	= INSTRUMENT CONSTANT
A+	= A+ COMPASS DIRECTION
A-	= A- COMPASS DIRECTION
B+	= B+ COMPASS DIRECTION
B-	= B- COMPASS DIRECTION
0,	= SHIFT ANALYSIS PRINT
0,	= A COMPONENT SHIFT
0,	= B COMPONENT SHIFT
1200.,	= CHANGE IN READING SCALE
3.0,	= DEFLECTION SCALE
READINGS ,	38

2.0,	177,	-179,	271,	-276
4.0,	202,	-195,	182,	-178
6.0,	266,	-283,	194,	-193
8.0,	259,	-261,	231,	-238
10.0,	254,	-249,	198,	-220
12.0,	247,	-248,	145,	-157
14.0,	237,	-236,	126,	-136
16.0,	234,	-247,	121,	-130
18.0,	255,	-256,	101,	-105
20.0,	243,	-257,	25,	-46
22.0,	267,	-279,	10,	-22
24.0,	313,	-319,	10,	-27
26.0,	335,	-328,	14,	-1
28.0,	362,	-362,	48,	-49
30.0,	288,	-294,	60,	-42
32.0,	265,	-266,	124,	-138
34.0,	283,	-279,	120,	-154
36.0,	290,	-234,	110,	-118
38.0,	273,	-281,	116,	-126
40.0,	271,	-269,	150,	-146
42.0,	194,	-195,	141,	-155
44.0,	182,	-187,	187,	-198
46.0,	190,	-192,	171,	-186
48.0,	176,	-175,	144,	-159
50.0,	200,	-203,	125,	-155
52.0,	221,	-223,	173,	-176
54.0,	224,	-237,	152,	-159
56.0,	254,	-260,	148,	-160
58.0,	192,	-197,	96,	-98
60.0,	240,	-261,	146,	-166
62.0,	224,	-231,	183,	-188
64.0,	143,	-146,	128,	-139
66.0,	167,	-184,	219,	-227
68.0,	207,	-214,	204,	-213
70.0,	180,	-191,	111,	-93
72.0,	204,	-210,	149,	-164
74.0,	204,	-207,	167,	-179
76.0,	197,	-198,	143,	-157

Fig. 3 Past datafile (SI1.SN)

The PAST and PRESENT sets of data are compared and calculations are presented. Fig. 4 shows the calculations of the change in reading and the deflection for the A-A plane.

Columns 1 and 2 give the readings from the first and second runs in the A-A plane for the PAST set of readings. Column 3 gives the algebraic difference of columns 1 and 2. For example, at a depth of 2.0 feet, the initial algebraic sum can be written as follows:

$$177 - (-179) = 356 \qquad [1]$$

Columns 4 and 5 show the readings from the first and second runs in the A-A plane for the PRESENT set of readings. Column 6 gives the algebraic difference of columns 4 and 5. At the 2.0 foot depth the current algebraic sum is,

$$124 - (-125) = 249 \qquad [2]$$

Column 7 gives the change in reading between the final difference (i.e., column 6) and the initial difference (i.e., column 3).

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BENCHMARK EXAMPLE NO. 1
DIGITILT DATA

	PAST	PRESENT	OUTPUT
FILE NAMES	SI1.SN	SI11.SN	OUT1.SN
JOB NUMBER	W-2553-01	W-2553-01	
HOLE NUMBER	B-1	B-1	
DATA SET NUMBER	7	8	
DATE	SEPT 20/73	OCT. 11/76	
TIME	13:10	12:30	
READINGS PER DIRECTION	2	2	
INSTRUMENT NUMBER	039	039	
CONSTANT	20000.	20000.	
ERROR ANGLE - A COMP.	.000	.000	
ERROR ANGLE - B COMP.	.000	.000	
ZERO SHIFT - A COMP.		0	
ZERO SHIFT - B COMP.		0	

PAST DATA			PRESENT DATA					
A+	A-	PAST DIFF.	A+	A-	PRESENT DIFF.	CHANGE	DEFL. IN.	DEPTH FT.
177	-179	356	124	-125	249	-107	1.0149	2.0
202	-195	397	210	-188	398	1	1.1112	4.0
266	-283	549	270	-283	553	4	1.1106	6.0
259	-261	520	267	-264	531	11	1.1082	8.0
254	-249	503	263	-251	514	11	1.1016	10.0
247	-248	495	246	-245	491	-4	1.0950	12.0
237	-236	473	234	-234	468	-5	1.0974	14.0
234	-247	481	241	-245	486	5	1.1004	16.0
255	-256	511	252	-250	502	-9	1.0974	18.0
243	-257	500	251	-259	510	10	1.1028	20.0
267	-279	546	263	-266	529	-17	1.0968	22.0
313	-319	632	319	-320	639	7	1.1070	24.0
335	-328	663	346	-328	674	11	1.1028	26.0
362	-362	724	355	-354	709	-15	1.0962	28.0
288	-294	582	299	-285	584	2	1.1052	30.0
265	-266	531	936	-936	1872	1341	1.1040	32.0
283	-279	562	549	-553	1102	540	.2994	34.0
290	-234	524	289	-277	566	42	-.0246	36.0
273	-281	554	278	-283	561	7	-.0498	38.0
271	-269	540	263	-258	521	-19	-.0540	40.0
194	-195	389	194	-193	387	-2	-.0426	42.0
182	-187	369	183	-183	366	-3	-.0414	44.0
190	-192	382	190	-190	380	-2	-.0396	46.0
176	-175	351	170	-171	341	-10	-.0384	48.0
200	-203	403	210	-205	415	12	-.0324	50.0
221	-223	444	219	-219	438	-6	-.0396	52.0
224	-237	461	225	-239	464	3	-.0360	54.0
254	-260	514	253	-250	503	-11	-.0378	56.0
192	-197	389	188	-191	379	-10	-.0312	58.0
240	-261	501	253	-267	520	19	-.0252	60.0
224	-231	455	213	-215	428	-27	-.0366	62.0

Fig. 4 Comparison of the past and present sets of data for the A-A plane

$$249 - 356 = -107 \qquad [3]$$

Column 8 gives the total deflection. These values are obtained by converting the change in slope readings to deflections, starting at the bottom of the casing. At a depth of 76.0 feet, the deflection computation is as follows:

$$\text{Deflection} = \frac{L(\Delta R_N - \Delta R_P)K}{2C} \qquad [4]$$

where:

L = Reading interval length (e.g., 2.0 feet)

C = Instrument Constant (e.g., 20000.)

ΔR_N = PRESENT Reading Difference

ΔR_P = PAST Reading Difference

K = Conversion to other units (e.g., feet to inches, 12.0)

$$\text{Deflection} = \frac{2.0 \times 12.0}{2 \times 20000} [-16] = -0.0096 \qquad [5]$$

Figure 5 shows a digital plot of the deflection versus depth for the A-A plane. The plot shows essetially no deflection below a depth of approximately 32.0 feet. All movement appears to be occurring at this depth. Figure 6 shows a digital plot of change in reading versus depth for the

A-A plane. The plot shows a high change in reading at the 32.0 foot depth. Both the change in reading plot and the deflection plot can be used in the interpretion of the data. Similar calculations and plots are performed for the B-B plane.

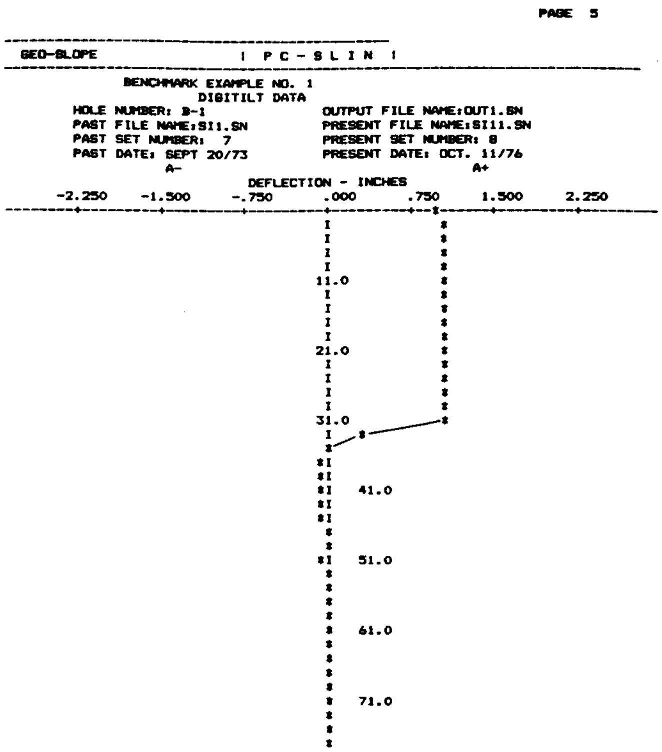

Fig. 5 Plot of deflection versus depth on the A-A plane

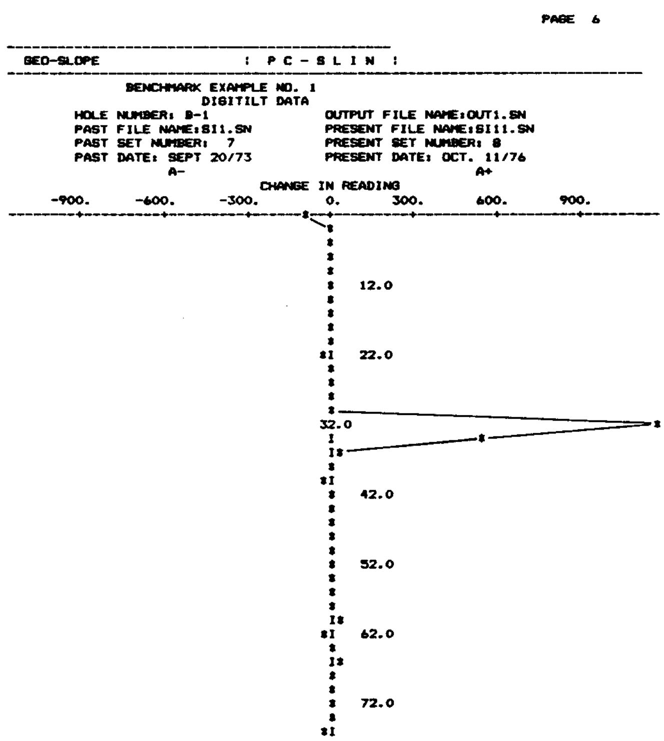

Fig. 6 Plot of change in reading versus depth on the A-A plane

Figure 7 tabulates the instrument performance check for the A-A plane. The readings for each set of readings are compared to assess the reliability of the measurements. For example, columns 1 and 2 are added (e.g., 2-foot depth) to check the similarity in their readings (i.e., column 3).

$$-179 + 177 = -2 \qquad [6]$$

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BENCHMARK EXAMPLE NO. 1
DIGITILT DATA
INSTRUMENT PERFORMANCE CHECK

HOLE NUMBER: B-1 OUTPUT FILE NAME: OUT1.SN
PAST FILE NAME: SI1.SN PRESENT FILE NAME: SI11.SN
PAST SET NUMBER: 7 PRESENT SET NUMBER: 8
PAST DATE:SEPT 20/73 PRESENT DATE:OCT. 11/76

A+	A-	PAST SUM	A+	A-	PRESENT SUM	DIFF	DEPTH FT.
177	-179	-2	124	-125	-1	1	2.0
202	-195	7	210	-188	22	15	4.0
266	-283	-17	270	-283	-13	4	6.0
259	-261	-2	267	-264	3	5	8.0
254	-249	5	263	-251	12	7	10.0
247	-248	-1	246	-245	1	2	12.0
237	-236	1	234	-234	0	-1	14.0
234	-247	-13	241	-245	-4	9	16.0
255	-256	-1	252	-250	2	3	18.0
243	-257	-14	251	-259	-8	6	20.0
267	-279	-12	263	-266	-3	9	22.0
313	-319	-6	319	-320	-1	5	24.0
335	-328	7	346	-328	18	11	26.0
362	-362	0	355	-354	1	1	28.0
288	-294	-6	299	-285	14	20	30.0
265	-266	-1	936	-936	0	1	32.0
283	-279	4	549	-553	-4	-8	34.0
290	-234	56	289	-277	12	-44	36.0
273	-281	-8	278	-283	-5	3	38.0
271	-269	2	263	-258	5	3	40.0
194	-195	-1	194	-193	1	2	42.0
182	-187	-5	183	-183	0	5	44.0
190	-192	-2	190	-190	0	2	46.0
176	-175	1	170	-171	-1	-2	48.0
200	-203	-3	210	-205	5	8	50.0
221	-223	-2	219	-219	0	2	52.0
224	-237	-13	225	-239	-14	-1	54.0
254	-260	-6	253	-250	3	9	56.0
192	-197	-5	188	-191	-3	2	58.0
240	-261	-21	253	-267	-14	7	60.0
224	-231	-7	213	-215	-2	5	62.0
143	-146	-3	136	-143	-7	-4	64.0
167	-184	-17	173	-198	-25	-8	66.0
207	-214	-7	204	-206	-2	5	68.0
180	-191	-11	181	-190	-9	2	70.0
204	-210	-6	205	-203	2	8	72.0
204	-207	-3	198	-202	-4	-1	74.0
197	-198	-1	191	-188	3	4	76.0

Fig. 7 Instrument performance check calculations on the A-A plane

Similar calculations are performed for the PRESENT set of readings (e.g., 2-foot depth).

$$-125 + 124 = -1 \qquad [7]$$

The PRESENT and PAST sums are then subtracted (i.e., DIFF, column 7) for each depth (e.g.,2-foot depth).

$$-1 - (-2) = +1 \qquad [8]$$

These values are subsequently analysed over a prescribed depth (e.g., 20-feet). When deflections and changes in readings are small, these statistics assist in appraising the significance of the measurements.

Figure 8 tabulates the statistics on the differences in reading (i.e., DIFF) for the A-A plane. Depth increments of 20-feet were used to compute the MEAN difference in reading and the STANDARD DEVIATIONS. The statistics are computed for the PAST and PRESENT sets of readings.

The differences in the statistics between the PAST and PRESENT readings are tabulated as well as the averages for the entire hole.

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BENCHMARK EXAMPLE NO. 1

HOLE NUMBER: B-1	OUTPUT FILE NAME: OUT1.SN
PAST FILE NAME: SI1.SN	PRESENT FILE NAME: SI11.SN
PAST SET NUMBER: 7	PRESENT SET NUMBER: 8
PAST DATE:SEPT 20/73	PRESENT DATE:OCT. 11/76

A+ A- COMPONENT

INTERVAL	PAST SUM MEAN	PAST SUM STD. DEV.	PRESENT SUM MEAN	PRESENT SUM STD. DEV.	DIFFERENCE MEAN	DIFFERENCE STD. DEV.
2.0 TO 20.0	-4.	8.	1.	10.	5.	5.
22.0 TO 40.0	4.	19.	4.	8.	0.	17.
42.0 TO 60.0	-6.	7.	-2.	7.	3.	4.
62.0 TO 76.0	-7.	5.	-6.	9.	1.	5.
ENTIRE HOLE	-3.	12.	0.	9.	3.	9.

Fig. 8 Instrument performance check statistics on the A-A plane

ZERO SHIFT ANALYSIS

The algebraic sum of opposite inclinometer readings are referred to as "check sums". Check sums are used to determine errors, mistakes, or problems in the results, but are not used to calculate changes or defections. Ideally, the check sum should remain constant for all data sets at each depth interval, but in reality it varies according to the casing conditions, instrument performance, and operator technique.

Normal variations in the check sum which produce minimal or no errors are of two types. Non-parallelity of opposite running grooves, open telescoping joints, and random errors in sensor positioning cause the check sum to vary randomly around a mean value. A variation of 1 to 3 digits is considered very good. Variations more than 10 to 15 digits may indicate problems. Random variations in the check sum of 10 digits around a constant is not generally considered a problem.

The other type of check sum change which does not produce an error is a shift in the instrument zero between data sets. This type of check sum change is normal to observe between inclinometers, as well as between data sets from the same inclinometer. The change in the mean check sum represents a zero shift in the instrument and may be caused by one of several factors, (i.e., temperature, shock, mechanical problem).

The main reason for obtaining readings in opposite directions is specifically to minimize the random error and to eliminate the systematic shift error described. However, if zero shift occurs, the change in the opposite readings would be equal in magnitude and polarity. When a zero shift occurs during one or both data sets, a systematic error is introduced and the algebraic difference is changed, resulting in apparent deflection.

Figure 9 illustrates typical plots due to Zero Shift errors as well as explaining how each type of Zero Shift can be recognized. Corrections can be applied to the A-A and B-B planes using the PC-SLIN and PC-SLINM programs.

ERROR ANGLE CORRECTION

Small rotations of the accelerometer suspension axis relative to the sensor wheels can cause significant overall tilt in the measured deformation profiles. This can be caused by rough handling of the instrument or whenever an accelerometer is replaced or repaired.

Types of Zero Shift	Producing Systematic Error?
1. Between data sets	No
2. Between first and opposite run	Yes
3. During first run, gradual	Yes
4. During first run, sudden shift	Yes
5. During opposite run, gradual	Yes
6. During opposite run, sudden shift	Yes

Typical Plots due to Zero Shift Error

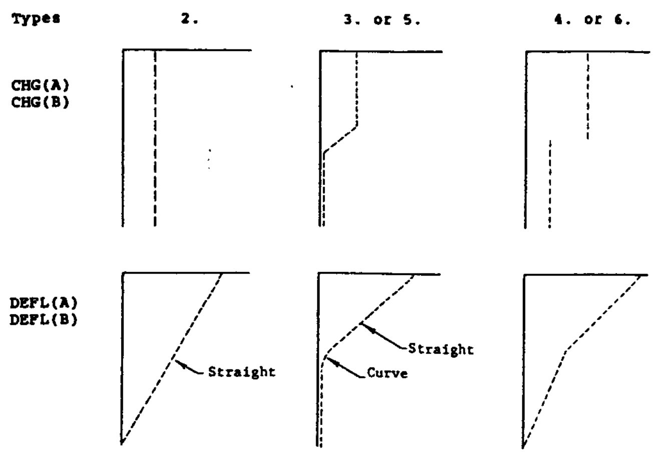

Fig. 9 Recognizing zero shift errors

Sensor axis rotation error is directly proportional to the absolute profile of the casing in a direction perpendicular to a sensor axis. If such an error has occurred, it will appear as an apparent ground movement proportional to the absolute profile of the casing in the direction perpendicular to that being measured. In applying an Error Angle correction, it is necessary to assume that no significant overall uniform tilt has occurred. The measurement error introduced by a combination of sensor alignment change (i.e., rotation) and initial inclination of the casing can be expressed by a simple mathematical relationship.

$$|\epsilon_x| = |T_y| \sin \alpha_x \qquad [9]$$

and

$$|\epsilon_y| = |T_x| \sin \alpha_y \qquad [10]$$

where:

ϵ_x and ϵ_y = measurement error in the two perpendicular planes of measurement (i.e., inches per depth interval),

T_y and T_x = horizontal components of tilt of the inclinometer casing from the vertical in two perpendicular planes (i.e., inches per depth interval),

α_x and α_y = rotation angle of sensor alignment (i.e., change) with respect to the initial planes (i.e., degrees).

These equations can be used to calculate the Error Angle correction. For example, in the case of an inclinometer casing installed tilting 100 inches to the west in 100 feet of depth, one would expect a measurement error in the north-south direction. For a sensor rotation change of 1.0 degree between two dates of measurement, the corresponding error would be 1.75 inches for that 100-foot depth interval.

(ϵ = 100 inches) x sin $(1.0)^{o}$ = 1.745 inches) The direction of the error (or apparent movement) is a function of the direction of the sensor rotation angle. The rule is as follows: looking in the direction of the initial tilt (i.e., bottom to top) the error will be to the left provided the sensor rotated in a clockwise direction after the initial reading. The error will be to the right if a counterclockwise rotation occurred.

In most instances, the rotation angle is back-calculated. The error is normally discovered when the data is reduced without any correction. Typically, the deflection plot will indicate a gradual apparent tilt from bottom to top. By closer study one will discover that the deflection plot is proportional in shape to the casing profile (i.e., relative to vertical) in the perpendicular plane. The proportionality factor will be sin , where is the rotation angle of the sensor measuring in the plane of the deflection plot. Initially, a correction is applied to reduce the apparent ground surface displacement to zero, allowing an addition for any distinct shear movements that may have been detected. Having done this, the magnitude of the Error Angle correction can be adjusted to try to minimize noticeable deviations at depth and some judgement is required to obtain a 'least deviation' type fit of the data. The Error Angle correction can be applied in both the PC-SLIN and PC-SLINM programs.

CATALOGING OF FILES

After two sets of slope indicator readings are read into the computer and the computations are completed (i.e., using PC-SLIN or PC-SLINM), the user is asked whether the files should be catalogued. If the response is 'YES', the elapsed time between the two sets of readings is computed and this information along with the names of the files is recorded in a catalogue file. Some of the information that appears on the monitor is shown in Fig. 10.

In order for the computer to calculate the elapsed time between two sets of readings, it is necessary for each date and time to be interpreted. Since this data is recorded as an alphanumeric variable, many forms may be used. It is necessary to place some restrictions on the form for the date and time. The DATE must always be recorded in the order MONTH-DAY-YEAR. The month may be either in numeric or alphabetic form. Delineators between the month, day, and year can be i) blanks, ii) commas, iii) slashes, iv) colons, v) hyphens, vi) periods, or vii) dashes.

The TIME must be in the order of HOUR-MINUTE. A 24-hour clock must be used to record the time. Any of the above delineators apply. The elapsed time is a 'real' variable in days. Typical, acceptable forms for date and time are as follows:

Date	Time
Feb. 12,82	13:00
July 6, 1981	18:30
Oct 20/84	09/30
06-08-83	8-20

```
SHOULD THE FILE NAMES BE CATALOGUED?  (Y/N)  Y

ENTER CATALOGUE FILE NAME. (DEFAULT IS CAT.CAT)

DATE MUST BE IN THE ORDER: MONTH, DAY, YEAR

DECODE PAST OR REFERENCE DATE AND TIME

DATE IS GIVEN AS:     SEPT 20/73
DECODE INTO INTEGERS
--------------------
MONTH = 9
MONTH DECODED CORRECTLY? (Y/N)  Y
DAY = 20
DAY DECODED CORRECTLY? (Y/N)  Y
YEAR = 1973
YEAR DECODED CORRECTLY? (Y/N)  Y

TIME IS GIVEN AS:       13:10
DECODE INTO INTEGERS
--------------------
HOUR = 13
HOUR DECODED CORRECTLY? (Y/N)  Y
MINUTE = 10
MINUTE DECODED CORRECTLY? (Y/N)  Y

DECODE PRESENT DATE AND TIME

DATE IS GIVEN AS:     OCT. 11/76
DECODE INTO INTEGERS
--------------------
MONTH = 10
MONTH DECODED CORRECTLY? (Y/N)  Y
DAY = 11
DAY DECODED CORRECTLY? (Y/N)  Y
YEAR = 1976
YEAR DECODED CORRECTLY? (Y/N)  Y

TIME IS GIVEN AS:       12:30
DECODE INTO INTEGERS
--------------------
HOUR = 12
HOUR DECODED CORRECTLY? (Y/N)  Y
MINUTE = 30
MINUTE DECODED CORRECTLY? (Y/N)  Y
```

Fig. 10 The cataloging of the PC-SLIN and PC-SLINM files

The user is requested to verify the interpretation as each component of the date and time is analysed. Only the last two numbers of the year need to be entered. Leap years are also taken into account in the calculation of the elapsed time.

Figure 11 shows a typical catalogue of files. The information catalogued is i) the hole number, ii) the PRESENT input datafile name, iii) the PAST datafile name, iv) the output computations file name, v) the PRESENT date, and vi) the elapsed time in days between the PRESENT and PAST sets of inclinometer readings. The catalogue file is mainly of value when executing the PC-DOT9 program.

CATALOGUE OF SLOPE INDICATOR READINGS & COMPUTATIONS

Hole No.	Input Data File	Reference File	Output Computations File	Date	Elapsed Time (Days)
B-1	SI1.SN	SI11.SN	OUT1.SN	OCT. 11/76	1115.970
B-1	SI2.SN	SI22.SN	OUT2.SN	OCT. 11/76	1115.970
I-5	SI3.SN	SI33.SN	OUT3.SN	JUNE 10/85	242.000
B-1	SI5.SN	SI55.SN	OUT5.SN	OCT. 11/76	.000
S-1	A:BN1.SI	A:BN4.SI	OT14.SN	JULY 11/83	237.130
S-1	A:BN1.SI	A:BN2.SI	A:OT12.SN	MAY 18/83	183.042
S-1	A:BN1.SI	A:BN3.SI	A:OT13.SN	JUNE.14/83	210.084
S-1	A:BN1.SI	A:BN5.SI	A:OT15.SN	AUG.22/83	279.170
S-1	A:BN1.SI	A:BN6.SI	A:OT16.SN	SEPT 27/83	315.170
S-1	A:BN1.SI	A:BN7.SI	A:OT17.SN	OCT.26/83	344.209
S-1	A:BN1.SI	A:BN8.SI	OT18.SN	DEC.14/83	393.250
M-1	SI4.SN	SI44.SN	OUT4.SN	DEC. 10/81	10.042
M-1	SI4.SN	SI44.SN	OUT4.SN	DEC. 10/81	110.042

Fig. 11 Typical catalogue file

DOT MATRIX PLOTTING

There are three graphics programs for producing various dot matrix plots of the computer output.

PC-DOT8

The PC-DOT8 program reads an output file of computations from PC-SLIN or PC-SLINM and plots of various variables versus depth. The plots that can be requested are as follows:

i) the PAST A+ and A- data,
ii) the PRESENT A+ and A- data,
iii) the PAST Difference and PRESENT Difference from the A-A Plane,
iv) the Change in Slope for the A-A Plane,
v) the deflection multiplied by 1000 for the A-A Plane,
vi) the PAST and PRESENT Sums for the A-A Plane,
vii) the Sum Differences for the A-A Plane.

All the above plots can be repeated for the B-B plane. In other words, there is a total of 14 possible plots when using PC-DOT8.

Following are three typical plots. Figure 12 shows a plot of the PAST indicator readings versus depth. Figure 13 shows the PAST and PRESENT differences versus depth. Figure 14 shows the PAST and PRESENT sums versus depth.

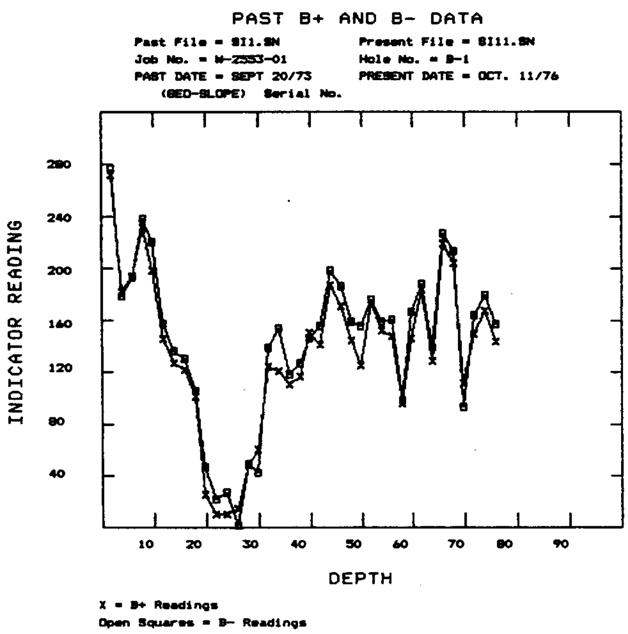

Fig. 12 Past B+ and B- indicator readings versus depth using PC-DOT8

PC-DOT9

The PC-DOT9 program produces plots of 'Total Displacement' or 'Change in Slope' versus time. This means that PC-DOT9 must search many files in order to find the desired data. The PC-SLIN and PC-SLINM output files to be searched are selected by reading a catalogue file (e.g., CAT.CAT). A particular casing or hole number can be selected and all relevant output files will be read. Up to five depths can be selected for plotting. The graphs that can be plotted are:

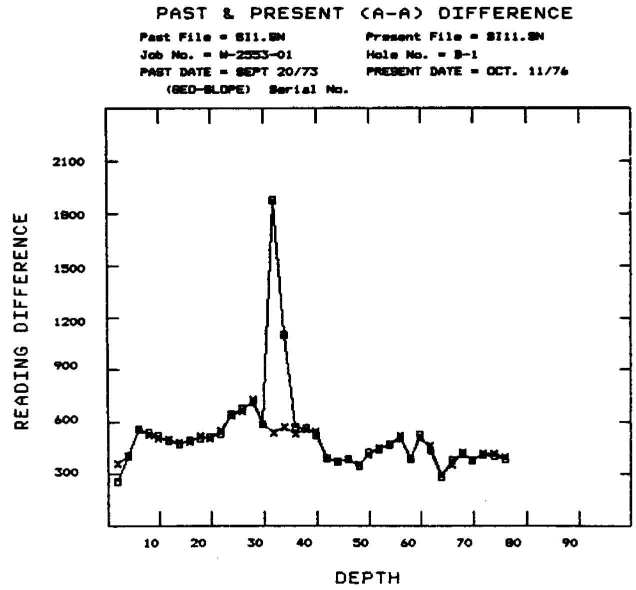

Fig. 13 Past and Present (A-A) difference versus depth using PC-DOT8

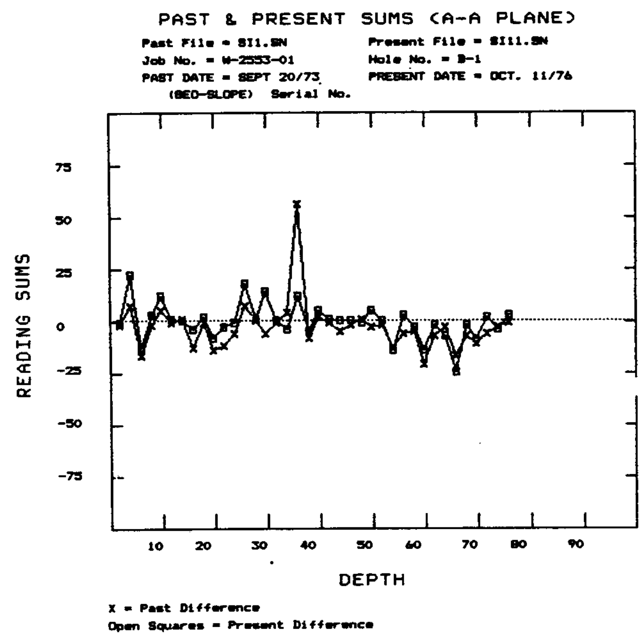

Fig. 14 Past and present sums (A-A plane) versus depth using PC-DOT8

i) total displacement versus time for the A-A and B-B planes,
ii) change in slope versus time for the A-A and B-B planes.

Either the 'Detailed' or 'Reduced' output files can be searched to obtain the above data. Fig. 15 shows a typical plot of movement versus time for four depths.

PC-DOT11

PC-DOT11 plots up to five sets of computations

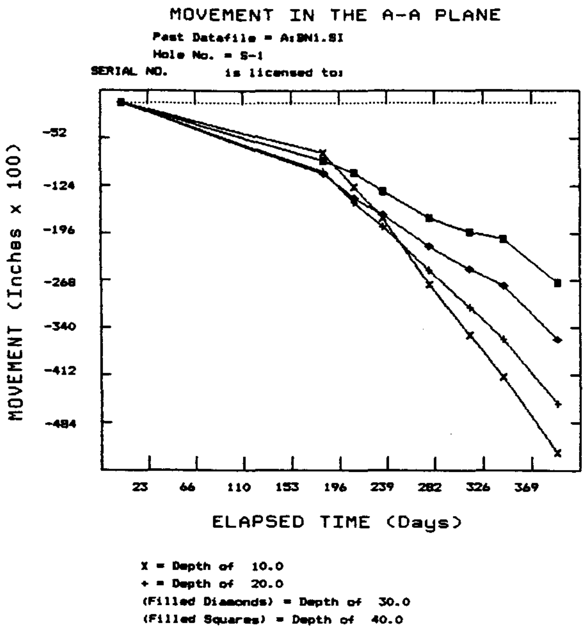

Fig. 15 Movement in the A-A plane versus time using PC-DOT9

of 'Total Displacement' or 'Change in Slope' versus depth. The plots can be produced for both the A-A and B-B planes. These plots are similar to the digital plots produced during data reduction. However, it is possible to combine up to five sets of readings on one graph and each set of readings are joined by a continuous line.

Figure 16 shows 'deflection' versus depth for four sets of data. A plot of 'change in slope' versus depth for the same data are shown in Fig. 17.

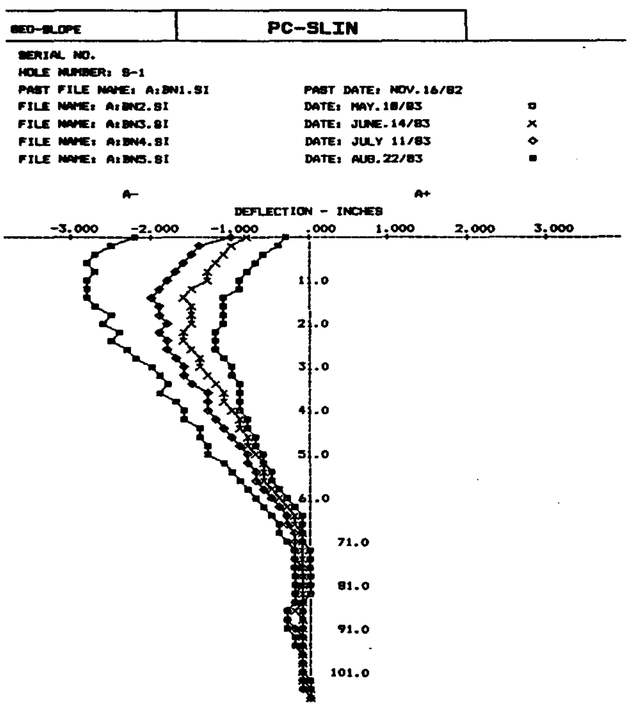

Fig. 16 Deflection versus depth in the A-A plane

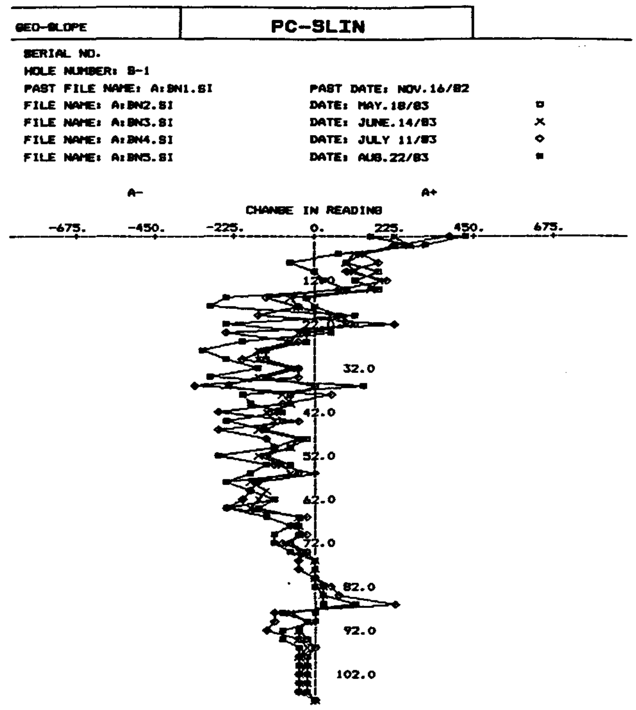

Fig. 17 Change in reading versus depth in the A-A plane

SUMMARY

The computations associated with slope inclinometer readings are relatively simple. The main difficulty is associated with the handling of the voluminous input and output data. The design of the PC-SLIN family of programs is directed at assisting the engineer in more easily handling and interpreting slope inclinometer data.

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