

USER'S MANUAL TO COMPUTER PROGRAM CALIBRAT  
A PROGRAM FOR CALIBRATION OF NONDESTRUCTIVE TESTING DEVICES

by

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Research Project 913

DEVELOPMENT OF AN ABSOLUTE CALIBRATION SYSTEM FOR  
NONDESTRUCTIVE TESTING DEVICES

Conducted for

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by

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## ABSTRACT

The Falling Weight Deflectometer (FWD) and Dynaflect devices are presently being used by highway agencies. The primary function of the FWD and Dynaflect devices is to measure a deflection basin due to a load imparted to the pavement. Deflection basins measured in the field are used in backcalculating modulus profiles of pavement sections. As such, it is critical to determine the deflection basins in the field with great accuracy. Velocity transducers (also called geophones) are used to determine the deflections, and load cells are utilized to measure applied load.

It has become increasingly important in recent years to be able to evaluate the performance of the deflection and load sensors of the Falling Weight Deflectometer or the Dynaflect devices. It has been shown that a small error in the deflection measured in the field may yield significantly erroneous modulus values. As such, a very reliable method for evaluating the accuracy of the sensors used for determining these deflections is necessary.

If geophones are used to determine deflections, the algorithm developed for calculating deflection also becomes important. A geophone measures the so-called "raw" particle velocity of the pavement surface directly underneath it. Therefore, the methodology and algorithm employed to obtain the "actual" displacement must be carefully considered. Errors in the load cell measurements are not as important, but should be avoided for reliable results.

This report contains a user's manual for a computer program called CALIBRAT. The program has been developed to control the acquisition and digitization of sensor's signals, to reduce the collected data, and to present the data. The program is coded for an IBM-PC Compatible equipment with DT 2825 Analog-to-Digital board manufactured by Data Translation, Inc. The program is written in FORTRAN and compiled with MICROSOFT FORTRAN (4.1) Compiler.

KEY WORDS: Falling Weight Deflectometer, Dynaflect, Sensors, Calibration, Software

# METRIC (SI\*) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

Symbol When You Know Multiply By To Find Symbol

### LENGTH

in	inches	2.54	centimetres	cm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

### AREA

in <sup>2</sup>	square inches	645.2	centimetres squared	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.0929	metres squared	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.836	metres squared	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.59	kilometres squared	km <sup>2</sup>
ac	acres	0.395	hectares	ha

### MASS (weight)

oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

### VOLUME

fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft <sup>3</sup>	cubic feet	0.0328	metres cubed	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.0765	metres cubed	m <sup>3</sup>

NOTE: Volumes greater than 1000 L shall be shown in m<sup>3</sup>.

### TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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\* SI is the symbol for the International System of Measurements

## APPROXIMATE CONVERSIONS TO SI UNITS

Symbol When You Know Multiply By To Find Symbol

### LENGTH

mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

### AREA

mm <sup>2</sup>	millimetres squared	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	metres squared	10.764	square feet	ft <sup>2</sup>
km <sup>2</sup>	kilometres squared	0.39	square miles	mi <sup>2</sup>
ha	hectares (10 000 m <sup>2</sup> )	2.53	acres	ac

### MASS (weight)

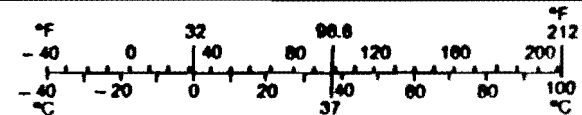
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

### VOLUME

mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m <sup>3</sup>	metres cubed	35.315	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	metres cubed	1.308	cubic yards	yd <sup>3</sup>

### TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F
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These factors conform to the requirement of FHWA Order 5190.1A.

## PREFACE

This report is the third of four reports which describes work done on Project 913, "Development of an Absolute Calibration System for Nondestructive Testing Devices." The study is being conducted at the Center for Geotechnical and Highway Materials Research, the University of Texas at El Paso with the cooperation of the Texas State Department of Highways and Public Transportation.

Many people have contributed their help towards the completion of this report. Thanks are extended to the University of Texas at El Paso, Civil Engineering Department Secretarial staff and Mr. Amin Solehjou for excellent work in preparing the electronics parts.

Invaluable comments and support were provided by Mr. Robert Briggs, Richard Rogers and all other personnel of SDHPT.

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Soheil Nazarian

August, 1990

## LIST OF REPORTS

Research Report 913-1F, Volume 1, "Comprehensive Evaluation of Five Sensors Used for Pavement Monitoring," by Vivek Tandon and Soheil Nazarian, presents an extensive testing program to evaluate the accuracy and precision of five deflection sensing transducers used in pavement engineering, for use by Texas State Department of Highways and Public Transportation, August, 1990.

Research Report 913-1F, Volume 2, "An Absolute Calibration System for Nondestructive Testing Devices," by Vivek Tandon and Soheil Nazarian, presents a system developed for the absolute calibration system of the FWD and Dynaflect devices, for use by the Texas State Department of Highways and Public Transportation, August, 1990.

Research Report 913-1F, Volume 3, "User's Manual to Computer Program Calibrat," by Vivek Tandon and Soheil Nazarian, contains a user's manual for a computer program called CALIBRAT, for use by the Texas State Department of Highways and Public Transportation, August, 1990.

Research Report 913-1F, Volume 4, "Appendices and Supporting Data," by Vivek Tandon and Soheil Nazarian, for use by the Texas State Department of Highways and Public Transportation, August, 1990.

## SUMMARY

A software was developed for a Compaq Portable 386™ computer, manufactured by Compaq Computer Corporation. The computer program is capable of: 1) controlling the acquisition and retrieval of the analog data captured by the sensors; 2) reducing the collected data and 3) displaying and analyzing the raw and reduced data. The program provides software-controlled initialization and identification of the A/D board and facilitates the collection of data using Direct Memory Access (DMA). The acquired data are stored in a file for further processing. The program can be used in two modes: 1) the data are collected through the board and processed or 2) previously collected data are reduced.

The software is preprogrammed for calibration of either the dynaflect or the FWD device. In order to make the system flexible, a third option is provided. With this option, any other type of sensor under either a steady-state sinusoidal load or an impulse load can be calibrated. If this option is selected, a table containing variables that can be varied as well as default values for these variables will appear on the screen. The variables consist of a number of channels used for collection of data, the type of sensor used with each channel, the calibration properties of each sensors, the time span for collection of data and the number of data points per channel. The default values can also be read from a file previously saved.

## IMPLEMENTATION STATEMENT

The software can be immediately used for the purpose of calibrating the eleven FWD devices owned and operated by the SDHPT.

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# COMPUTER PROGRAM CALIBRAT

## 1. INTRODUCTION

Program CALIBRAT is an interactive program coded for the purpose of calibrating nondestructive testing devices. The program had been developed to control the acquisition, digitization and retrieval of analog data produced by the calibration sensors, to reduce the collected data and to present the data. The program provides software-controlled initialization and identification of the analog-to-digital conversion (A/D) board and facilitates the collection of data using Direct Memory Access (DMA).

This program is coded for an IBM compatible computer equipped with a DT 2825 A/D board, manufactured by Data Translation, Inc. The program is written in FORTRAN and compiled with Microsoft Version 4.1 FORTRAN compiler. In addition, two graphics libraries also required.

## 2. INITIAL PREPARATION

The following equipments are needed for executing the calibration program:

- 1) IBM PC or Compatible
- 2) Dos 3.3 (Compaq) or later versions
- 3) Microsoft FORTRAN Compiler (Version 4.1)
- 4) ATLAB Software by Data Translation, Inc. (Version 1.11)
- 5) PLOTIT Graphics Software
- 6) Floating point math coprocessor (80387)
- 7) Signal Conditioning unit
- 8) Two well-calibrated geophones
- 9) Three or Two (Depending on the device ) load cells and power amplifiers for load cells.
- 10) Triggering mechanism (only for calibration of the FWD device).
- 11) Proper connectors for geophones and load cells.

For compiling the calibration program, the following files and libraries are needed:

- 1) ATLAB.LIB developed by Data Translation, Inc.(Version 1.11)
- 2) DIG.LIB and VIG.LIB graphics library
- 3) Microsoft FORTRAN (Version 4.1) Libraries.
- 4) ATLDEFS.FOR (The file has information about the board and the board is initialized and identified by the definitions available in this file.)
- 5) ATLERRS.FOR (the errors detected by the board are displayed on the screen with the help of this file.)
- 6) CALIBRAT.FOR (this program)
- 7) CALIBRAT.BAT (this file is used to compile the program and is included in Appendix A).

For compiling the program, the COMPILE command should be typed at the DOS prompt.

### 3. EXECUTION OF PROGRAM

The program can be started by typing "CALIBRAT" at the DOS prompt. The execution of the program is described in the following steps:

**STEP 1:** The following message will appear on the screen:

**WELCOME  
to  
CALIBRATION  
PROGRAM**

*PRESS ENTER TO CONTINUE*

At this point user should use the enter key to proceed.

**STEP 2:** The following message will appear on the screen:

*TO STOP EXECUTION AT ANY TIME, PLEASE ENTER -99  
PLEASE CHOOSE ONE OPTION  
<C> COLLECT AND REDUCE DATA  
<R> REDUCE COLLECTED DATA*

One of the two options should be selected. If Option C is selected, the program will resume to the next step. However, if Option R is selected, the program will skip Steps 3 through 12.

**STEP 3:** The type of machine needed to be calibrated can be selected by answering the following question:

*WHICH DEVICE DO YOU WANT TO CALIBRATE ?  
<1> FOR DYNAFLECT  
<2> FOR FWD  
<3> FOR OTHERS*

Option 1, selects the default values suitable for the calibration of the Dynaflect device. While option 2, selects the default values suitable for the calibration of the FWD device. If Option 1 or 2 is selected, Steps 4 and 5 will be skipped. However, if Option 3 is selected, Steps 4 and 5 will appear. The default values for Option 3 (Others) are similar to that of the FWD device.

**STEP 4:** The following question will appear on the screen :

*WOULD YOU LIKE TO HAVE EXTERNAL TRIGGER (Y/N)?*

If Y is selected, the A/D board will be activated using the external trigger provided by the SCU for data collection; otherwise, if N is selected, the data collection process will start immediately (See Step 11).

**STEP 5:** The nature of load applied to the pavement is defined in response to the following question:

*PLEASE ENTER THE TYPE OF LOAD IMPARTED*

*<1> STEADY STATE SINUSOIDAL LOADING*

*<2> IMPULSE LOADING*

If option 1 is selected, the imparted load by the device will be assumed to be sinusoidal. Conversely, if Option 2 is selected, the load will be assumed to be an impulse loading. Once the type of load is selected, the default values used by the program will be shown on the screen. The default values can be seen in Table 1. Basically, the total number of channels, number of geophones, number of load cells are set based upon the calibration system developed. If any other sensors are utilized, the user can add these sensors to the configuration. The identification code of the load cells and geophones are used to distinguish different sensors. It is important to note that Identification Codes of G1, G2, L1, L2, L3 are reserved. Identification codes G1 and G2 correspond to the two well-calibrated geophones provided by the calibration system. The calibration characteristics of these five sensors are internally stored in the program. If any other Identification Codes are used, the program will inquire about the calibration characteristics of the sensor. The time span and number of data points can be changed as needed. However, the user is discouraged from changing these values for Options 1 and 2.

**STEP 6:** The next question can be used to change the default values.

*DO YOU WANT TO CHANGE DEFAULT VALUES (Y/N) ?*

Due to a negative response the execution of the program will resume from Step 10. However, the selection of Y will give the message described in the next step.

**STEP 7:** This question will appear:

*DO YOU WANT TO READ DEFAULT VALUES FROM A FILE (Y/N)?*

This option will allow the user to read the default values from a file previously stored by the program. Then the following message will appear on the screen, if the response to the previous question is "Y":

*INPUT THE NAME OF INPUT FILE*

The filename should not be longer than eight characters and the extension of the filename should not be more than three characters.

Table 1. Default Values for Dynaflect and FWD Devices.

Item	Dynaflect	Falling Weight Deflectometer
Total Number of Channels	4	5
Number of Geophones	2	2
Number of Load Cells	2	3
Number of Other Sensors	0	0
Geophones Connected to	Channels 1 and 2	Channels 1 and 2
Load Cells Connected to	Channels 3 and 4	Channels 3, 4 and 5
ID of Geophones	G1 and G2	G1 and G2
ID of Load Cells	L1, L2	L1, L2 and L3
Time Spans (Sec)	1.000	0.125
Number of Data Points	256	256

\* The default values of other devices are similar to the Dynaflect Device.

\*\* Note that these identification codes are reserved for well calibrated sensors used in the system. (see step 5)

**STEP 8:** In this step, facilities for changing the default values are provided. The question is:

*WHAT VALUES DO YOU WANT TO CHANGE*

*<T>OTAL NUMBER OF CHANNELS*

*<D>ESCRPTION OF CHANNELS*

*<S>TIME SPAN FOR COLLECTING DATA*

*<N>UMBER OF DATA POINTS*

*<A>LL VALUES*

If Option 1 or 2 was selected in Step 3, the first two items cannot be changed. Depending on the option selected, one or all of Steps 9A through 9E may appear. If "T" is selected Step 9A will appear. In general, the number and nature of channels and sensors used are defined. If "D" is selected, the user will be able to change the identification codes of different channels as described in Step 9B. Once again, it should be mentioned that unless one of the five reserved Identification Codes are used, the program will inquire about the calibration characteristics of the sensor. Step 9C will appear if Option "S" is selected so that the sampling period can be varied. Should the number of data points per record be changed, Option N should be selected. Step 9D will appear as the result of selecting this option.

**STEP 9A:** The following messages will appear on the screen, if Option T is selected

*ENTER NUMBER OF GEOPHONES =*

*ENTER NUMBER OF LOAD CELLS =*

*ENTER NUMBER OF OTHER DEVICES =*

The computer program will activate the number of channels of A/D board depending upon the total number of channels selected. The program will resume from the next step.

**STEP 9B:** The following questions will be asked if Option "D" or "T" is selected

*ENTER CHANNEL NAME (20 CHAR MAX)*

*ENTER DESIRED GAIN [1,10]:*

*ENTER DESIRED CHANNEL FOR GEOPHONE NUMBER 1*

The first question will change according to the selected sensor. For example if load cell is selected instead of geophones, then the program will ask to enter the desired channel for load cell 1. The second question requests information about whether the data collected by the board needs to be multiplied by that factor. The third question requests to give some name for identification. These messages will appear for all the channels selected for collection of data.

After above three questions are answered, the program will resume and ask about the

calibration factors for each sensors. Depending on the type sensor selected the program will request the identification codes for each channel

*ENTER THE ID OF GEOPHONE NUMBER 1 (3 CHAR MAX)*

*ENTER THE ID OF LOAD CELL NUMBER 1 (3 CHAR MAX)*

If the entered ID of the geophone is G1 or G2 and ID of the load cells are L1, L2 and L3, the program will skip the next step. Otherwise, the program will ask for the natural frequency, damping ratio and transductivity of each geophone and the calibration factor for each load cell as shown:

*ENTER THE NATURAL FREQUENCY IN Hz FOR GEOPHONE G3*

*ENTER THE DAMPING RATIO IN DECIMAL FOR GEOPHONE G3*

*ENTER THE TRANSDUCTIVITY FOR GEOPHONE G3 VOLTS/in/Sec*

*ENTER THE CALIBRATION FACTOR IN lbs/Volts FOR LCEL4*

However, if the selected sensor is other than the geophone or load cell, the program is capable of only considering a constant calibration factor.

**STEP 9C:** The next message will appear on the screen, if Option S is selected in Step 8.

*ENTER TIME SPAN FOR COLLECTING DATA (Sec) =*

This option allows the user to change the time span for collecting the data. For FWD device, the time span is 0.125 mSec and for Dynaflect device, the time span is 1.0 Sec. However, the program is not capable of collecting data for more than 1.0 Sec due to limitations of the A/D board.

**STEP 9D:** The following message will appear on the screen

*ENTER THE DESIRED NO OF DATA POINTS PER CHANNEL*

*[256,512,1024]*

The number of data points per channel to be collected can be changed using this option. However, the maximum limit is 1024 data points per channel. The Option A of Step 8 will ask the questions of Step 9A through Step 9D. However, the Option T and D of Step 8 are not available if Option 1 or 2 of Step 3 was selected.

**STEP 10:** After changing the default values, the following message will appear on the screen:

*DO YOU WANT TO CHANGE THE DEFAULT VALUES (Y/N) ?*

If the answer to the above question is Y, the program will go back to Step 8. However, if the answer is N, the program will proceed.

**STEP 11:** The following message will appear on the screen

*NOW BOARD IS READY TO COLLECT DATA  
INPUT THE NAME OF OUTPUT FILE*

The filename should not be longer than eight characters and the extension of the filename should not be more than three characters ( the file is straight binary file). The content of the file will be the selected test conditions and the data collected by the board.

After the data file has been selected, the program is ready to collect the data through the A/D board.

**STEP 12:** The following message will appear on the screen

*HIT ENTER TO BEGIN ACQUISITION*

When no external trigger is used, as soon as the enter key is depressed the data acquisition will start. However, if the external trigger is used, the data acquisition will start as soon as the triggering level is satisfied. The following message appears on the screen:

*PLEASE WAIT WHILE DATA IS COLLECTED....*

**STEP 13:** If Option R is selected in Step 1, then the program will skip all these steps and asks the following question:

*ENTER THE INPUT FILENAME*

The filename should not be longer than eight characters and the extension of the filename should not be more than three characters. The program will read the data from the specified file and will display the test set-up.

**STEP 14:** In this step the data will be reduced. The following message will appear on the screen:

*PRESS ENTER TO CONTINUE*

The program will reduce the data and will show on the screen the final deflection and load values obtained from the geophones and load cells.

**STEP 15:** The following messages will appear on the screen giving the information about how to use the cursor in the plot option.

*PRESS ENTER TO CONTINUE*

*!!!!!!!!!!!! HOW TO USE THE CURSOR !!!!!!!!!!!!!!!*

*THIS PROGRAM HAS A CURSOR TO FIND THE COORDINATES OF ANY POINT ON THE GRAPH*

- 1) CHOOSE ONE OF THE PLOT OPTIONS*
- 2) HIT ENTER TO INITIALIZE THE CURSOR*
- 3) USE CURSOR KEYS TO MOVE AROUND THE GRAPH*
- 4) HIT ENTER TO GET THE COORDINATES*
- 5) HIT ENTER TO RETURN TO PLOT OPTION MENU*

*IN CASE YOU DON'T WANT TO USE THE CURSOR, HIT ENTER THREE TIMES TO RETURN TO PLOT OPTION MENU.*

For example for a four channel set-up the following statements will appear

*PRESS ENTER TO CONTINUE*

*PLEASE ENTER THE PLOT OPTION*

- <1> RAW DATA OF CHANNEL NUMBER 1*
- <2> RAW DATA OF CHANNEL NUMBER 2*
- <3> RAW DATA OF CHANNEL NUMBER 3*
- <4> RAW DATA OF CHANNEL NUMBER 4*
  
- <5> REDUCED DATA OF CHANNEL NUMBER 1*
- <6> REDUCED DATA OF CHANNEL NUMBER 2*
- <7> REDUCED DATA OF CHANNEL NUMBER 3*
- <8> REDUCED DATA OF CHANNEL NUMBER 4*
  
- <17> DEVIATION FROM AVERAGE OF EACH LOAD CELL*
- <19> CONTINUE DATA COLLECTION*
- <20> QUIT*

Options 1 through 8 are self-explanatory. Actually Options 1 to 16 are reserved for raw and reduced data. The numbers shown on the screen will vary depending on the number of channels activated. Option 17 plots the deviation of loads from average. If Option 19 is selected, the execution of the program will be returned to Step 11 while the Option 20 will stop the execution of the program.



#### 4. EXAMPLE 1

In Example 1, the calibration program is used for calibrating a FWD device. The default values and the test conditions will be shown in the next paragraph. The answers entered from the keyboard are highlighted for better understanding.

The following message will appear on the screen.

### WELCOME to CALIBRATION PROGRAM

PRESS RETURN TO CONTINUE

TO STOP EXECUTION AT ANY TIME, PLEASE ENTER -99

<CR>

PLEASE CHOOSE ONE OPTION

<C> COLLECT AND REDUCE DATA

<R> REDUCE COLLECTED DATA

C

WHICH DEVICE DO YOU WANT TO CALIBRATE ?

<1> FOR DYNAFLECT

<2> FOR FWD

<3> FOR OTHERS

2

```

*****
*****THE DEFAULT VALUES ARE:*****
*****

```

```

TOTAL NUMBER OF CHANNELS      = 5
NUMBER OF GEOPHONE             = 2
NUMBER OF LOAD CELLS           = 3
NUMBER OF OTHER DEVICE         = 0

```

#### CHANNEL DESCRIPTION

CHANNEL	GAIN	ID	NAME
1	1	G1	GEO 1
2	1	G2	GEO 2
3	1	L1	LCEL 1
4	1	L2	LCEL 2
5	1	L3	LCEL 3

TIME SPAN FOR COLLECTING DATA (SECONDS) = .1250

DATA POINTS PER CHANNEL = 256

10

DO YOU WANT TO CHANGE DEFAULT VALUES (Y/N)?

Y

DO YOU WANT TO READ DEFAULT VALUES FROM A FILE (Y/N)?

N

WHAT VALUES DO YOU WANT TO CHANGE

<S>TIME SPAN FOR COLLECTING DATA

<N>UMBER OF DATA POINTS

<A>LL VALUES

A

FOR FWD DEVICE, TIME SPAN SHOULD BE =0.125 Sec.

DO YOU STILL WANT TO CHANGE IT (Y/N)?

Y

THE TIME SPAN SHOULD BE IN MULTIPLES OF 0.125 Sec.

ENTER TIME SPAN FOR COLLECTING DATA (Sec)=

0.250

ENTER THE DESIRED NO OF DATA POINTS PER CHANNEL

[256,512,1024]:

512

```

*****
*****THE NEW VALUES ARE *****
*****

```

TOTAL NUMBER OF CHANNELS= 5  
 NUMBER OF GEOPHONES= 2  
 NUMBER OF LOAD CELLS= 3  
 NUMBER OF OTHER DEVICES= 0

CHANNEL DESCRIPTION

CHANNEL	GAIN	ID	NAME
1	1	G1	GEO 1
2	1	G2	GEO 2
3	1	L1	LCEL 1
4	1	L2	LCEL 2
5	1	L3	LCEL 3

TIME SPAN FOR COLLECTING DATA (SECONDS)=.250

DATA POINTS PER CHANNEL =512

DO YOU WANT TO CHANGE DEFAULT VALUES (Y/N)?

N

DO YOU LIKE TO SAVE CHANGED VALUES IN A FILE(Y/N)

Y

INPUT FILE NAME FOR NEW DEFAULT VALUES

TEMP.DAT

TEMP.DAT ALREADY EXISTS. DO YOU WANT TO OVERWRITE? (Y/N)

Y

NOW BOARD IS READY TO COLLECT THE DATA

INPUT THE NAME OF OUTPUT FILE

TEMP

TEMP ALREADY EXISTS. DO YOU WANT TO OVERWRITE? (Y/N)

N

INPUT THE NAME OF OUTPUT FILE

TEMP1

HIT ENTER TO BEGIN ACQUISITION

&lt;CR&gt;

PLEASE WAIT WHILE DATA IS COLLECTED.....

```

.....
DATE ON WHICH DATA COLLECTED:- 05:08:1990
.....

```

```

TOTAL NUMBER OF CHANNELS=          5
NUMBER OF GEOPHONES=              2
NUMBER OF LOAD CELLS=              3
NUMBER OF OTHER DEVICES=          0

```

## CHANNEL DESCRIPTION

CHANNEL	GAIN	ID	NAME
1	1	G1	GEO 1
2	1	G2	GEO 2
3	1	L1	LCCEL 1
4	1	L2	LCCEL 2
5	1	L3	LCCEL 3

```

.....
TIME SPAN FOR COLLECTING DATA (SECONDS) =.250
DATA POINTS PER CHANNEL =512
.....

```

PRESS ENTER TO CONTINUE

&lt;CR&gt;

DEFLECTION FROM GEOPHONE G1 27.29 MILS (PEAK)

DEFLECTION FROM GEOPHONE G3 18.29 MILS (PEAK)

LOAD FROM LOAD CELL L1 2345 lbs

LOAD FROM LOAD CELL L2 1800 lbs

LOAD FROM LOAD CELL L3 2400 lbs

PRESS ENTER TO CONTINUE

!!!!!!!!!!!! HOW TO USE THE CURSOR !!!!!!!!!!!!!!!

THIS PROGRAM HAS A CURSOR TO FIND THE COORDINATES OF ANY POINT ON THE GRAPH

- 1) CHOOSE ONE OF THE PLOT OPTIONS
- 2) HIT ENTER TO INITIALIZE THE CURSOR
- 3) USE CURSOR KEYS TO MOVE AROUND THE GRAPH
- 4) HIT ENTER TO GET THE COORDINATES
- 5) HIT ENTER TO RETURN TO PLOT OPTION MENU

IN CASE YOU DON'T WANT TO USE CURSOR, HIT ENTER  
THREE TIMES TO RETURN TO PLOT OPTION MENU.

PRESS ENTER TO CONTINUE

PLEASE ENTER THE PLOT OPTION

- < 1> RAW DATA OF CHANNEL NUMBER 1
- < 2> RAW DATA OF CHANNEL NUMBER 2
- < 3> RAW DATA OF CHANNEL NUMBER 3
- < 4> RAW DATA OF CHANNEL NUMBER 4
- < 5> RAW DATA OF CHANNEL NUMBER 5
  
- < 6> REDUCED DATA OF CHANNEL NUMBER 1.
- < 7> REDUCED DATA OF CHANNEL NUMBER 2
- < 8> REDUCED DATA OF CHANNEL NUMBER 3
- < 9> REDUCED DATA OF CHANNEL NUMBER 4
- <10> REDUCED DATA OF CHANNEL NUMBER 5
  
- <17> DEVIATION FROM AVERAGE OF EACH LOAD CELL
- <19> CONTINUE COLLECTION OF DATA
- <20> QUIT

If Option 1 is selected, a graph similar to one shown in Figure 1 will appear on the screen. In this figure, the raw velocity obtained from the geophone is shown. The Option 6 will show the plot on the screen as shown in Figure 2. In this figure, deflection obtained from the geophone is shown. Options 8, 9 and 10 will result in graphs on the screen similar to that shown in Figure 3. Options 3, 4 and 5 will also show the similar graph with only one difference, the graph will show the raw voltage obtained from the load cell. Option 17 will result in a graph similar to Figure 4.

Finally, a data file will be obtained consisting of the test conditions used for testing and data obtained from the sensors. For this example, this file will be called TEMP1 (See Step 11). This file can be utilized for future reference.

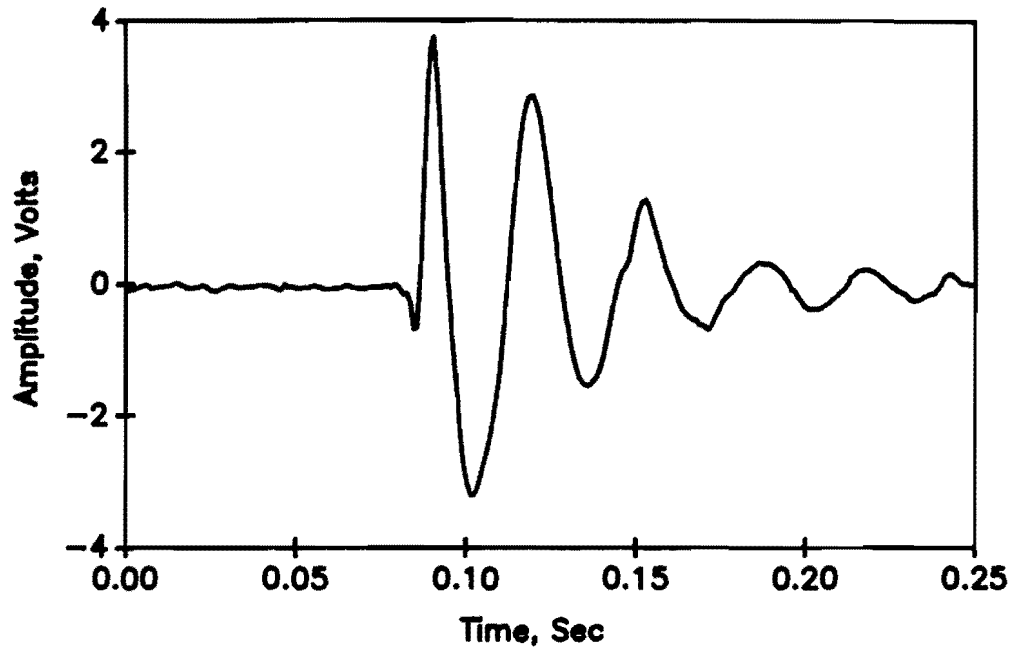


Figure 1. Example of Raw Data Obtained from a Geophone.

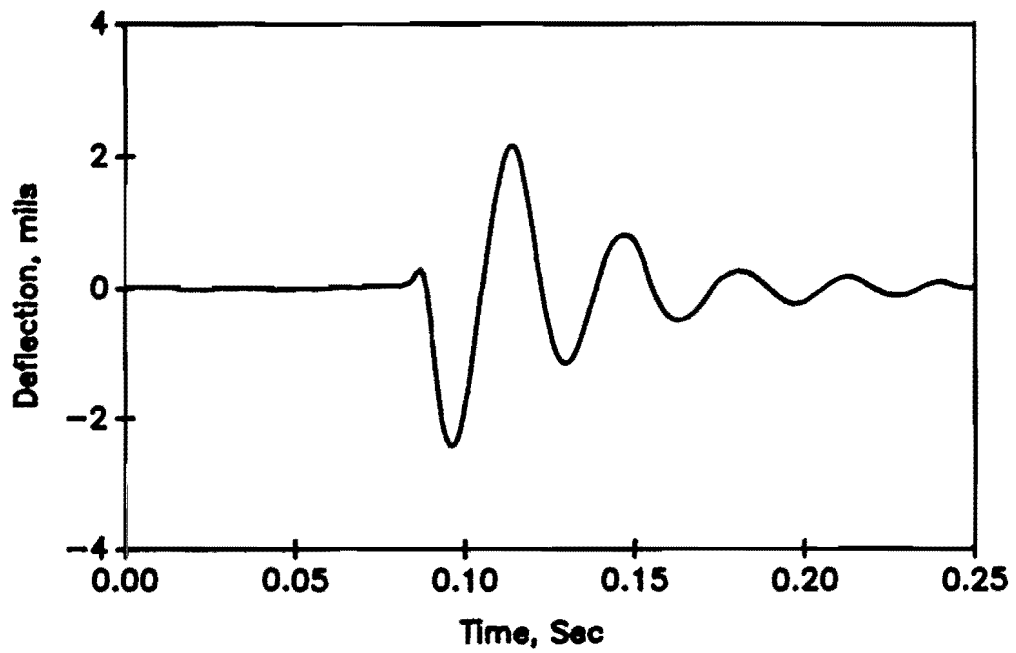


Figure 2. Example of Deflection Obtained from a Geophone.

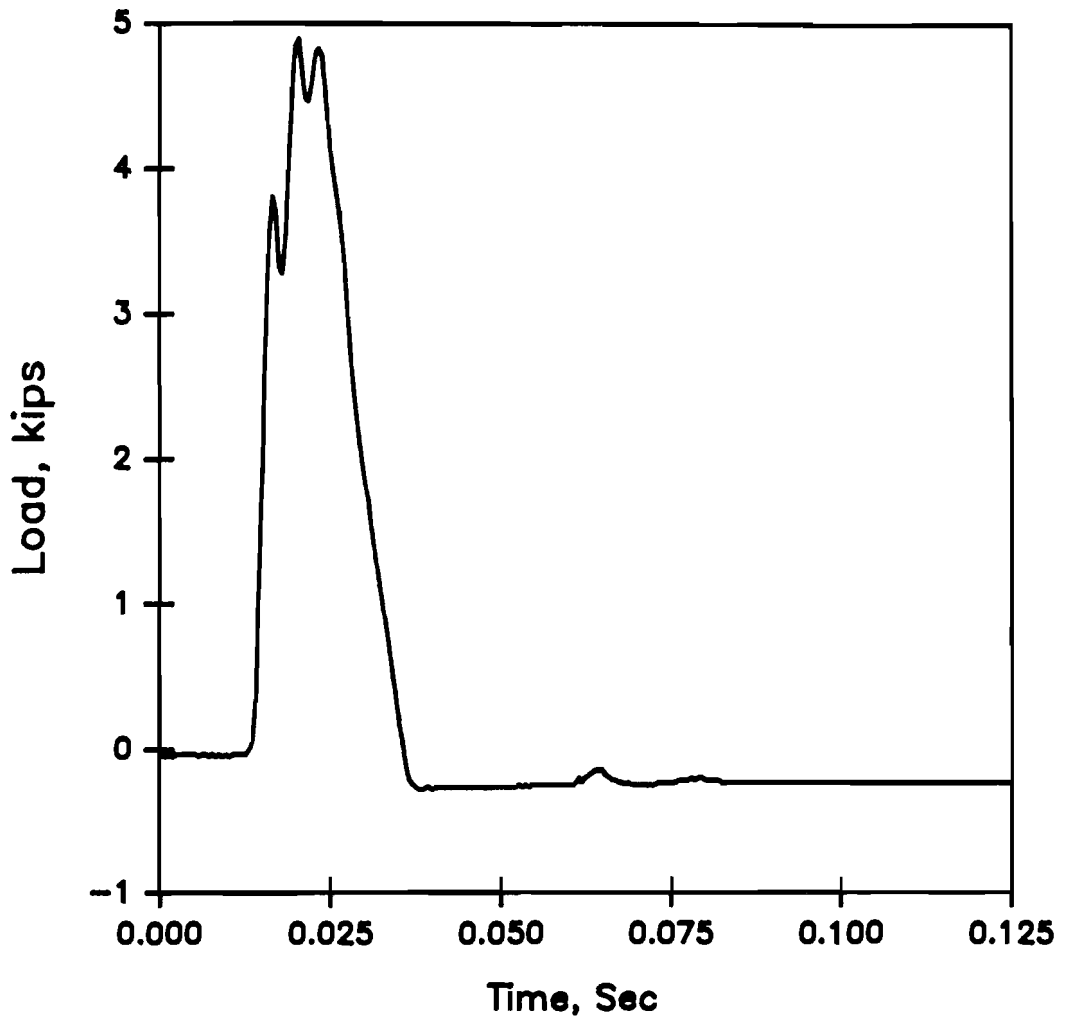


Figure 3. Example of Load Obtained from Load Cells.

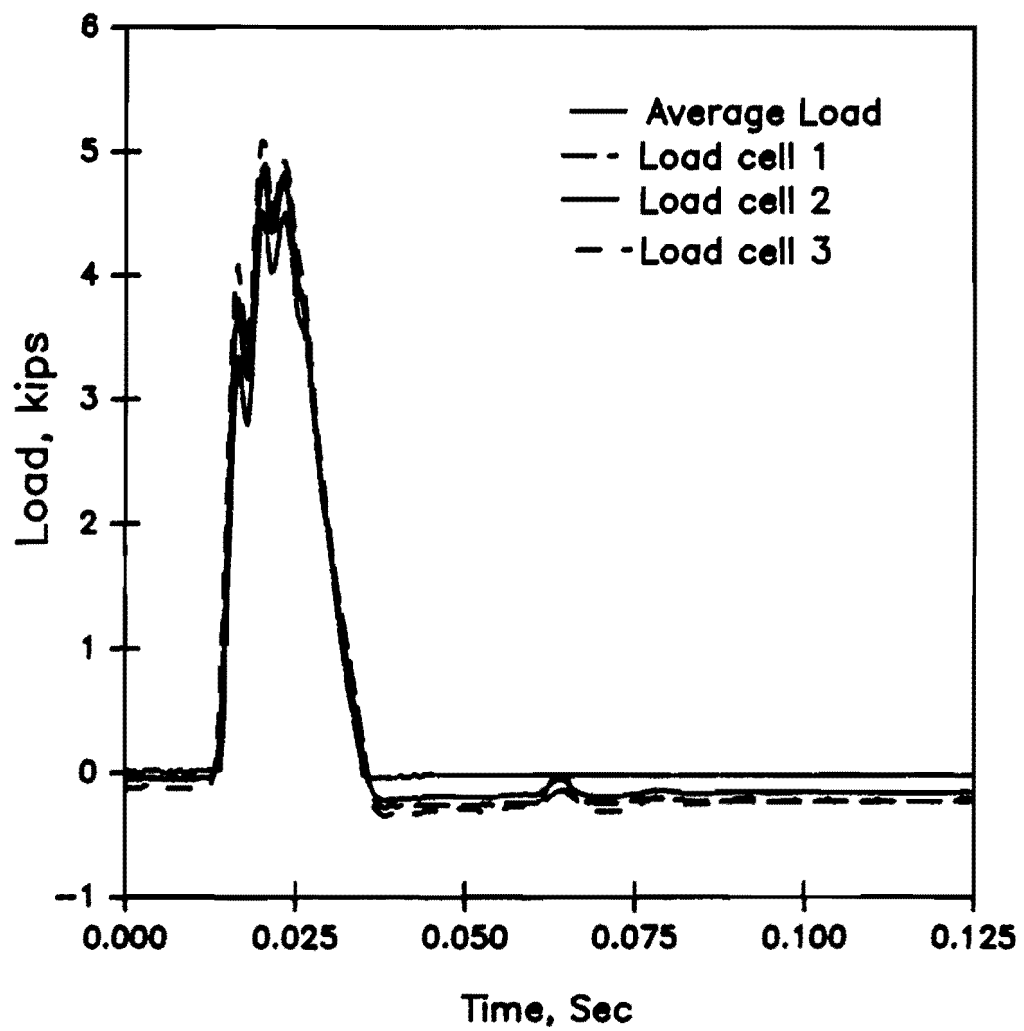


Figure 4. Example of Average Load Compared with Individual Load Cells.

## 5. EXAMPLE 2

This example is selected to show how the devices other than the Dynaflect and FWD can be calibrated. The program can be started as described in Section 1.3. The following message will appear on the screen:

### WELCOME to CALIBRATION PROGRAM

PRESS RETURN TO CONTINUE

TO STOP EXECUTION AT ANY TIME, PLEASE ENTER -99

<CR>

PLEASE CHOOSE ONE OPTION

<C> COLLECT AND REDUCE DATA

<R> REDUCE COLLECTED DATA

C

WHICH DEVICE DO YOU WANT TO CALIBRATE ?

<1> FOR DYNAFLECT

<2> FOR FWD

<3> FOR OTHERS

3

WOULD YOU LIKE TO HAVE EXTERNAL TRIGGER (Y/N)?

Y

PLEASE ENTER THE TYPE OF LOAD IMPARTED

<1> STEADY STATE SINUSOIDAL LOADING

<2> IMPULSE LOADING

1

```

*****
*****THE DEFAULT VALUES ARE:*****
*****

```

```

TOTAL NUMBER OF CHANNELS=      5
NUMBER OF GEOPHONES=           2
NUMBER OF LOAD CELLS=          3
NUMBER OF OTHER DEVICES=       0

```

#### CHANNEL DESCRIPTION

CHANNEL	GAIN	ID	NAME
1	1	G1	GEO 1
2	1	G2	GEO 2
3	1	L1	LCEL 1
4	1	L2	LCEL 2
5	1	L3	LCEL 3



TIME SPAN FOR COLLECTING DATA (SECONDS)      =.1250  
 DATA POINTS PER CHANNEL                      =256  
 DO YOU WANT TO CHANGE DEFAULT VALUES (Y/N)?  
 Y  
 DO YOU WANT TO READ DEFAULT VALUES FROM A FILE (Y/N)?  
 N  
 WHAT VALUES DO YOU WANT TO CHANGE  
 <T>OTAL NUMBER OF CHANNELS  
 <D>ESCRIPTION OF CHANNELS  
 <S>TIME SPAN FOR COLLECTING DATA  
 <N>UMBER OF DATA POINTS  
 <A>LL VALUES  
 A  
 ENTER NUMBER OF GEOPHONES=  
 2  
 ENTER NUMBER OF LOAD CELLS=  
 1  
 ENTER NUMBER OF OTHER DEVICES=  
 1  
 ENTER DESIRED CHANNEL FOR GEOPHONE NUMBER 1  
 1  
 ENTER DESIRED GAIN [1,10]:  
 1  
 ENTER CHANNEL NAME (20 CHAR MAX)  
 GEOPHON1  
 ENTER DESIRED CHANNEL FOR GEOPHONE NUMBER 2  
 2  
 ENTER DESIRED GAIN [1,10]:  
 1  
 ENTER CHANNEL NAME (20 CHAR MAX)  
 GEOPHON2  
 ENTER DESIRED CHANNEL FOR LOAD CELL NUMBER 1  
 2  
 TWO CHANNELS ARE CONNECTED TO SAME DEVICE  
 REVISE THE CHANNEL NUMBER  
 ENTER DESIRED CHANNEL FOR LOAD CELL NUMBER 1  
 3  
 ENTER DESIRED GAIN [1,10]:  
 1  
 ENTER CHANNEL NAME (20 CHAR MAX)  
 LOAD1  
 ENTER DESIRED CHANNEL FOR OTHER DEVICE 1  
 4  
 ENTER DESIRED GAIN [1,10]:  
 1  
 ENTER CHANNEL NAME (20 CHAR MAX)  
 OTHER1  
 ENTER THE ID OF GEOPHONE NUMBER 1 (3 CHAR MAX)  
 G1  
 ENTER THE ID OF GEOPHONE NUMBER 2 (3 CHAR MAX)  
 G3

ENTER THE NATURAL FREQUENCY IN Hz FOR GEOPHONE G3  
 4.5  
 ENTER THE DAMPING RATIO IN DECIMAL FOR GEOPHONE G3  
 .7  
 ENTER THE TRANSDUCTIVITY FOR GEOPHONE G3 VOLTS/in/Sec  
 .799  
 ENTER THE ID OF LOAD CELL NUMBER 1 (3 CHAR MAX)  
 L4  
 ENTER THE CALIBRATION FACTOR IN mV/lbs FOR L4  
 2345.  
 ENTER THE ID OF OTHER DEVICE 1 (3 CHAR MAX)  
 O1  
 ENTER THE CALIBRATION FACTOR FOR OTHER DEVICE O1  
 5.67  
 ENTER TIME SPAN FOR COLLECTING DATA (Sec)=  
 .125  
 ENTER THE DESIRED NO OF DATA POINTS PER CHANNEL  
 [256,512,1024]  
 512

\*\*\*\*\*  
 \*\*\*\*\*THE NEW VALUES ARE \*\*\*\*\*  
 \*\*\*\*\*

TOTAL NUMBER OF CHANNELS= 4  
 NUMBER OF GEOPHONES= 2  
 NUMBER OF LOAD CELLS= 1  
 NUMBER OF OTHER DEVICES= 1

CHANNEL DESCRIPTION

CHANNEL	GAIN	ID	NAME
1	1	G1	GEOPHON1
2	1	G3	GEOPHON2
3	1	L4	LOAD1
4	1	O1	OTHER1

TIME SPAN FOR COLLECTING DATA (SECONDS)= .125

DATA POINTS PER CHANNEL = 512

DO YOU WANT TO CHANGE DEFAULT VALUES (Y/N)?

N

DO YOU LIKE TO SAVE CHANGED VALUES IN A FILE(Y/N)

Y

INPUT FILE NAME FOR NEW DEFAULT VALUES

TEMP.DAT

TEMP.DAT ALREADY EXISTS. DO YOU WANT TO OVERWRITE? (Y/N)

Y

INPUT THE NAME OF OUTPUT FILE

TEMP

TEMP ALREADY EXISTS. DO YOU WANT TO OVERWRITE? (Y/N)

N

INPUT THE NAME OF OUTPUT FILE

TEMP1

HIT ENTER TO BEGIN ACQUISITION

<CR>

PLEASE WAIT WHILE DATA IS COLLECTED.....

.....  
 DATE ON WHICH DATA COLLECTED:- 05:08:1990  
 .....

TOTAL NUMBER OF CHANNELS= 4  
 NUMBER OF GEOPHONES= 2  
 NUMBER OF LOAD CELLS= 1  
 NUMBER OF OTHER DEVICES= 1

CHANNEL DESCRIPTION

CHANNEL	GAIN	ID	NAME
1	1	G1	GEOPHON1
2	1	G3	GEOPHON2
3	1	L4	LOAD1
4	1	O1	OTHER1

.....  
 TIME SPAN FOR COLLECTING DATA (SECONDS)=.125

DATA POINTS PER CHANNEL =512

.....

PRESS ENTER TO CONTINUE

<CR>

PEAK AT FREQUENCY 15 Hz FOR GEOPHONE G1

PEAK AT FREQUENCY 10 Hz FOR GEOPHONE G3

DEFLECTION FROM GEOPHONE G1 .43 MILS (PEAK)

DEFLECTION FROM GEOPHONE G3 .56 MILS (PEAK)

LOAD FROM LOAD CELL L4 2345 lbs

OUTPUT FROM OTHER DEVICE O1 2.3 VOLTS

PRESS ENTER TO CONTINUE

<CR>

!!!!!!!!!!!! HOW TO USE THE CURSOR !!!!!!!!!!!!!!!

THIS PROGRAM HAS A CURSOR TO FIND THE COORDINATES OF ANY POINT ON THE GRAPH

- 1) CHOOSE ONE OF THE PLOT OPTIONS
- 2) HIT ENTER TO INITIALIZE THE CURSOR
- 3) USE CURSOR KEYS TO MOVE AROUND THE GRAPH

4) HIT ENTER TO GET THE COORDINATES

5) HIT ENTER TO RETURN TO PLOT OPTION MENU

IN CASE YOU DON'T WANT TO USE CURSOR, HIT ENTER

THREE TIMES TO RETURN TO PLOT OPTION MENU.

PRESS ENTER TO CONTINUE

<CR>

PLEASE ENTER THE PLOT OPTION

<1> RAW DATA OF CHANNEL NUMBER 1

<2> RAW DATA OF CHANNEL NUMBER 2

<3> RAW DATA OF CHANNEL NUMBER 3

<4> RAW DATA OF CHANNEL NUMBER 4

<5> REDUCED DATA OF CHANNEL NUMBER 1

<6> REDUCED DATA OF CHANNEL NUMBER 2

<7> REDUCED DATA OF CHANNEL NUMBER 3

<8> REDUCED DATA OF CHANNEL NUMBER 4

<17> DEVIATION FROM AVERAGE OF EACH LOAD CELL

<19> CONTINUE COLLECTION OF DATA

<20> QUIT

The selection of graph option will produce the graph for that channel on the screen.