STA PULLOUT

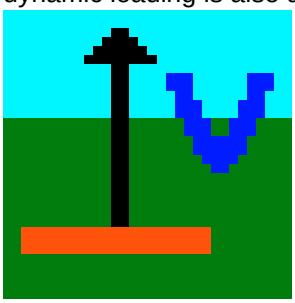
ANCHOR PLATE PULLOUT RESISTANCE

Version 1.1, January 1999

USER MANUAL

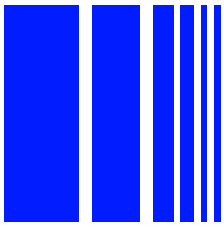
STA PULLOUT is a computer program for the design and analysis of plate anchors. The program does not consider how the plate may have been embedded. The pulling line attachment is assumed to be arranged such that the line pull is perpendicular to the plate and the pulling force is directly above the plate center of area.

STA PULLOUT permits the user to specify up to three different soil layers, each of which may have varying strength properties. The layers may be a mixture of cohesive and cohesionless soils. Primary results from the program provide the ultimate capacity of plate anchors for vertical pullout resistance. The program provides factors of safety against failure for short term and long term loading. Resistance to dynamic loading is also accounted for.



This program has been developed by Stewart Technology Associates (STA). Users of the program are cautioned to exercise experienced and careful engineering judgment when interpreting the results from STA PULLOUT. This is especially important with this program, since results can be obtained in seconds on a modern PC. This rapid speed and ease of use does not alter the care and attention needed from the user associated with selecting the appropriate geotechnical and loading conditions. The program runs in the environment of Microsoft Windows and Microsoft Excel. A mouse is used to click on option buttons in order to move rapidly through the analysis. A large number of Help screens are provided. No experience of Excel is required to use STA PULLOUT.

No part of this document should be taken in isolation or out of context and interpreted in a manner inconsistent with the overall framework and intent of this document.



STEWART TECHNOLOGY ASSOCIATES
5619 Val Verde
Houston, Texas 77057
Tel: (713) 789-8341
Fax: (713) 789-0314
e-mail: info@stewart-usa.com

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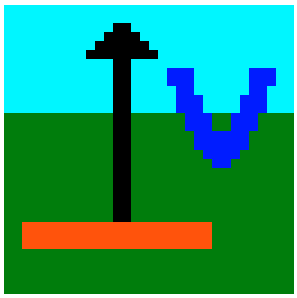
CONTENTS LIST

1.0 INTRODUCTION

STA PULLOUT is a computer program for the design and analysis of plate anchors. The program does not consider how the plate may have been embedded. The original application was developed for marine plate anchors embedded in the seabed and loaded vertically. STA PULLOUT can be used to estimate the maximum force needed to recover a drag embedment anchor. The program has also been used to solve onshore problems.

STA PULLOUT permits the user to specify up to three different soil layers, each of which may have varying strength properties. The layers may be a mixture of cohesive and cohesionless soils. Primary results from the program provide the ultimate capacity of plate anchors for vertical pullout resistance. The program provides factors of safety against failure for short term and long term loading. Resistance to dynamic loading is also accounted for.



2.0 FAILURE MECHANISM

Two general failure mechanisms are assumed by the program: shallow failure and deep failure. These failure mechanisms are illustrated in Figure 1 below.

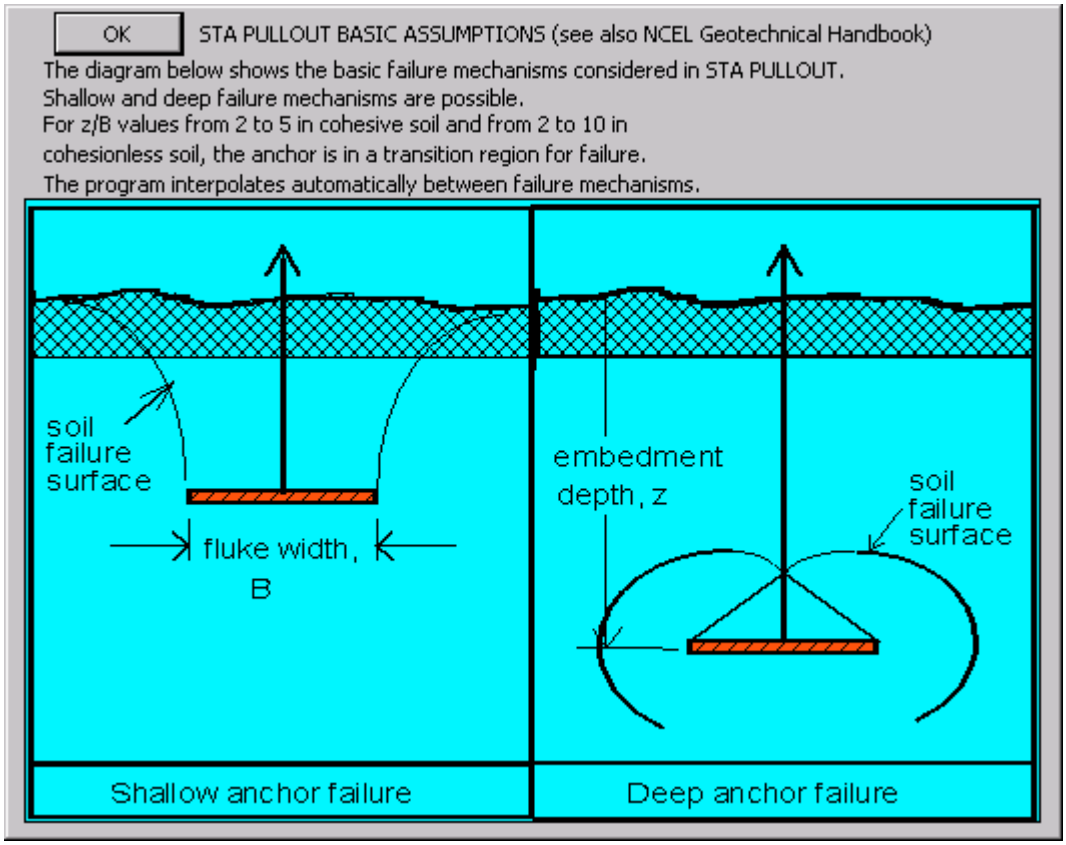


FIGURE 1

When computing plate pullout resistance, STA PULLOUT adjusts the bearing capacity factors accounting for plate geometry, plate burial depth and soil properties.

3.0 PROGRAM INSTALLATION

3.1 Introduction

STA PULLOUT is a computer program for the design and analysis of pile anchors. The latest release of the program (Version 1.5, October 1998) runs in the environment of Microsoft Excel 97, or later, under Windows 95, NT4, or later. The program is distributed as a series of Excel workbook with macro files on a single 3.5 inch floppy disk.

This section of the manual provides instructions for loading the program and setting up the Windows icon.

3.2 Install Files and Create Directories

STA PULLOUT must be set up in sub-directory on your hard disk. Before installing STA PULLOUT, you must have Excel already installed on your hard disk. You must manually set up the necessary directory and copy the files over. The manual procedure is as follows:

> *Create a sub-directory, for example, called STAPULLOUT. All files from the floppy disk should be copied into the STAPULLOUT sub-directory. You will then have a path to the program files as shown below:*
>
> ***X:**\MY_PROJECTS/STAPULLOUT/program_files*

In the example above, ***X:*** is the name of your hard disk (most likely this will be *C:* or *D:*) and the *MY_PROJECTS* directory may be where you store your projects.

3.3 Install Icon

Once the directory structure has been created and the program files have been copied from the distribution floppy diskette to the STAPULLOUT sub-directory, you can set up the icon (see your Windows documentation, or simply right-click on your desktop and be intuitive).

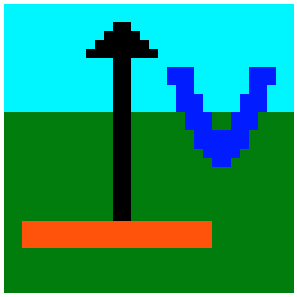
3.4 Program Files On Distribution Diskettes

Each distribution diskette for STA PULLOUT is a self-contained version of the program. The files on your diskette should be as listed below.

File Name	Description
STAPULLOUT.ICO	Icon for STA PULLOUT. The icon is displayed by Windows. Double click on the icon to start STA PULLOUT after program is installed.
STAPULLOUT.XLS	This is the main file displayed to the user by Excel. All the data input is specified in this file. All principle results are contained in this file.

Other files may be present on your diskette, and the names of some of the above files may be changed slightly on some diskettes.

The STA PULLOUT icon is shown to the right.



4.0 HARDWARE REQUIREMENTS AND PRINTING

STA PULLOUT requires an IBM PC with Microsoft Excel 67 or later, running under Microsoft Windows 95 or later environment. Program output has been customized such that it prints all principal input and output on one page as shown in Figure 2, on the following page.

For best quality print, it is recommended that a color ink jet printer be used with a minimum resolution of 300 dpi. Significantly better quality will be obtained with a dot resolution of 400 dpi or above.

True Type fonts have been used throughout the worksheet. Almost all the fonts are Arial. Many of the fonts are Arial Narrow. If you do not have these fonts on your machine, the program will select the nearest font style. It is recommended that you obtain the Arial Narrow font if it is not currently available on your system.

You may elect to print any of the output in color, for example on a HP Deskjet printer. If a color printer is used, you may have to disable certain third party fontware, such as Adobe Type Manager, in order to get color text and numbers to print. However, once your printer is set up to print any other spreadsheets from Excel, you should have no problem in printing output from STA PULLOUT.

You may have a higher resolution screen driver (than VGA, which is the minimum required for STA PULLOUT) in use on your system. This will be advantageous in that it allows you to see more of the main worksheet than you can see with a VGA driver. Most of the examples in this manual show screens with an 800 x 600 screen driver.

STA PULLOUT — Anchor Vertical Pullout Resistance

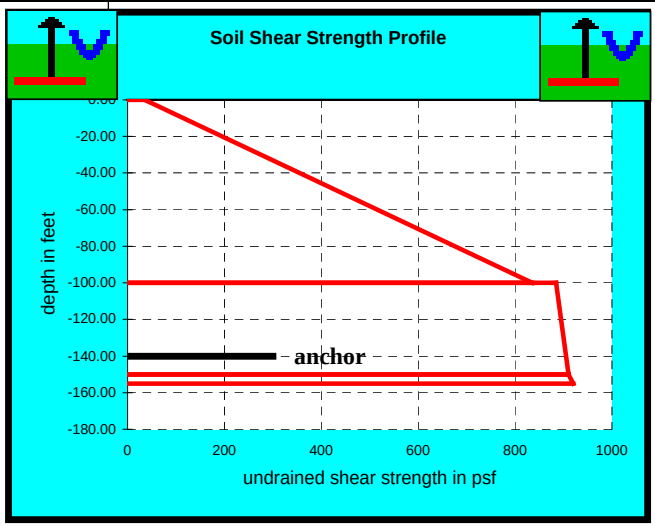
v.1.0 May 1993 | Run ref: *Example For User Manual* | 2/8/99 9:11

Assumptions | Explain | Permeability & Plasticity for Cyclic Loading | Print this screen

INPUT DATA BELOW

SOIL PROPERTIES	
100.00	Z1, thickness of upper soil layer (ft)
50.00	Z2, thickness of middle soil layer (ft)
5.00	Z3, thickness of lowest soil layer (ft)
35.00	cu1, undrained sh. strength top 1st layer (psf)
835.00	cu2, undrained sh. strength bottom 1st layer (psf)
885.00	cu3, undrained sh. strength top 2nd layer (psf)
910.00	cu4, undrained sh. strength bottom 2nd layer (psf)
910.00	cu5, undrained sh. strength top 3rd layer (psf)
920.00	cu6, undrained sh. strength bottom 3rd layer (psf)
22.00	drained friction angle 1st layer (deg)
27.00	drained friction angle 2nd layer (deg)
32.00	drained friction angle 3rd layer (deg)
35.00	Gamma1, 1st layer buoyant weight (pcf)
73.00	Gamma2, 2nd layer buoyant weight (pcf)
30.00	Gamma3, 3rd layer buoyant weight (pcf)
0	ratio of drained/undrained soil cohesion

ANCHOR PROPERTIES & ANALYSIS CONTROL			
7.00	fluke length (ft)	0.8	Strength reduction factor
7.00	fluke width (ft)	200	av.static uplift load (kips)
44.10	fluke area (sqft)	77	dynamic load double amp. (kips)
140.00	burial depth (ft)	2	1=cohesionless, 2=cohesive
12.00	storm duration (hours)	1	1=normal, 2=delta mud
12.00	av.wave period (sec)		



Results	
479	Short-term ultimate capacity (kips)
479	Long-term ultimate capacity (kips)
2.39	Static short-term safety factor
2.39	Static long-term safety factor

Holding Capacity Factors at Anchor	
15.00	Ncs short-term (calculated)
9.50	Nc long-term (calculated)
8.37	Nq cohesionless (calculated)

Dynamic Loading Parameters			
0.003	estimated soil permeability (ft/sec)	202	maximum dynamic load range for single storm (kips)
0	time reqd.for pore press.dissipation (days)	12	number of loading cycles in single storm
		2.63	dynamic load range safety factor (single storm)

FIGURE 2

5.0 RUNNING THE PROGRAM

Once you have set up the program using the instructions in Section 4.0, you will be able to click on the STAPULLOUT icon to start Excel and STA PULLOUT. The main spreadsheet (*STAPULLOUT.XLS*) will load. You may need to *maximize* the spreadsheet. Do this by clicking once on the middle symbol in the upper right hand corner of the spreadsheet as shown in the figure on the right.

The spreadsheet will always contain values in every editable cell. It is recommended that following an analysis with the program, you save the spreadsheet before closing down the application.

You may also want to set Excel calculations to automatic. You do this through the *Tools, Options*, menus.

6.0 GETTING HELP

In Figure 2, two of the buttons are labeled “Explain”. Highlight any data entry or results cell (by clicking on it once) and then click once on any “Explain” button. A dialog box will be flashed up onto the screen containing information regarding the selected cell. An example of this is shown in Figure 3. In this figure, the user has selected the input cell *strength reduction factor*. A dialog box has been brought up onto the screen describing what this input data does.

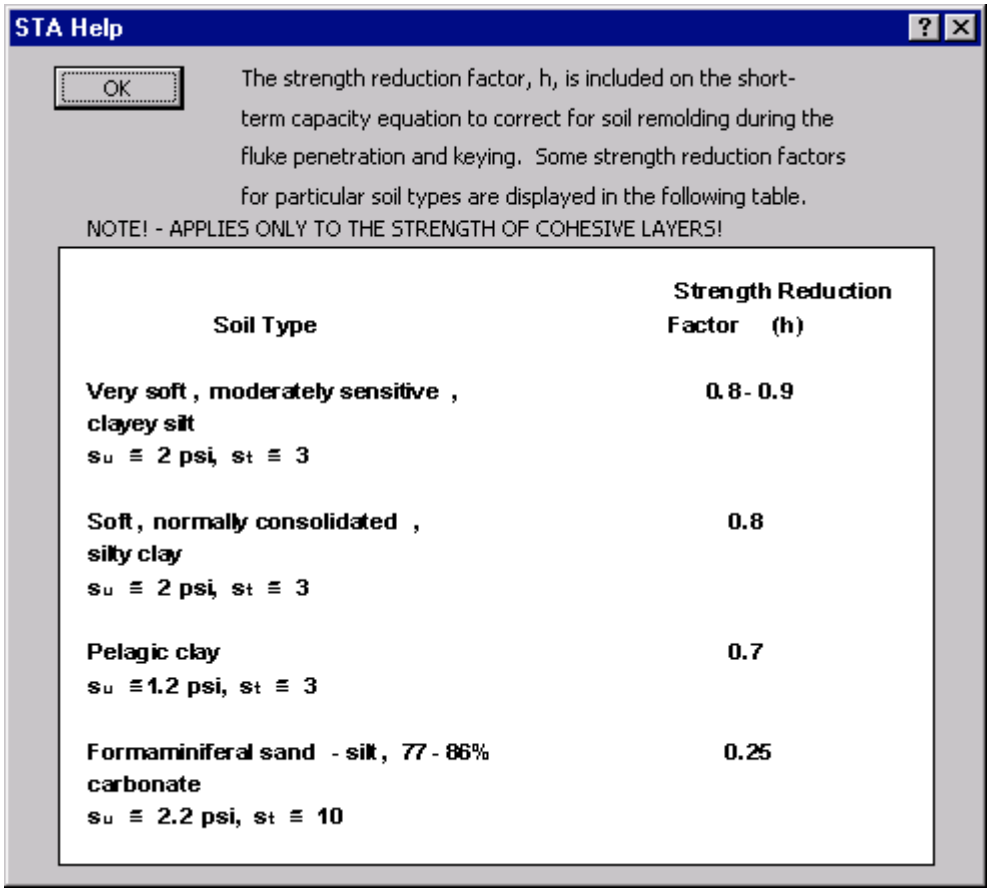


FIGURE 3

Help is also available in interpreting the results. The main summary results for an installed pile analysis are seen in the lower right hand corner of Figure 2.

If the user selects a cell for which there is no help available, a dialog box will be flashed up on the screen, suggesting that the cursor be repositioned in another cell. An example of this is shown in Figure 4.

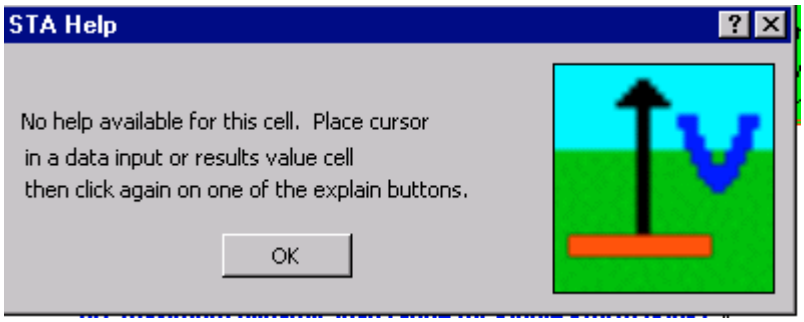

STA Help
No help available for this cell. Place cursor
in a data input or results value cell
then click again on one of the explain buttons.
OK

FIGURE 4

7.0 BASIC ANALYSIS ASSUMPTIONS

The user can be reminded of the basic analysis assumptions when running the program by clicking once on the button a*ssumptions.*

STA PULLOUT uses the geotechnical formulae and nomenclature of the NCEL Geotechnical Handbook. The user should have the Handbook at the ready when using the program, especially if the dynamic soil properties are of interest.

7.1 Permeability and Plasticity for Cyclic Loading

In accordance with the procedures in the NCEL Geotechnical Handbook, the user can select a soil characterization from the dialog box shown in Figure 5. This box appears when the button *Permeability and Plasticity for Cyclic Loading* is clicked.

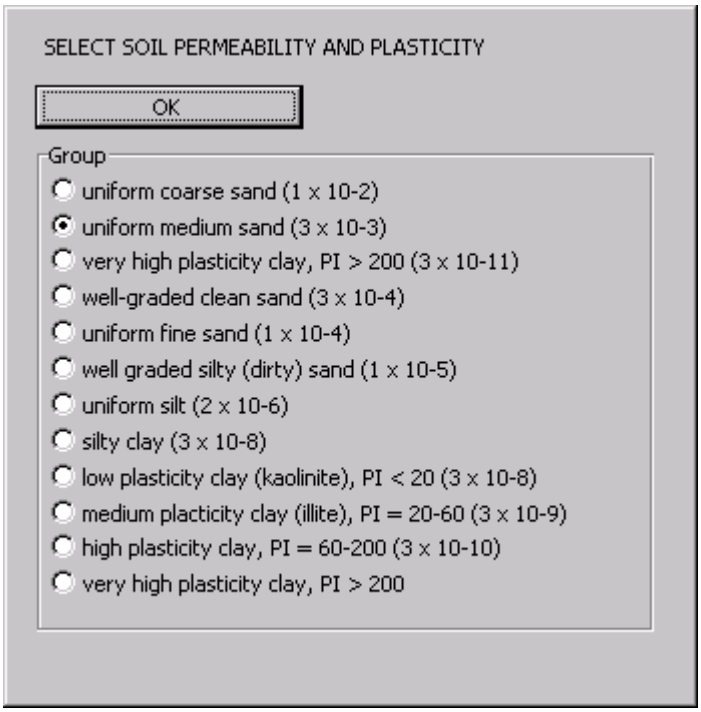


FIGURE 5

After selecting one of the soil types, click OK and the program will display the dialog box shown in Figure 6, indicating the maximum soil cyclic load capacity without causing soil loss of strength.

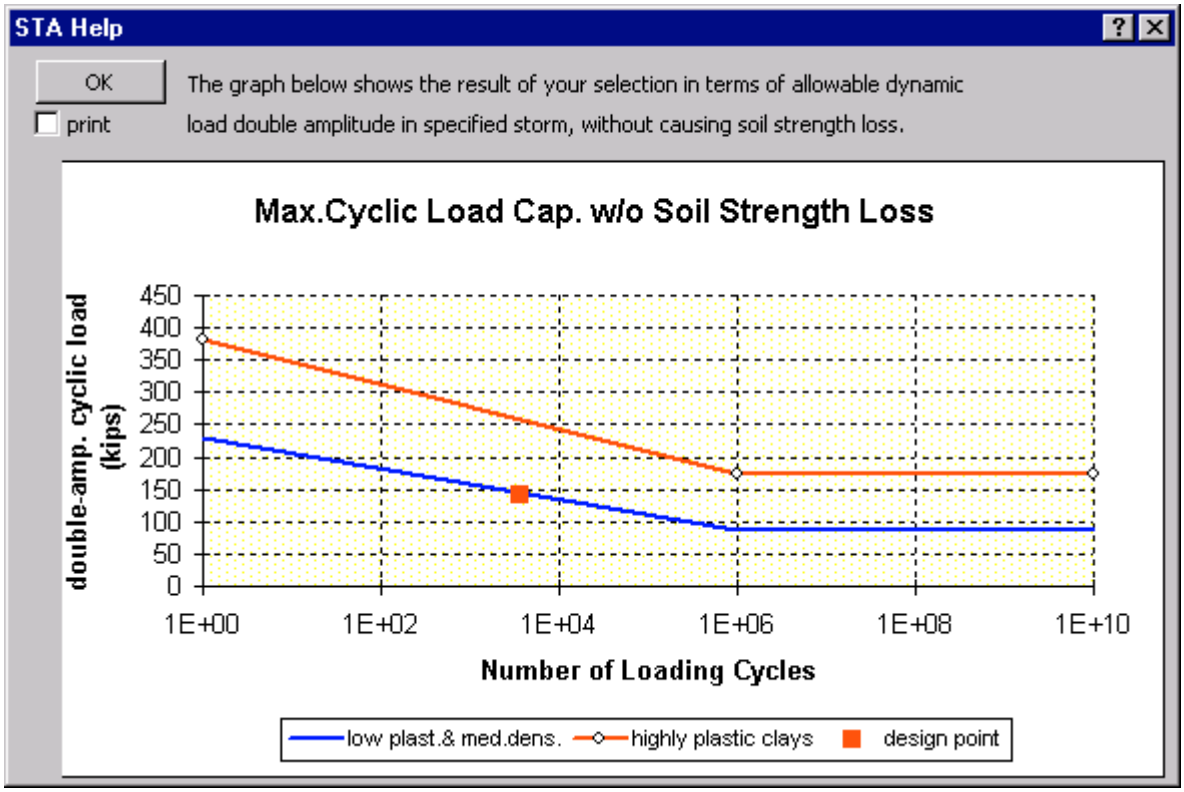


FIGURE 6

Layered Soils

Up to three soil the user in STA PULLOUT can specify layers which may be mixed cohesive and cohesionless layers. In each layer, the above equations are implemented for each elemental length of the pile. Overburden pressure is calculated for buried cohesionless layers.

8.0 RESULTS

The pullout resistance results are shown in the bottom left hand corner of Figure 2. A larger view is shown in Figures 7 and 8.

Results	
2370	Capacity in cohesionless soil (kips)
	cohesionless soil selected
11.85	Static short-term safety factor

FIGURE 7

Results	
479	Short-term ultimate capacity (kips)
479	Long-term ultimate capacity (kips)
2.39	Static short-term safety factor
2.39	Static long-term safety factor

FIGURE 8

Results in Figure 7 are for a cohesionless soil. Results in Figure 8 are for a cohesive soil.

REFERENCES

1. "Handbook For Marine Geotechnical Engineering", Technical Editor, Rocker, K. March 1985, available from Naval Civil Engineering Laboratory Port Hueneme, California 93043.

APPENDIX 1

DEFINITION OF INPUT DATA

This Appendix lists each of the input data terms that the user may edit. Note that by placing the cursor on any input data cell and clicking on the button, *EXPLAIN VALUE*, the User is presented with a dialog box containing a detailed description of the input data term. This Appendix provides a reference for each of these terms.

Z1, thickness of upper soil layer (ft)
This is the thickness of the first soil layer from the sea bed downwards. Units are feet.

Z2, thickness of middle soil layer (ft)
This is the thickness of the second soil layer beneath the seabed. Units are feet. Note that a visual check on the input data is provided in the upper diagram on the main results page for the program entitled, *Soil Shear Strength Profile*.

Z3, thickness of lowest soil layer, (ft)
This is the thickness of the lowest soil layer in the analysis. Units are feet. Note that if the plate is defined as being embedded to a depth within the sea bed beneath the bottom of this lowest soil layer, the properties for the soil at the bottom of the layer will be extended to the plate location.

Phi1, 1st layer friction angle (deg.)
This is the friction angle to be used in the analysis for cohesionless soil in the first layer. Units are degrees. If the first soil layer is cohesive, Phi1 should be specified as zero. The program will issue a warning if both cohesive and cohesionless properties are specified for any soil layer.

Phi2, 2nd layer friction angle (deg.)
This is the friction angle to be used in the analysis for the second soil layer. Comments as for Phi1 apply.

Phi3, 3rd layer friction angle (deg.)
This is the third layer friction angle. Comments as for Phi1 apply.

cu1, undrained sh. strength top 1st layer (psf)
This is the UNDISTURBED undrained shear strength for the soil at the top of the first layer, in other words, at the seabed. Units are in pounds force per square foot.

cu2, undrained sh. strength bottom 1st layer (psf)
This is the UNDISTURBED undrained shear strength for the soil at the bottom of the first layer, in other words, at the seabed. Units are in pounds force per square foot. The undrained shear strength is considered to vary in a linear manner between the top and bottom of each layer.

cu3, undrained sh. strength top 2nd layer (psf)
This is the undrained shear strength for the soil at the top of the second layer, in other words, at the seabed. Units are in pounds force per square foot.

cu4, undrained sh. strength bottom 2nd layer (psf)
Comments as for cu2 apply.

cu5, undrained sh. strength top 3rd layer (psf)
Comments as for cu1 apply.

cu6, undrained sh. strength bottom 3rd layer (psf)
Comments as for cu2 apply. Note that if the pile is specified as being embedded with its bottom beneath the third soil layer, the soil strength and weight parameters at the bottom of the third layer will be continued downwards.

Gamma1, 1st layer buoyant weight (pcf)
This is the submerged, or buoyant weight of the soil in the first layer. Units are in pounds per cubic foot.

Gamma2, 2nd layer buoyant weight (pcf)
This is the submerged, or buoyant weight of the soil in the second layer. Units are in pounds per cubic foot.

Gamma3, 3rd layer buoyant weight (pcf)
This is the submerged, or buoyant weight of the soil in the third layer. Units are in pounds per cubic foot.

fluke length (ft)
This is the maximum length of the plate

fluke width (ft)
This is the maximum width of the plate

Fluke area (sqft)
This is the actual area of the plate and does not have to be equal to the length times the width as the plate does not have to be rectangular.

Burial Depth (ft)
The depth beneath the seabed where the plate is located. If a keying operation is to take place, as with a driven plate anchor, this should be the depth after keying.

Storm duration (hours)
If dynamic information on plate behavior is required, this is the duration of a “design” storm.

Av.wave period (sec)
If dynamic information on plate behavior is required, this is average period of the waves in the design storm and can be set equal to the average zero-crossing period.

Strength reduction factor
This term is used to multiply the undisturbed undrained shear strength of each layer. A reduction factor of 0.5 means that the actual undrained strength of the soil used in resistance and pullout calculations will be 50% of that input by the User. A reduction factor of 0.75 means that the actual undrained shear strength of the soil will be 75% of that specified by the User.

Av.static uplift load (kips)
This is the design load required by the user. If dynamic loads are also considered, this should be the average load, normally equal to the static component only.

Dynamic load double amp. (kips)
If dynamic loading is considered this should generally be equal to the significant load in a storm. More conservatively, it can be set equal to the maximum anticipated load.

1=cohesionless, 2=cohesive
This is a switch that must be set by the user. If all layers are cohesionless select 1. Otherwise select 2 and use the long-term pullout resistance results if the plate is in a cohesionless layer.

1=normal, 2=delta mud
This is a switch that must be set by the user. The switch function is explained below.