SNAILZ

NOTE: THIS PROGRAM WILL BE PERIODICALLY UPDATED UNTIL ALL OPTIONS ARE COMPLETED. PLEASE ACCESS THE FOLLOWING INTERNET ADDRESS FOR UPDATES AND/OR CORRECTIONS.

INTERNET ADDRESS: http://www.dot.ca.gov/hq/esc/geotech

TABLE OF CONTENTS

MANUAL OF INSTRUCTIONS FOR SNAILZ

INTRODUCTION

In recent years, soil nailing technique has been widely employed for many soil reinforcement projects including temporary excavations, soil foundations beneath existing structures or abutments for bridge widening projects.

Engineers at CALTRANS Division of Materials and Foundations have developed a soil nailing program which uses a 2 or 3 part wedge analysis for determining the minimum factor of safety in a one to seven layer soil system with interslice forces included. The factor of safety is determined by iteration. The problem includes options for two surcharges, water table, earthquake loading, two slopes below the toe of the wall, failure surfaces daylighting from points below the toe of the wall, and an externally applied horizontal or inclined wall force. The version discussed herein, version 3.XX, has been updated from previous versions to include the English and Metric systems. The program can also be used for slope stability analysis with and without reinforcement, and for tie back walls. The disk attached to this manual should include:

- Snail.exe
- Scale.dat (see notes on Page 19)
- Four data sets for examples

The program is simple and easy to use. Data should be entered for each parameter as presented. You can use the Pg Down key to call the next screen or Page Up key to call the previous screen. Each parameter is discussed in the initial pages and is followed by four example problems for user convenience. Definitions of some terms are given at the end of the manual. It is recommended to go through the example problems to better understand the program. (PLEASE REFER TO THE ATTACHED SNAILZ.DOC FOR CLARIFYING THE VARIATIONS BETWEEN SNAILZ AND THE OLDER SNAIL.EXE PROGRAM, Ver 2.11).

This manual consists of the following sections:

Section I : General Program Description

Section II : Example Problems

Section III : Theoretical Explanation and Comparative Problems

(8/10/99)

SECTION I
GENERAL PROGRAM DESCRIPTION

BASIC THEORY

The program uses a bi-linear wedge analysis for failure planes exiting at toe of wall and tri-linear for failure planes developing below and beyond the wall toe. It is a fully balanced force equilibrium equation with only soil interslice forces included, based on a mobilized ϕ and c. The basic wedge theory is presented at the end of this manual. For failure planes daylighting beyond the wall toe, a three part wedge is used. The third wedge develops at user specified depths directly below the wall toe. Resistance is determined by passive earth pressure principles wherein the passive force is inclined at an angle of 1/3 the mobilized ϕ on the vertical plane. Reinforcement in the third wedge is not considered in the analysis (Section III).

PROGRAM EXECUTION

The initial data entry must be made using the input panels provided by the program. The data files created may be recalled and modified (Section III). Once, the program has been executed:

1. A graphical representation will appear which illustrates the geometry of the wall and the failure plane with the minimum factor of safety.
2. A summarization of the version of the results can be viewed and saved or printed.
3. Additional internal analyses may be conducted by varying one or more parameters.

INPUT PARAMETERS

SNAIL requires the following information to run:

- -Project Description (Optional)
- -Wall Geometry
- -Reinforcement Parameters
- -Soil Parameters
- -Search Limit

Additional Data input may be required if one or more of the following options are used:

- -Surcharge (You can input two surcharges here)
- -Earthquake Acceleration
- -Water Surface
- -Limiting Search to Specific Nodes
- -Slope Below the Wall
- -Varying Reinforcement Parameters
- -External Horizontal Force
- -Specified Failure Plane

All data must be entered in the units requested.

LIST OF OPTIONS

Following are the list of options and their intended use for Program SNAIL :

Option 1: In this option the user defines the maximum usable reinforcement strength. The option name used is FLAGT. If we set FLAGT=0 then the values of Bond, Yield and Punching shear stress are input as (minimum) ultimate values. Under FLAGT=0 the program automatically divides these input parameters by the indicated factor of safety. Alternatively, if FLAGT=1 then the user inputs factored Bond, Yield, and Punching shear values. Under FLAGT=1 the program utilizes all of the input strengths in the analysis of the factor of safety. FLAGT=2 is used only for tie-back walls using soldier piles. FLAGT=2 prevents any vertical component of the pre-tensioned tendon to be transmitted to the failure wedge.

Option 2: In this option we can specify the search region within the search limit from LS to LN. FSEARCH is the option name used. If FSEARCH is 0 then the search for the failure plane is done from nodes 1 to 10. If FSEARCH=1 then the search is conducted between the specified nodes LA and LB. If FSEARCH=2 then Factor of Safety (FS) of a specified failure plane is computed. You must enter data for II and JJ. (See p 58, item 9 for added information).

Option 3: In this option we can specify a toe. FLAG is the option name used. If FLAG is 0 then no toe is considered. If FLAG is 1 then the toe is considered and values for parameters like slope angle below the wall toe, slope distance, maximum depth of search directly below the wall toe, and number of searches (maximum of five) in that depth has to be given.

Option 4: The value of the external horizontal force (PD) acting on the wall is specified here. The horizontal force acting into the wall (force on soil) is taken as positive and any force acting away from the wall (or soil) is taken as negative. Moments due to the force are not considered. The force PD is transmitted only to the second (lower) wedge.

Option 5: The option name here is FLAGN. If FLAGN is 0 then this option is not used. If FLAGN is 1 then the data for varying reinforcement parameters is entered.

INPUT PANELS AND DESCRIPTION OF PARAMETERS

The various input panels a user will come across and a general explanation to the various terms used is shown. All keyboard commands and keys that are to entered are shown in **bold** letters.

ONCE YOU ENTER THE SNAIL PROGRAM
You will see on the Screen

Engineers at 'CALTRANS' Division of New Technology, Materials & Research have developed a soil nailing program for determining the minimum factor of safety in a one to seven layer soil system using wedge analysis procedure with interslice forces included. The factor of safety is determined by iteration. The program includes options for two surcharges, water table, earthquake loading, two slopes below the toe of wall, varying reinforcement parameters, and failure surfaces daylighting from points below the toe of wall. Recent version also includes the option to select ENGLISH or METRIC units.

Even though SNAIL has been tested, CALTRANS MAKES NO WARRANTY OR REPRESENTATION, EITHER EXPRESSED OR IMPLIED, WITH RESPECT TO THIS SOFTWARE; ITS QUALITY OR PERFORMANCE; OR ITS FITNESS FOR A PARTICULAR PURPOSE. AS A RESULT THIS SOFTWARE IS DISTRIBUTED 'AS IS'. BECAUSE THE DIVERSITY OF HARDWARE AND CONDITION UNDER WHICH THIS PROGRAM CAN BE USED, NO WARRANTY FOR SUITABILITY FOR A PARTICULAR PURPOSE IS OFFERED. THE USER MUST ASSUME THE ENTIRE RISK OF USING THE PROGRAM, AND IS ADVISED TO TEST IT THOROUGHLY AND USE APPROPRIATE ENGINEERING JUDGEMENT IN INTERPRETING RESULTS.

****
* This is Program SNAIL - Version 3.XX *
****

***** - Press <ENTER> to Continue - *****

You will see on the Screen

The following are your options:

		INPUTS:		OUTPUTS:	
1.	From	English	to	English	measurement system.
2.	From	English	to	Metric	measurement system.
3.	From	Metric	to	Metric	measurement system.

Select your option now (1, 2, or 3). Enter ?

You will see on the Screen

Do you wish to use an old data file as input for
this run or for editing? (Y/N)

==> IF **'N'** then
You will see on the Screen

SOIL REINFORCEMENT PROGRAM - CALTRANS
DIST-CO-RTE-PM or Description : (Type in the name of your Data File now)*****.

Hit **<ENTER>** to Continue
*Max 32 characters – Hit 'Backspace' to erase

==> If **'Y'** then
You will see on the Screen

INPUT FILES MUST HAVE BEEN CONSTRUCTED USING THIS PROGRAM

The name entered should include disk designation.
Only the file name needs to be entered.

ENTER THE NAME OF THE FILE NOW **-** (Type in the name of your Data File now) *.

Hit **<ENTER>** to Continue
* Max 8 characters – Hit 'Backspace' to erase

You will see on the Screen

SOIL REINFORCEMENT PROGRAM **-** CALTRANS
DIST-CO-RTE-PM or Description : (Name of old data file)\
Do you want to change the title? (Y/N)

==> If **'Y'** then you will see on the Screen

Soil Reinforcement Program **-** Caltrans

DIST-CO-RTE-PM or Description:
DIST-CO-RTE-PM or Description: (type in your new title)** **-** Hit <ENTER>

Do you want to change the title ? (Y/N)

** Max 32 characters-Hit 'Backspace' to erase.

⇨ If **'N'** then you are now ready to input data. Data is entered in the input panels as shown in the
⇨ following pages.

==> Once the data have been entered in the input panels hit the **<esc>** key.

==> You will be asked if you want to save the input data. If **'YES'**

You will see on the Screen

You will need to save the input file with a name you choose to give.
If the name you choose is the same as another, the previous file will be overwritten.
The name entered should include the disk designation. If not, the data file will automatically be saved in the current disk. (Data will be stored as .inp files)

ENTER THE NAME OF THE FILE NOW **-**

Hit **<ENTER>** to continue

You will see on the screen your initial data inputs and graphical presentation of the wall. Check your data and hit '**Y'** or **'N'**.

==> If **'N'**, the program will return to the input panels for correction.

==> If **'Y'**, the program will run.

Once the program runs there will be a graphical presentation with a menu at the bottom of the screen. The results can be seen if you hit 'R'. Follow the self explanatory screens to create a new data file or to edit the previous data file.

Project Description

The description is a name or an expression which will identify the project. It may contain any character or number EXCEPT COMMAS. Any characters following a comma will be overlooked. (This is true only for the description).

You will see on the Screen

```
1.-WALL GEOMETRY:
 H =       ft-------Vertical Wall Height.
 B =       Degree---Wall Batter from Vertical Line.
 I1=      Degree| S1=      ft---1st Slope Angle and Distance.
 I2=      Degree| S2=      ft---2nd Slope Angle and Distance.
 I3=      Degree| S3=      ft---3rd Slope Angle and Distance.
 I4=      Degree| S4=      ft---4th Slope Angle and Distance.
 I5=      Degree| S5=      ft---5th Slope Angle and Distance.
 I6=      Degree| S6=      ft---6th Slope Angle and Distance.
 I7=      Degree-----7th Slope Angle.
  2.-REINFORCEMENT INPUTS:(Use OPTION 5 if LE, AL, SV, D, or BSF* varies.)
 N =       ---------Number of Reinforcement Levels.
 LE=       ft-------Reinforcement Length.
 AL=       Degree---Reinforcement Inclination.
SV1=       ft-------Vertical Distance to first Level.
 SV=       ft-------Vertical Spacing from second to N level.
 SH=       ft-------Horizontal Spacing
 PS=       Kips-----Punching Shear at reinforcement head.
 FY=       Ksi------Yield Stress of Reinforcement.
 D =       in-------Diameter of Reinforcement.
 DD=       in-------Diameter of Grouted Hole.
 Use Arrow and Return Keys to move around, Backspace and Delete Keys to edit
 When data entry finished, press Page Up, or Down, or Esc Key to Run program.
```

Hit **PAGE UP** or **PAGE DOWN** to Continue

1.-Wall Geometry

Wall Geometry includes all lengths and angles above the toe of the wall. Figure 1 shows the locations of the requested data. Enter all Data in the blank spaces provided. No entry means zero. The user may edit data at any time.

1. Vertical Wall Height.
2. Wall Batter from the vertical axis.
3. First Slope Angle.
4. First Slope Distance from Wall crest.
5. Second Slope Angle.
6. Second Slope Distance from First Slope.
7. Third Slope Angle.
8. Third Slope Distance from Second Slope.
9. Fourth Through Seventh Slope Angle, and Slope Lengths.

2.-Reinforcement Parameters

The reinforcement parameters are divided into two groups. The first group (Items 1-9) is the set of parameters which remain constant from one level to another. The second group that is marked with an asterisk can be varied from one level to another. This group will be discussed later under varying reinforcement parameters (Option 5). Figure 2 shows the locations of the required data

Constant Parameters are:

1. Number of Reinforcement Levels. (Maximum of 30).
2. Reinforcement Length.*
3. Reinforcement Inclination.*
4. Vertical Distance to first Level. (Can also be a negative value).
5. Vertical Spacing.*
6. Horizontal Spacing. (See Pg 16 if varying).
7. Punching Shear Capacity.
8. Yield Stress of Reinforcement.
9. Diameter of Reinforcement Element.*
10. Diameter of Grouted Hole.
11. Soil-Grout Bond Stress.*

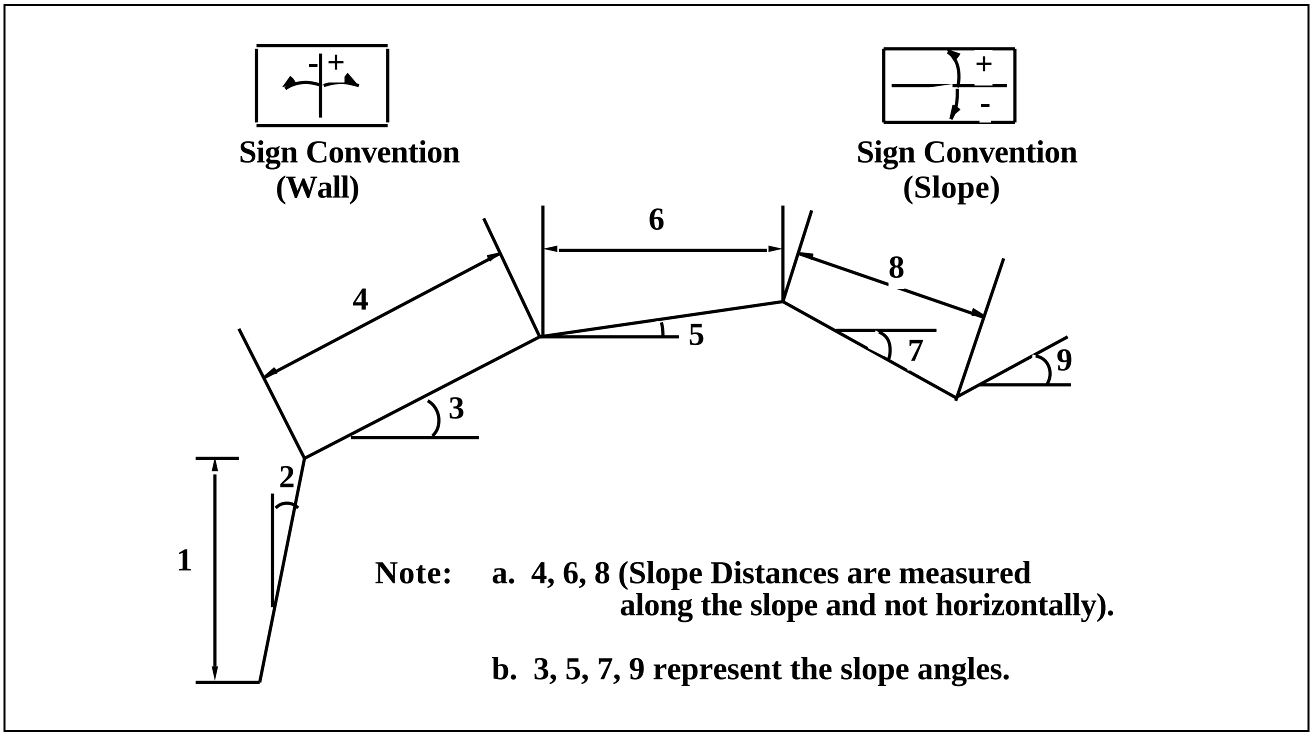


FIGURE 1. WALL GEOMETRY.

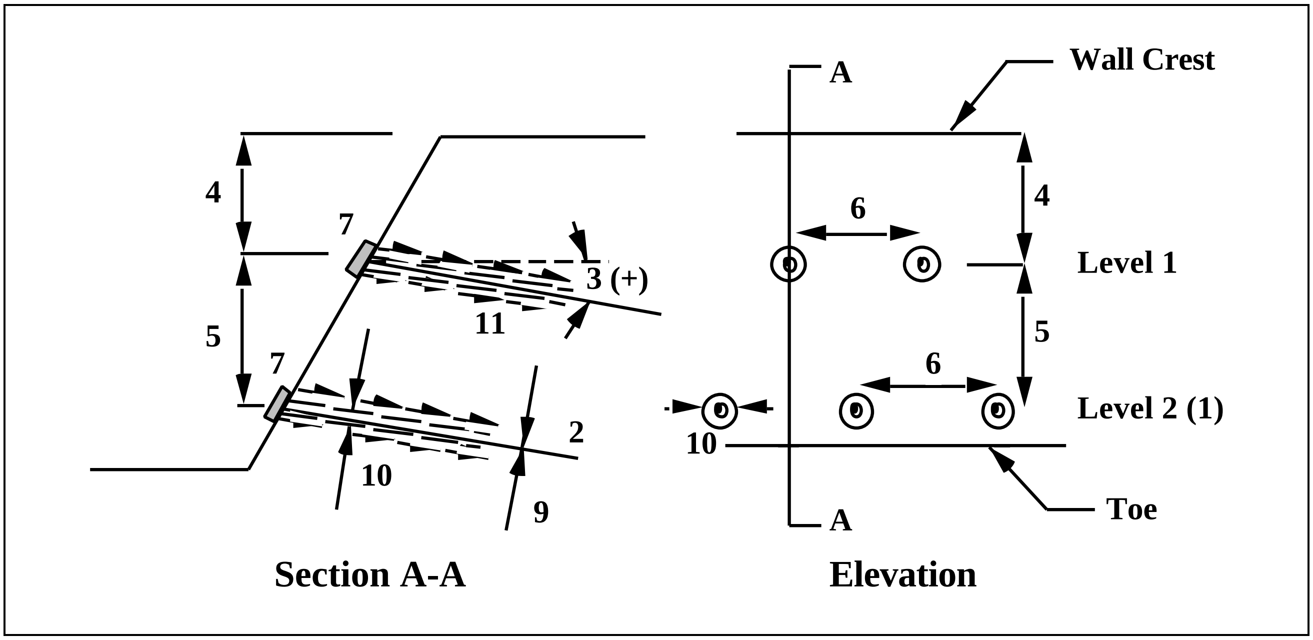


FIGURE 2. REINFORCEMENT PARAMETERS - (See Page 7 for description).

You will see on the Screen

```
3.-SOIL PARAMETERS:
 NS =      Number of soil types.(1=Top layer to 7=Bottom layer-
          Layers must not intersect within limits of search).
     Weight| Angle|Cohes.| Bond*|  XS  |  YS  |  XE  |  YE
LAYER   Pcf | Deg. |  Psf |  Psi | (ft) | (ft) | (ft) | (ft)
  1







   4.-SEARCH LIMIT:
 LS=        ft-Begin Search.If LS=0, Search starts at wall crest.
 LN=        ft-End Search.(Horizontal Distance From Wall Toe).
+++++++++++ End of Data Inputs required to run SNAIL.++++++++++++
   5.-SURCHARGE: Maximum of 2 different surcharges are entered.
     First  | Second
 XL=        |         ft-----Begin Surcharge: Dist. from Toe.
 XR=        |         ft-----End Surcharge:   Dist. from Toe.
 PL=        |         psf/ft-Loading At Begin Surcharge.
 PR=        |         psf/ft-Loading At End Surcharge.
+++++ Use 'UP'or'DOWN'arrows to scroll. Hit 'Q' or 'q' to quit.+++++
```

Hit **PAGE UP** or **PAGE DOWN** to Continue

3. -Soil Parameters

Up to seven soil layer types can be defined by giving the following values.

1. Unit Weight, GAM.
2. Friction Angle, PHI.
3. Cohesion, COH.
4. Bond Stress, SIG.

In case of multiple soil layers the boundary between the soils can be defined by giving the values of two positive coordinate points (XS1,YS1) and (XS2,YS2) within the wall geometry. (Coordinate (0,0) is toe of wall). Layer order is from left to right, or from top to bottom.

4. -Search Limit

The horizontal distance beginning at the wall crest or user selected starting point to a point selected by the user is defined as the Search Limit. (For each node, 56 failure planes will be analyzed but only the lowest factor of safety will be stored. There are a total of 560 failure planes searched for all 10 nodes).

The distance over which the searches will be conducted is required.

1. Search Limit - (see Figure 3).

The search limit defines the dimensions of the grid in which failure planes will be analyzed. For calculations, SNAIL divides the search limit into ten equal parts.

In the case where there is a wall batter, the HORIZONTAL distance from the wall toe to the top of the wall crest is subtracted from the search limit; the result is then divided into ten equal parts.

Intervals begin at the crest or user selected starting point of the wall. Each end point of a search limit interval is defined as a node (L). If L_S is not specified ($L_S = 0$), search starts at the wall crest. If $L_S \neq 0$, search starts at L_S from wall toe.

In Figure 3, I and J define the search grid at each node. 56 failure search combinations for each node are predetermined by the program.

5. -Surcharge

The loading cases handled by the program are no load, uniformly distributed load, and uniformly varying load. A maximum of two sets of surcharges can be entered. Surcharge can be placed in front of the wall (- X value), behind the wall (+ X value), or both. If surcharge in front of the wall extends to the wall, use $X_R = -0.1$. Far left point in either case is begin surcharge. Surcharge is shown in Figure 4.

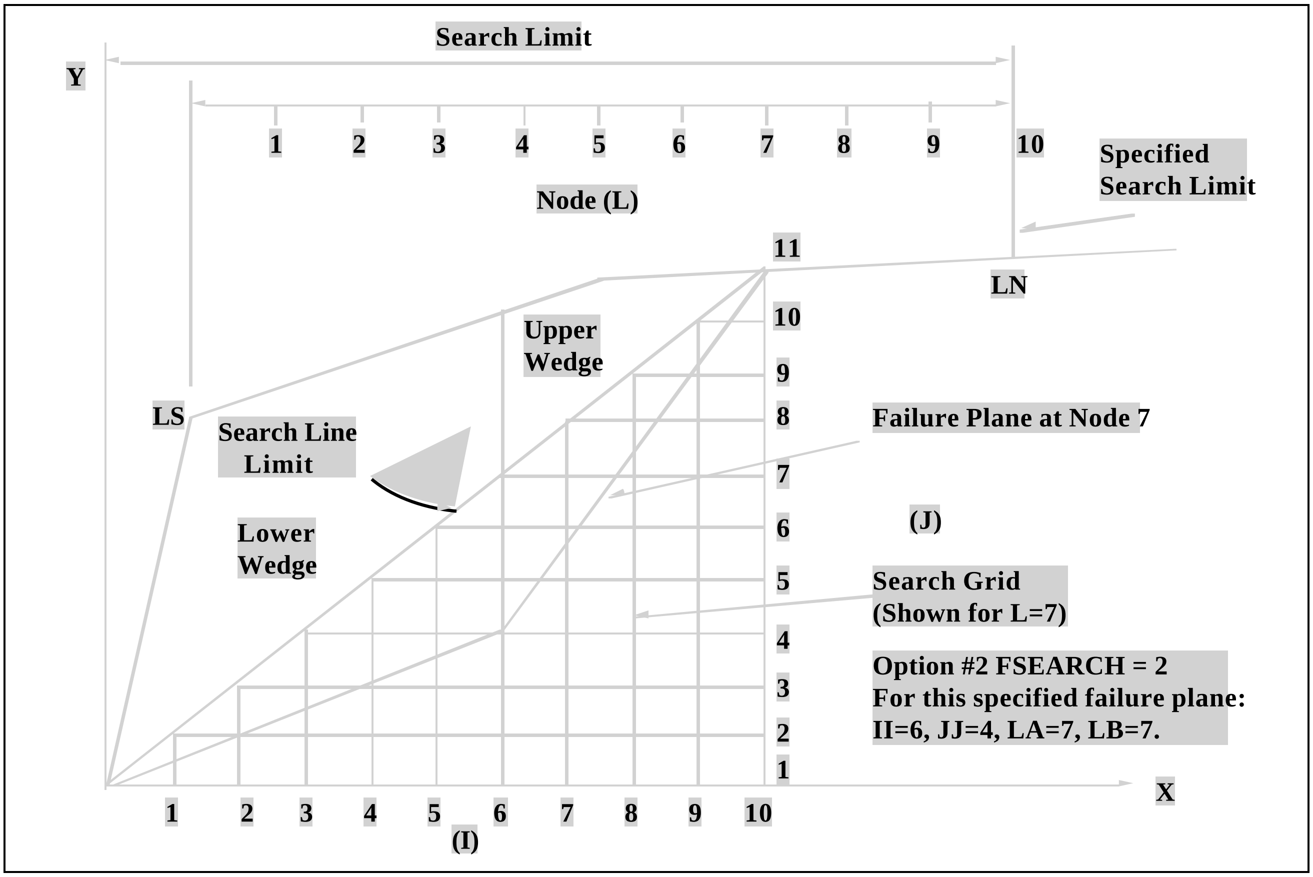


FIGURE 3. SEARCH GRID PATTERN FOR NODE 7.

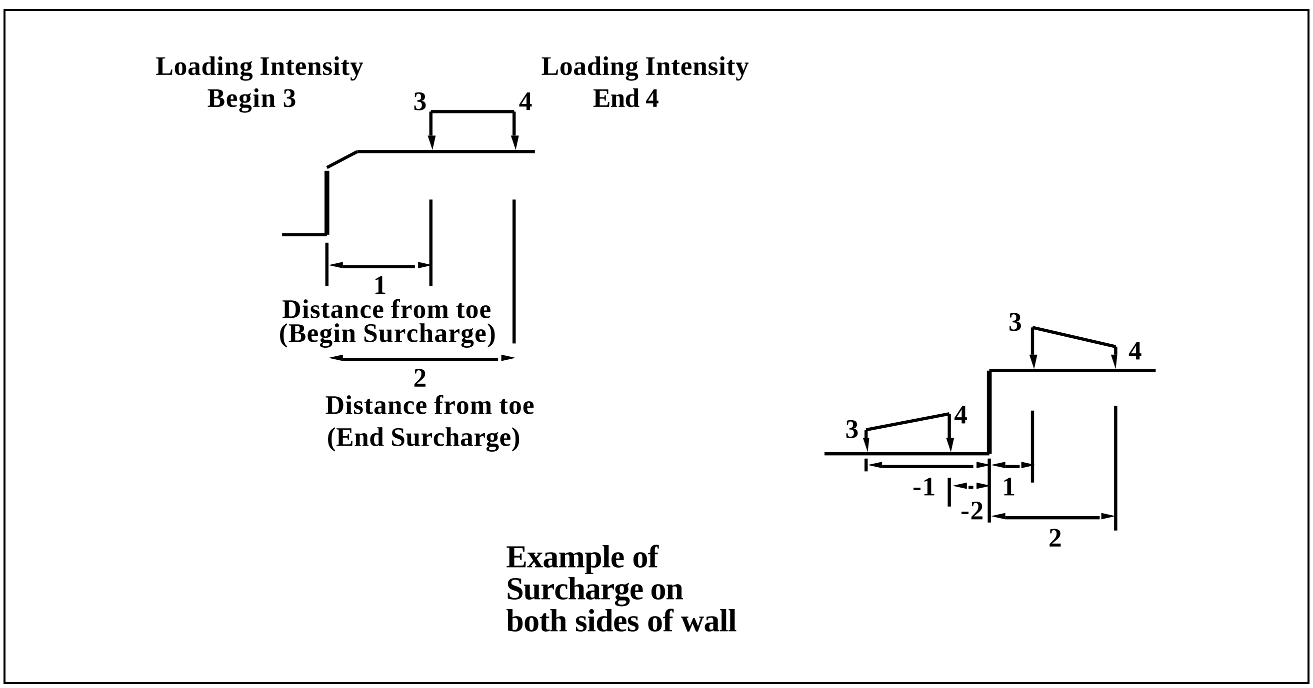


FIGURE 4. SURCHARGE.

You will see on the Screen

```
6.-EARTHQUAKE ACCELERATION:
 KH=        A/G------Horizontal Earthquake Coefficient.
PKH=        %KH/100--Vertical Earthquake Coefficient.
   7.-WATER:
 FLAGW=     ==> 0= not Used. 1= Piezometric. 2= Phreatic
            1st Point     2nd Point     3rd Point
X-Coor.===> XW1=      ft  XW2=      ft  XW3=      ft
Y-Coor.===> YW1=      ft  YW2=      ft  YW3=      ft
 ************************ OPTION  #1 ******************************
 FLAGT=     ==> 0= Ultimate Bond, Yield, &Punching Shear values.
              1= Factored Bond, Yield, &Punching Shear values.
              2= Tie-back Wall only (with Soldier pile wall).
 ************************ OPTION  #2 ******************************
 FSEARCH=   ==> 0= The Search is Routinely from Nodes 1 to 10.
              1= The Search is conducted from nodes LA to LB.
              2= For Specified Failure Plane. Input II And JJ.
   LA=     Beginning at node 'LA'.       II =       Horizontal
   LB=     Ending at node 'LB'.         JJ =       Vertical
 ************************ OPTION  #3 ******************************
 FLAG =     ==> 0= There is no TOE; 1= There is TOE. Enter DATA:
 1st Slope Angle|1st Slope Length| 2nd Slope Angle|2nd Slope Length
 I8=      Degree| S8=        Feet| I9=      Degree| S9=        Feet
 SD=     Ft, Vertical Depth of search.| NTS=     No. of Searches.


Hit PAGE UP or PAGE DOWN to Continue
```

6. -Earthquake Acceleration

1. Horizontal Earthquake Coefficient.
2. Vertical Earthquake Coefficient.

The vertical earthquake coefficient (if used) is a percentage of the horizontal earthquake coefficient but when entering in the input panels it must be expressed as a percentage of the horizontal value IN DECIMAL FORM. The vertical coefficient should be tried as a positive (+) value first then as a negative (-) value. Use the lesser of the two results as the correct factor of safety.

7. -Water Surface

Enter the three x and y coordinate points for the water table in the form asked on the screen. (0,0 is at wall toe). If the option for slope below wall is used, the water table will be assumed as follows:

1 - Initial coordinates on the wall face, water surface coincident with remaining wall and ground surface below.
2 - Initial Y- coordinate negative, water surface flat or coincident with ground surface See example 7.

NOTE: For program execution the water table coordinates points must form a positive curve. If input incorrectly, an error message occurs.

Limiting Search to Specific Nodes

Even though SNAIL will calculate factors of safety at all ten nodal points, the user may choose to limit the results to a select range of nodes.

A limited search range must be provided by giving the appropriate node number.

1. Begin searching at node (select node) LA -
2. End searching at node (select node) LB -

Slope Below the Wall

The following data must be provided. (See Figure 5).

1. First Slope Angle (positive counter clockwise)
2. Length of first slope.
3. Second slope angle (positive counter clockwise)
4. Length of second slope.
5. Maximum depth of search below wall toe.
6. Number of search depths below toe. (Maximum of five).

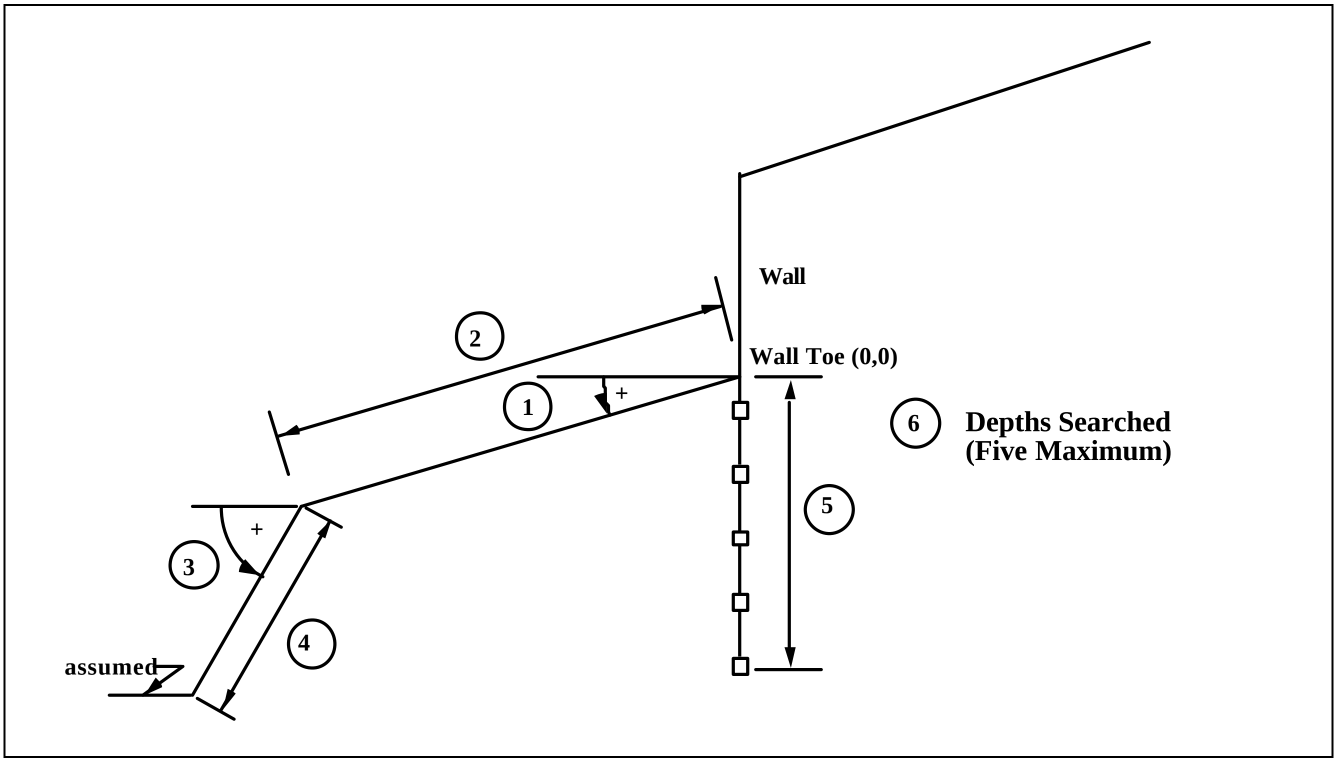


FIGURE 5. SLOPE BELOW THE WALL.

You will see on the Screen

```
************************* OPTION  #4 ********************************
 PD=      Kips/ft-Width. External force on Wall. -->(+)|(-)<--
 AN=      Degrees from horizontal. Positive = Counterclockwise.
 ************************* OPTION  #5 ********************************
 FLAGN=    ==> 0= OPTION #5 is not Used; 1= Used. Enter DATA:
   Reinf.       Reinf.      Vert.       Bar        Bond
  Length     Inclination   Spacing    Diameter    Stress
   (ft)       (Degree)      (ft)       (inch)     Factor*
 LE(01)=     AL(01)=     SV(01)=     D(01)=     SIG(01)=
 LE(02)=     AL(02)=     SV(02)=     D(02)=     SIG(02)=
 LE(03)=     AL(03)=     SV(03)=     D(03)=     SIG(03)=
 LE(04)=     AL(04)=     SV(04)=     D(04)=     SIG(04)=
 LE(05)=     AL(05)=     SV(05)=     D(05)=     SIG(05)=
 LE(06)=     AL(06)=     SV(06)=     D(06)=     SIG(06)=
 LE(07)=     AL(07)=     SV(07)=     D(07)=     SIG(07)=
 LE(08)=     AL(08)=     SV(08)=     D(08)=     SIG(08)=
 LE(09)=     AL(09)=     SV(09)=     D(09)=     SIG(09)=
 LE(10)=     AL(10)=     SV(10)=     D(10)=     SIG(10)=

*NOTES: The Bond Stress Factor (BSF) is a mutiplier of Bond applied
 throughout a bar, regardless of soil parameters. (Default = 1.00)

+++++ Use 'UP'or'DOWN'arrows to scroll. Hit 'Q' or 'q' to quit.+++++
```

Hit **PAGE UP** or **PAGE DOWN** to Continue

You will see on the Screen

```
LE(11)=     AL(11)=     SV(11)=     D(11)=      SIG(11)=
LE(12)=     AL(12)=     SV(12)=     D(12)=      SIG(12)=
LE(13)=     AL(13)=     SV(13)=     D(13)=      SIG(13)=
LE(14)=     AL(14)=     SV(14)=     D(14)=      SIG(14)=
LE(15)=     AL(15)=     SV(15)=     D(15)=      SIG(15)=
LE(16)=     AL(16)=     SV(16)=     D(16)=      SIG(16)=
LE(17)=     AL(17)=     SV(17)=     D(17)=      SIG(17)=
LE(18)=     AL(18)=     SV(18)=     D(18)=      SIG(18)=
LE(19)=     AL(19)=     SV(19)=     D(19)=      SIG(19)=
LE(20)=     AL(20)=     SV(20)=     D(20)=      SIG(20)=
LE(21)=     AL(21)=     SV(21)=     D(21)=      SIG(21)=
LE(22)=     AL(22)=     SV(22)=     D(22)=      SIG(22)=
LE(23)=     AL(23)=     SV(23)=     D(23)=      SIG(23)=
LE(24)=     AL(24)=     SV(24)=     D(24)=      SIG(24)=
LE(25)=     AL(25)=     SV(25)=     D(25)=      SIG(25)=
LE(26)=     AL(26)=     SV(26)=     D(26)=      SIG(26)=
LE(27)=     AL(27)=     SV(27)=     D(27)=      SIG(27)=
LE(28)=     AL(28)=     SV(28)=     D(28)=      SIG(28)=
LE(29)=     AL(29)=     SV(29)=     D(29)=      SIG(29)=
LE(30)=     AL(30)=     SV(30)=     D(30)=      SIG(30)=

Use Arrow and Return Keys to move around, Backspace and Delete Keys to edit
When data entry finished, press Page Up, or Down, or Esc Key to Run program.
```

Hit **PAGE UP** or **PAGE DOWN** to Continue

Varying Reinforcement Parameters

OPTION 5 allows the user to vary the reinforcement parameters (Items 13-20) with each level. If length, inclination, vertical spacing, bar diameter, horizontal spacing and/or bond stress changes at any level, OPTION 5 must be used.

The parameters which may vary level by level are:

13. Reinforcement Length.
14. Angle of Inclination of reinforcement.
15. Vertical Spacing.
16. Bar Diameter.
17. Reinforcement Soil-Grout Bond Stress.

* 18. Horizontal Spacing.

* 19. Grouted hole diameter.

* 20. Reinforcement yield stress.

Items 13-17 can be accommodated directly through the use of Option 5. However, items 18-20, marked with an asterisk (*) cannot be directly accommodated and the user must alter vertical spacing or manipulate (correct) the actual bond stress and/or bar diameter as shown below prior to entering into Option 5.

Case 1 - Varying Horizontal Spacing - Two Procedures

Procedure 1

If horizontal spacing (SH) is 1/n (n=1,2,3, etc.) of that specified on panel #2, additional bars are added to any given level by simply specifying a zero vertical spacing for subsequent data line(s) on the option 5 panel screen. The combination of the original level plus the subsequent level(s) specified with SV = 0 results in spacings just noted.

Procedure 2

In cases where the horizontal spacing (SH) varies differently than 1/n (n=1,2,3, etc.)with reinforcement level from what is input on panel #2, the bond stress and bar diameter must be corrected through the use of equations 1 & 2 and Option 5 is used.

Corrected Bond Stress: $SIG'_n = ((SH_n/ SH'_n)\text{-}2)\ SIG_n$ --------------------------eq. 1

where; SIG'_n = Corrected Bond Stress at level n.

SH = Horizontal spacing input on panel #2.

SH'_n = Horizontal spacing at level n.

SIG_n = Uncorrected bond stress at level n.

Corrected Bar Diameter: $D'_n = D_n\ ((SH_n/ SH'_n) - 2)^{1/2}$ --------------------------eq. 2

where; D'_n = Corrected bar diameter at level n.

D_n = Uncorrected bar diameter at level n.

SH'_n, SH_n = Defined as above.

Case 2 - Varying Grouted Hole Diameters

In cases where the grouted hole diameter (DD) varies with reinforcement level from what is input in panel #2, the bond stress must be corrected through the use of equation 3 and input into Option 5.

Corrected Bond Stress: $SIG''_n = (DD_n/DD)\ SIG_n$ --------------------------eq. 3

where; SIG''_n = Corrected value of SIG_n at level n.

DD_n = Grouted hole diameter at level n.

DD = Grouted hole diameter input on panel #2.

SIG_n = Uncorrected bond stress at level n.

Case 3 - Varying Reinforcement Yield Stress

In cases where the reinforcement yield stress (FY) varies with reinforcement level from what is input on panel #2, the bar diameter must be corrected through the use of equation 4 and input into Option 5.

Corrected Bar Diameter: $D''_n = D_n \, (FY'_n / FY)^{1/2}$ --------------------------eq. 4

where; D''_n = Corrected bar diameter at level n.

D_n = Uncorrected bar diameter at level n.

FY'_n = Yield stress at level n.

FY = Yield stress input in panel #2.

GRAPHICS

The hardware required for graphics output is a CGA, EGA, VGA, or SVGA video card and monitor. If your computer is not equipped with this type of hardware the program will not execute.

The graphics output describes the slope, water, reinforcement geometry and other information for the purpose of checking the input data and evaluating the results. The image created on the screen can be printed by referring to the SNAILZ supplement document. If your geometry exceeds the limits of the original screen the image will run off the sides. However, the screen can be scaled smaller or larger by depressing the key “Z” which causes a question to appear prompting for a scale factor. Any scale factor between 0.01 to 100 can be used. For example, a factor of 0.5 reduces the displayed screen by 50%, a factor of 2.5 increases the displayed screen by 250%. The printed copy will be correspondingly factored. The graphics display the cross-section in color for color monitors, or else in B/W. For B/W prints, hit S for screen mode (only B/W will appear).

The depression of key "N" will cause a question to appear prompting for a node point number. A value between 1 to 10 is acceptable. This number selects the node point for the failure plane to be plotted next. In the case of a slope below the wall the key "N" is replaced by the key "T" and it will cause a question to appear prompting for a toe number point. A value between 1 to 6 is acceptable but the limit depends on the number of search points selected in the input data. Toe point 1 is the toe of the wall and point 2 is the next point below the toe. Striking the "R" key will display the tabular results on the screen. PLEASE REFER TO THE ATTACHED SNAILZ.DOC (p 59) FOR PRINTING OF GRAPHICS.

Summary of the Graphical Presentation

These are the main components of the graphical presentation:

1. The geometry and the factor of safety for the critical failure plane.
2. The distance behind the wall where the failure plane surfaces.
3. Search depth below wall toe.
4. Surcharge, water table and the horizontal force (PD) on face.
5. A legend which contains soil parameters and water table surface if available. If NS = 2 or more (Soil Layers), the boundary lines will be shown.
6. The vertical and horizontal spacing, the height of the wall (H), and reinforcement length (L).
7. The choice of viewing another node (for problems with no slope below the wall) or toe or daylight points (for problems with slope below the wall). The user will only have to press "N" and the node number or "T" and the toe point number to obtain the desired failure plane.
8. If earthquake acceleration is involved, the graphics will show the values of KH **-** horizontal acceleration, PKH **-** vertical acceleration, and Ac **-** critical acceleration that yields a FS ~ 1.00.

After review of the graphics, hit 'R' for viewing tabular results of analysis and the <ENTER> key for scrolling through the result section. Repeating the <ENTER> key brings back the graphics screen. Hit 'Q' to quit. The program will then ask you:

You will see on the Screen

Do you want to print the Minimum factors of safety? (Y/N)

Do you want to edit previous data file for another run? (Y/N) Do you want to edit another file? (Y/N)

==> If your answer is '**Y**' to the first query then a report will be printed providing results of the analysis.
If '**N**' then the program will ask you to if you want to edit the previous data file
If your answer to the second query is '**N**' then the program will ask you if you want to edit another file or a new data file. Enter your selection appropriately.

<u>EDITING DATA FILES</u>

There are occasions when you may want to edit the data file rather than the screen input before running program SNAIL. The text and variables located in the data file are listed below.

"TITLE"
"ENTER TITLE HERE"
"FLAGS"
FLAGW, FLAGT, FSEARCH, FLAG, FLAGN

“GEOMETRY”

H, B, I1, S1, I2, S2, I3, S3, I4, S4, I5, S5, I6, S6, I7

“SURCHARGE”

XL, XR, PL, PR, XL2, XR2, PLL, PRR

“REINFORCEMENT LAYERS”

N, SH, PS, FY, DD

“SOIL”

NS

GAM1, PHI1, COH1, SIG1

GAM2, PHI2, COH2, SIG2, XS1, YS1, XS2, YS2

“EARTHQUAKE & HORIZONTAL FORCE”

KH, PKH, PD, AN

“SEARCH LIMIT”

LS, LN

“WATER TABLE”

XW1, YW1, XW2, YW2, XW3, YW3

“NODE LIMITS”

LA, LB

“TOE”

I8, S8, I9, S9, SD, NTS

“REINFORCEMENT”

LE, AL, SV1, SV, D (FLAGN=0)

LE(I), AL(I), SV(I), D(I), SIG(I) (FLAGN=1)

Caution: It is advisable to use the input panels to change the data values. Use the data file for editing only when absolutely necessary. While editing the data file, enter the data in the exact format as shown above and do not delete or add anything other than what is required.
Notes:
SCALE.DAT is present as follows:
"Color"
0.788,1.449
"Black & White"
.788,1.449

However, you may change the above values to adjust the scale on your screen and print-out.

SECTION II

EXAMPLE PROBLEMS

<u>INTRODUCTION</u>

This section shows example problems. It is recommended to do these problems on the computer to understand the program execution and its capabilities. A brief description of the types of problems shown in this section are as follows:

Problem SN1 -Bridge abutement with spread footing. 18′vertical wall with slope (1.5:1) above wall with surcharge.
- One soil layer with varying reinforcement lengths.

Problem SN2 - Stepped wall with batter on lower wall. 25′ overall wall height with slope (2.75:1) above wall and surcharge
- Two soil layers with water table and varying reinforcement lengths.

Problem SN3 - 30′ high soldier pile tieback wall with two tendons. Demonstrates how the program can be used for pile walls where tendon forces vary and vertical component not considered in front wedge for assessing factor of safety.
- Two soil layers with varing slope above wall.

Problem SN4 - A reinforced embankment using polymeric type materials. Design (pre-factored) reinforcement strengths used.

SOIL NAILED BRIDGE ABUTMENT

```
PROJECT TITLE : Soil Nailed Bridge Abutment              Date:
                                                         File: sn1
    Minimum Factor of Safety =  1.66

    20.0 ft Behind Wall Crest
     0.0 ft Below Wall Toe
```

File: sn1

```
**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION      *
*            ENGINEERING SERVICE CENTER           *
```

```
               *      OFFICE OF MATERIALS AND FOUNDATIONS        *
               *          Roadway Geotechnical Branch            *
               *    Date:                    Time:               *
               ***************************************************

 Project Identification - Soil Nailed Bridge Abutment

              --------- WALL GEOMETRY ---------

  Vertical Wall Height         =  18.0 ft
  Wall Batter                  =   0.0 degree
                                 Angle   Length
                                 (Deg)   (Feet)
  First Slope from Wallcrest.  =  32.7      7.0
  Second Slope from 1st slope. =   0.0      8.0
  Third Slope from 2nd slope.  = -89.0      3.0
  Fourth Slope from 3rd slope. =   0.0      4.0
  Fifth Slope from 4th slope.  =  89.0      3.0
  Sixth Slope from 5th slope.  =   0.0      0.0
  Seventh Slope Angle.         =   0.0

           --------- SLOPE BELOW THE WALL ---------

  First Slope Angle below Toe.       =   0.0 degrees
  First Slope Distance from Toe.     =   0.0 ft
  Second Slope Angle.                =   0.0 degrees
  Second Slope Distance from Toe.    =   0.0 ft
  Vertical Depth of Search.          =   5.0 ft
  Number of Searches below wall Toe. =   1


                --------- SURCHARGE ---------

  THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

  Begin Surcharge - Distance from toe =     14.0 ft
  End Surcharge - Distance from toe   =     17.9 ft
  Loading Intensity - Begin           =   4000.0 psf/ft
  Loading Intensity - End             =   4000.0 psf/ft

  Begin Second Surcharge - Distance from toe =     24.0 ft
  End Second Surcharge - Distance from toe   =     60.0 ft
  Loading Intensity - Begin           =    240.0 psf/ft
  Loading Intensity - End             =    240.0 psf/ft

                 --------- OPTION #1 ---------

  Factored Punching shear, Bond & Yield Stress are used.
```

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	125.0	30.0	300.0	7.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

_

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 0.0 to 40.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	4
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	36.0 ksi
Diameter of Grouted Hole	=	8.00 in
Punching Shear	=	30.0 kips

---------- (Varying Reinforcement Parameters) ---------

Vertical Bar

Level	Length (ft)	Inclination (degrees)	Spacing (ft)	Diameter (in)	Bond Stress Factor
1	25.0	15.0	2.5	1.13	1.00
2	20.0	15.0	4.5	1.13	1.00
3	17.0	15.0	4.5	1.13	1.25
4	15.0	15.0	4.5	1.13	1.25

DEPTH BELOW WALL TOE (ft)	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE		UPPER FAILURE PLANE	
			ANGLE (deg)	LENGTH (ft)	ANGLE (deg)	LENGTH (ft)
Toe	1.664	20.0	25.0	15.4	68.5	16.4

Reinf. Stress at Level 1 = 18.135 Ksi (Pullout controls...)
2 = 11.076 Ksi (Pullout controls...)
3 = 20.705 Ksi (Pullout controls...)
4 = 32.169 Ksi (Pullout controls...)

DEPTH BELOW WALL TOE (ft)	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE		UPPER FAILURE PLANE	
			ANGLE (deg)	LENGTH (ft)	ANGLE (deg)	LENGTH (ft)
5.00	1.524	20.0	37.4	17.6	69.5	17.2

Reinf. Stress at Level 1 = 17.714 Ksi (Pullout controls...)
2 = 10.492 Ksi (Pullout controls...)
3 = 14.461 Ksi (Pullout controls...)
4 = 21.087 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 6.389 Kips/level *
****

SOIL NAILED STEPPED WALL

File: sn2

```
**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*      OFFICE OF MATERIALS AND FOUNDATIONS       *
*          Roadway Geotechnical Branch           *
*    Date:                       Time:           *
**************************************************
```

Project Identification - Soil Nailed Stepped Wall

```
              --------- WALL GEOMETRY ---------

 Vertical Wall Height         =  12.0 ft
 Wall Batter                  =  13.0 degree
                                Angle   Length
                                (Deg)   (Feet)
 First Slope from Wallcrest.  =   0.0      6.0
 Second Slope from 1st slope. =  89.9     13.0
 Third Slope from 2nd slope.  =  20.0     15.0
 Fourth Slope from 3rd slope. =   0.0      0.0
 Fifth Slope from 4th slope.  =   0.0      0.0
 Sixth Slope from 5th slope.  =   0.0      0.0
 Seventh Slope Angle.         =   0.0

           --------- SLOPE BELOW THE WALL ---------

 First Slope Angle below Toe.       =   0.0 degrees
 First Slope Distance from Toe.     =   4.0 ft
 Second Slope Angle.                =  32.7 degrees
 Second Slope Distance from Toe.    =   8.0 ft
 Vertical Depth of Search.          =   7.0 ft
 Number of Searches below wall Toe. =   1


                --------- SURCHARGE ---------

 THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

 Begin Surcharge - Distance from toe =     30.0 ft
 End Surcharge - Distance from toe   =    100.0 ft
 Loading Intensity - Begin           =    240.0 psf/ft
 Loading Intensity - End             =    240.0 psf/ft


                 --------- OPTION #1 ---------

 Factored Punching shear, Bond & Yield Stress are used.
```

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	120.0	32.0	150.0	7.0	0.0	0.0	0.0	0.0
2	125.0	36.0	100.0	8.0	0.0	0.0	50.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

The Water Table is defined by three coordinate points.

X(1)-Coordinate = 0.00 ft Y(1)-Coordinate = -6.00 ft
X(2)-Coordinate = 30.00 ft Y(2)-Coordinate = 3.00 ft
X(3)-Coordinate = 100.00 ft Y(3)-Coordinate = 7.00 ft

--------- SEARCH LIMIT ---------

The Search Limit is from 0.0 to 60.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

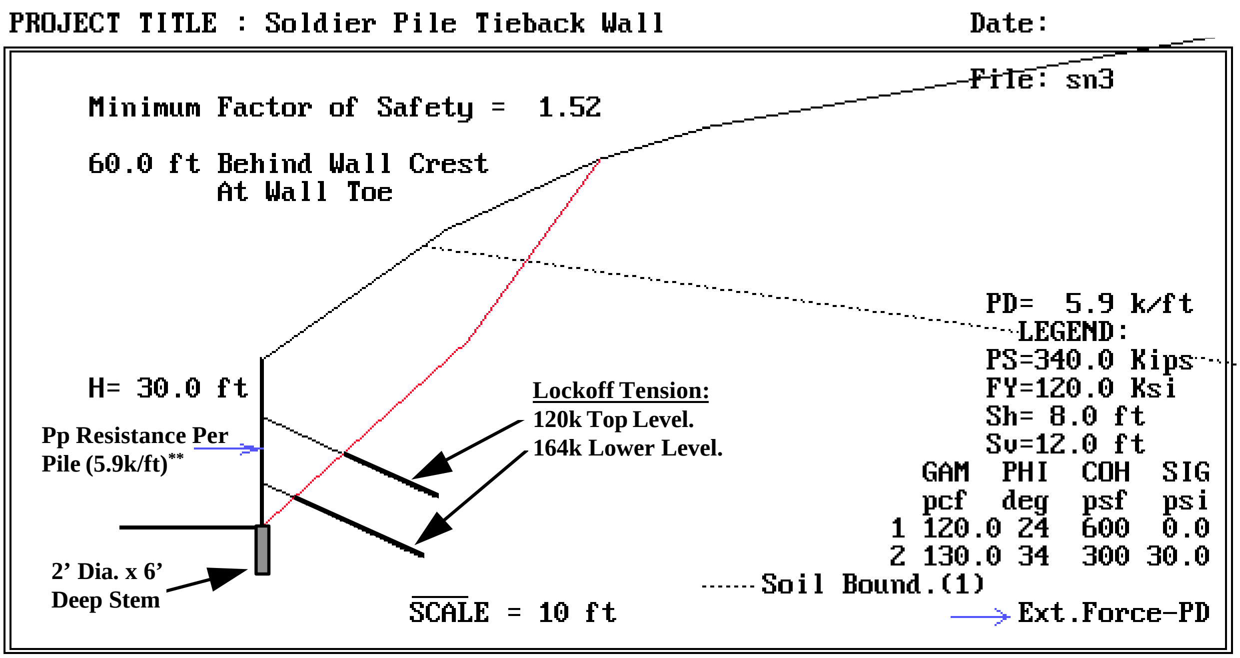
--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 6
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 36.0 ksi
Diameter of Grouted Hole = 8.00 in
Punching Shear = 35.0 kips

```
---------- (Varying Reinforcement Parameters) ---------

                                 Vertical     Bar
     Level   Length   Inclination   Spacing   Diameter   Bond
Stress
            (ft)     (degrees)     (ft)       (in)       Factor

        1     30.0        15.0        %-12.0        1.00        1.00
        2     29.0        15.0         4.0        1.00        1.00
        3     26.0        15.0         4.0        1.00        1.00
        4     21.0        15.0         6.0        1.00        1.00
        5     19.0        15.0         4.0        1.00        1.00
        6     17.0        15.0         4.0        1.00        1.00

  DEPTH    MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
  BELOW    SAFETY      BEHIND         PLANE           PLANE
 WALL TOE  FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
   (ft)                  (ft)     (deg)   (ft)    (deg)   (ft)

   Toe     1.948        54.3        0.0   16.3     38.4   48.5

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   1.232 Ksi (Pullout controls...)
                          3 =   1.738 Ksi (Pullout controls...)
                          4 =   1.154 Ksi (Pullout controls...)
                          5 =   4.348 Ksi (Pullout controls...)
                          6 =  28.485 Ksi (Pullout controls...)

  DEPTH    MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
  BELOW    SAFETY      BEHIND         PLANE           PLANE
 WALL TOE  FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
   (ft)                  (ft)     (deg)   (ft)    (deg)   (ft)

  7.00     1.476        54.3       18.9   11.5     37.6   54.8

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   2.622 Ksi (Pullout controls...)
                          3 =   3.380 Ksi (Pullout controls...)
                          4 =   3.172 Ksi (Pullout controls...)
                          5 =   6.618 Ksi (Pullout controls...)
                          6 =  11.501 Ksi (Pullout controls...)

*******************************************************************
      *                For Factor of Safety = 1.0
*
      *         Maximum Average Reinforcement Working Force:
*
```

```
      *                           2.210 Kips/level
*********************************************************************
```

SOLDIER PILE TIEBACK WALL



TOE ANALYSIS ONLY

NOTE: ** Use Lesser of Pp, Pile P-Y Resistance, or Pile Moment or Shear Capacity.

EXAMPLE SN3.INP

```
File: sn3

               **************************************************
               *    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
               *          ENGINEERING SERVICE CENTER            *
               *      OFFICE OF MATERIALS AND FOUNDATIONS       *
               *          Roadway Geotechnical Branch           *
               *    Date:                       Time:           *
               **************************************************

Project Identification - Soldier Pile Tieback Wall

              --------- WALL GEOMETRY ---------

 Vertical Wall Height         =  30.0 ft
 Wall Batter                  =   0.0 degree
                               Angle   Length
                               (Deg)   (Feet)
 First Slope from Wallcrest.  =  35.0     40.0
 Second Slope from 1st slope. =  25.0     30.0
 Third Slope from 2nd slope.  =  17.0     20.0
 Fourth Slope from 3rd slope. =  10.0    100.0
 Fifth Slope from 4th slope.  =   0.0      0.0
 Sixth Slope from 5th slope.  =   0.0      0.0
 Seventh Slope Angle.         =   0.0

           --------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall


                --------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.


                 --------- OPTION #1 ---------

 Tie-back with Soldier Pile Wall.
```

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	120.0	24.0	600.0	0.0	0.0	0.0	0.0	0.0
2	130.0	34.0	300.0	30.0	30.0	50.0	100.0	40.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

_

--------- EXTERNAL FORCE ---------

Horiz. Force applied to the Wall = 5.9 Kips

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 0.0 to 150.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 2
Horizontal Spacing = 8.0 ft
Yield Stress of Reinforcement = 120.0 ksi

Diameter of Grouted Hole = 12.00 in
Punching Shear = 340.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	34.0	25.0	10.0	1.13	1.00
2	31.0	25.0	12.0	1.32	1.00

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.493	15.0	62.1	32.1	89.9	12.2

Reinf. Stress at Level 1 = 120.000 Ksi (Yield Stress controls.)
2 = 120.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.667	30.0	53.7	50.6	89.9	10.2

Reinf. Stress at Level 1 = 120.000 Ksi (Yield Stress controls.)
2 = 120.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.534	45.0	46.2	65.0	89.9	11.7

Reinf. Stress at Level 1 = 120.000 Ksi (Yield Stress controls.)
2 = 120.000 Ksi (Yield Stress controls.)

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE	LOWER FAILURE PLANE ANGLE	LOWER FAILURE PLANE LENGTH	UPPER FAILURE PLANE ANGLE	UPPER FAILURE PLANE LENGTH

```
                   (ft)       (deg)   (ft)    (deg)   (ft)

NODE 4     1.522        60.0       42.4   48.7     53.8   40.7

  Reinf. Stress at Level  1 = 120.000 Ksi (Yield Stress controls.)
                          2 = 120.000 Ksi (Yield Stress controls.)

           MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
           SAFETY      BEHIND         PLANE           PLANE
           FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                        (ft)      (deg)   (ft)    (deg)   (ft)

NODE 5     1.528        75.0       43.1  102.7     89.9    0.0

  Reinf. Stress at Level  1 = 120.000 Ksi (Yield Stress controls.)
                          2 = 120.000 Ksi (Yield Stress controls.)

           MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
           SAFETY      BEHIND         PLANE           PLANE
           FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                        (ft)      (deg)   (ft)    (deg)   (ft)

NODE 6     1.540        90.0       39.2  116.1     89.9    0.0

  Reinf. Stress at Level  1 = 120.000 Ksi (Yield Stress controls.)
                          2 = 120.000 Ksi (Yield Stress controls.)

           MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
           SAFETY      BEHIND         PLANE           PLANE
           FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                        (ft)      (deg)   (ft)    (deg)   (ft)

NODE 7     1.587       105.0       35.9  129.6     89.9    0.0

  Reinf. Stress at Level  1 = 120.000 Ksi (Yield Stress controls.)
                          2 = 120.000 Ksi (Yield Stress controls.)

           MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
           SAFETY      BEHIND         PLANE           PLANE
           FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                        (ft)      (deg)   (ft)    (deg)   (ft)

NODE 8     1.648       120.0       33.3  143.5     89.9    0.0

  Reinf. Stress at Level  1 = 120.000 Ksi (Yield Stress controls.)
                          2 = 120.000 Ksi (Yield Stress controls.)

           MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
           SAFETY      BEHIND         PLANE           PLANE
```

	FACTOR	WALL TOE (ft)	ANGLE (deg)	LENGTH (ft)	ANGLE (deg)	LENGTH (ft)
NODE 9	1.714	135.0	31.1	157.6	89.9	0.0

Reinf. Stress at Level 1 = 120.000 Ksi (Yield Stress controls.)
2 = 120.000 Ksi (Yield Stress controls.)

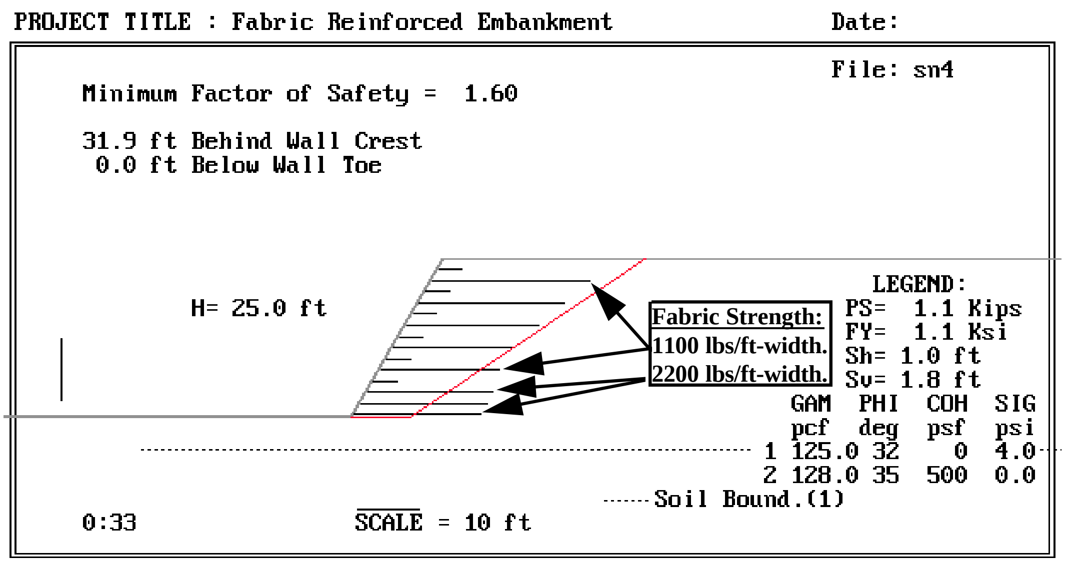
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.781	150.0	29.2	171.9	89.9	0.0

Reinf. Stress at Level 1 = 120.000 Ksi (Yield Stress controls.)
2 = 120.000 Ksi (Yield Stress controls.)

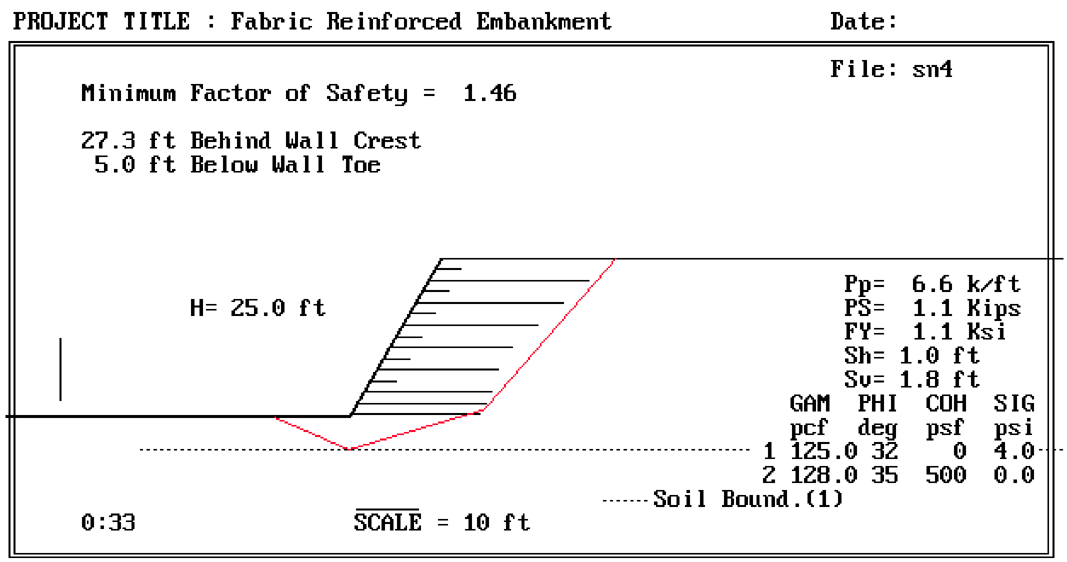
****
*
* For Factor of Safety = 1.0
*
* Maximum Average Reinforcement Working Force:
*
* 27.800 Kips/level
*

****
*

FABRIC REINFORCED EMBANKMENT



TOE ANALYSIS



BELOW TOE ANALYSIS

```
File: sn4

               **************************************************
               *    CALIFORNIA DEPARTMENT OF TRANSPORTATION      *
               *          ENGINEERING SERVICE CENTER             *
               *      OFFICE OF MATERIALS AND FOUNDATIONS        *
               *          Roadway Geotechnical Branch            *
               *    Date:                        Time:           *
               **************************************************

Project Identification - Fabric Reinforced Embankment

              --------- WALL GEOMETRY ---------

 Vertical Wall Height          =  25.0 ft
 Wall Batter                   =  30.0 degree
                                 Angle   Length
                                 (Deg)   (Feet)
 First Slope from Wallcrest.  =   0.0    120.0
 Second Slope from 1st slope. =   0.0      0.0
 Third Slope from 2nd slope.  =   0.0      0.0
 Fourth Slope from 3rd slope. =   0.0      0.0
 Fifth Slope from 4th slope.  =   0.0      0.0
 Sixth Slope from 5th slope.  =   0.0      0.0
 Seventh Slope Angle.         =   0.0

           --------- SLOPE BELOW THE WALL ---------

 First Slope Angle below Toe.       =   0.0 degrees
 First Slope Distance from Toe.     =   0.0 ft
 Second Slope Angle.                =   0.0 degrees
 Second Slope Distance from Toe.    =   0.0 ft
 Vertical Depth of Search.          =   5.0 ft
 Number of Searches below wall Toe. =   1


                --------- SURCHARGE ---------
```

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	125.0	32.0	0.0	4.0	0.0	0.0	0.0	0.0
2	128.0	35.0	500.0	0.0	0.0	-5.0	30.0	-5.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

_

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 14.3 to 60.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 14

Horizontal Spacing	=	1.0	ft
Yield Stress of Reinforcement	=	1.1	ksi
Diameter of Grouted Hole	=	8.00	in
Punching Shear	=	1.1	kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	4.0	0.0	1.8	1.13	1.00
2	25.0	0.0	1.8	1.13	0.20
3	4.0	0.0	1.8	1.13	1.00
4	23.0	0.0	1.8	1.13	0.40
5	4.0	0.0	1.8	1.13	1.00
6	21.0	0.0	1.8	1.13	0.60
7	4.0	0.0	1.8	1.13	1.00
8	19.0	0.0	1.8	1.13	0.80
9	4.0	0.0	1.8	1.13	1.00
10	19.0	0.0	1.8	1.13	1.00
11	4.0	0.0	1.8	1.13	1.00
12	20.0	0.0	1.8	1.60	1.00
13	20.0	0.0	1.8	1.60	1.00
14	20.0	0.0	1.8	1.60	1.00

DEPTH BELOW WALL TOE (ft)	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	1.599	46.3	0.0	9.3	34.0	44.7

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.000 Ksi
3 = 0.000 Ksi
4 = 0.000 Ksi
5 = 0.000 Ksi
6 = 0.000 Ksi
7 = 0.000 Ksi
8 = 0.000 Ksi

```
                              9 =   0.000 Ksi
                             10 =   1.100 Ksi (Yield Stress controls.)
                             11 =   0.000 Ksi
                             12 =   1.100 Ksi (Yield Stress controls.)
                             13 =   1.100 Ksi (Yield Stress controls.)
                             14 =   1.100 Ksi (Yield Stress controls.)
```

DEPTH BELOW WALL TOE (ft)	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
5.00	1.457	41.8	16.0	21.7	49.0	31.8

```
 Reinf. Stress at Level  1 =   0.000 Ksi
                         2 =   0.000 Ksi
                         3 =   0.000 Ksi
                         4 =   0.000 Ksi
                         5 =   0.000 Ksi
                         6 =   0.000 Ksi
                         7 =   0.000 Ksi
                         8 =   0.000 Ksi
                         9 =   0.000 Ksi
                        10 =   0.000 Ksi
                        11 =   0.000 Ksi
                        12 =   0.000 Ksi
                        13 =   0.000 Ksi
                        14 =   0.691 Ksi (Pullout controls...)
```

```
*******************************************************************
*
      *                 For Factor of Safety = 1.0
*
      *          Maximum Average Reinforcement Working Force:
*
                          0.630 Kips
*******************************************************************
```

SECTION III

THEORETICAL EXPLANATION

&

COMPARATIVE PROBLEMS

INTRODUCTION

Section III discusses the basic methodology in the analysis of internal and global stability of soil nailed walls using a bi-linear failure wedge, incorporating classical limit equilibrium methods wherein all forces are balanced. Results are shown comparing predicted failure planes and bar forces to a full scale test wall and information obtained from two instrumented soil nail walls. Comparison to results obtained from PC STABL 4, a modified Bishops circular analysis using moment equilibrium methods to results obtained by program SNAIL for a pre-stressed slope reinforcement problem and a non reinforced slope is also shown.

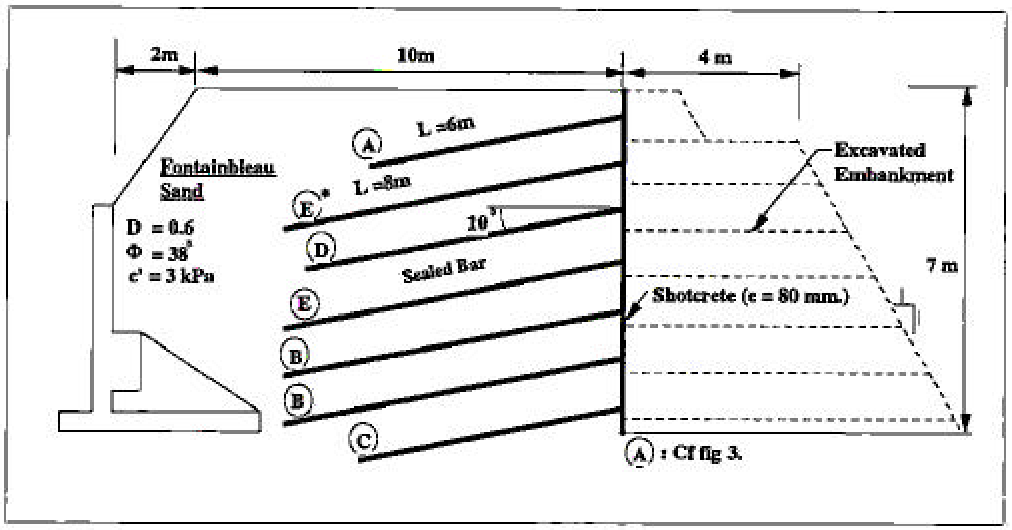
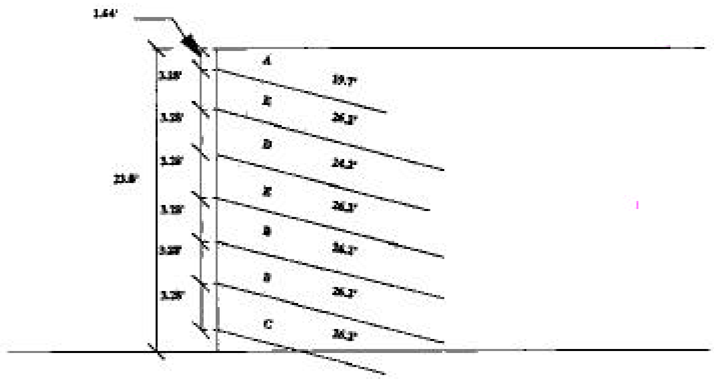


FIGURE 6. FULL SCALE EXPERIMENTAL SOIL NAIL WALL FOR 'FRENCH NATIONAL RESEARCH PROJECT' (DESIGN & PERFORMANCE OF EARTH RETAINING STRUCTURES', PP 660-675, GEOTECHNICAL SPECIAL PUBLICATION No. 25, CORNELL UNIVERSITY, ITHACA, NEW YORK, JUNE 18-21, 1990).

FRENCH WALL - (C,E,B,T,P)



REINFORCEMENT

BAR RUPTURE = 19.9 Ksi.
GROUT DIA. = 2.48 in.
SOIL GROUT BOND STRESS = 8 psi.
HOR. SPA. = 3.77 ft.

A. 0.305 in.
B. 0.601 in.
C. 0.493 in.
D. 0.493 in.
E. 0.493 in.

EQUIVALENT SOLID BAR DIA. TO MATCH AREA OF TUBES USED IN STUDY.

SOIL

BEFORE FLOODING

γ_T = 96.1 pcf
Φ = 38°
C = 60 psf
F = 1.12 (TOP BAR BROKEN)

AFTER FLOODING

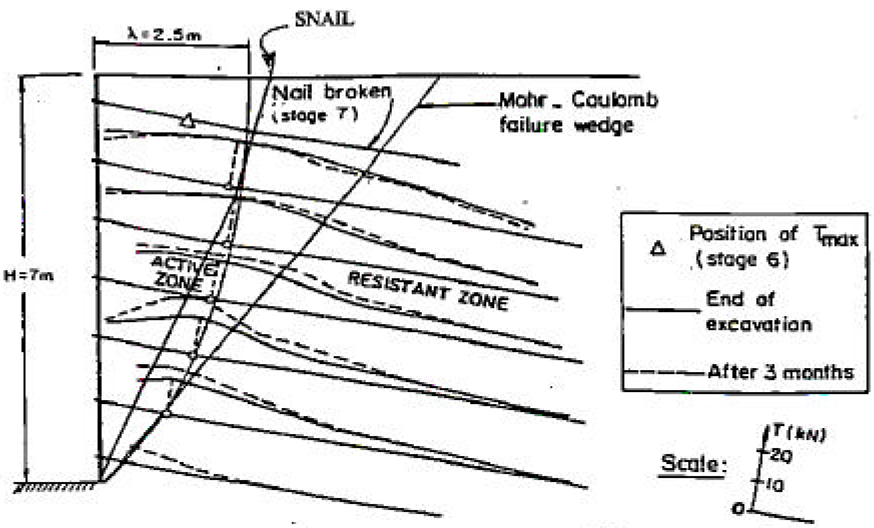
TOP: γ_T = 105 pcf
Φ = 38°
C = 60 psf

BOT: γ_T = 129.1 pcf
Φ = 38°
C = 0 psf

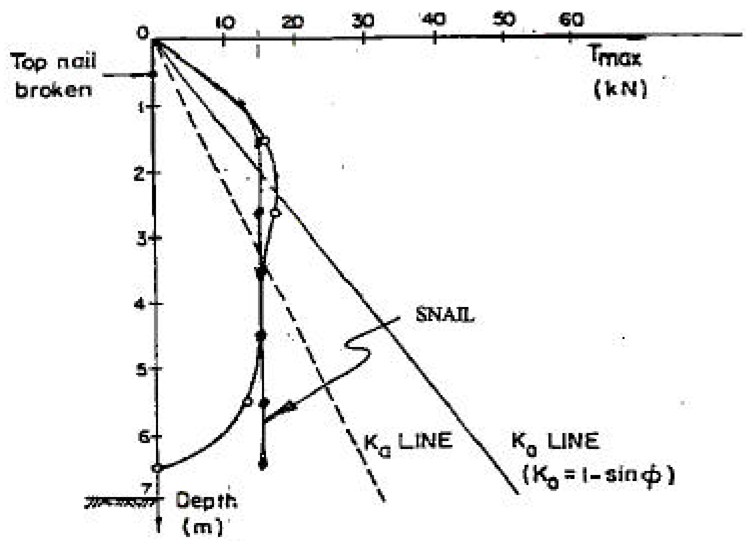
F = 1.000 @* h' =8.7'
*(Determined by Trial)

*(NO POSITIVE EVIDENCE IN PAPER ON WHERE ACTUAL WATER TABLE EXISTED AT FAILURE.ZONE OF SATURATION, HOWEVER, STATED TO BE BETWEEN 16-20 FEET).

FIGURE 7. PERTINENT DATA USED IN PROGRAM SNAIL FOR PROBLEM ANALYSIS.



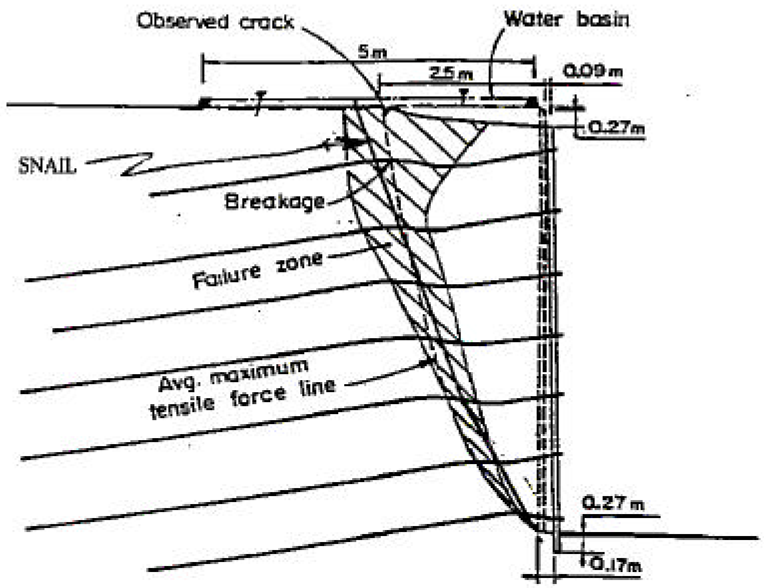
a. Distribution of the Tensile Forces in the Nails



b. Variation of the Measured Maximum Tensile Forces in the Nails with Depth (End of Construction)

FRENCH WALL - (C.E.B.T.P)

FIGURE 8. a) PROGRAM SNAIL PREDICTION OF PEAK BAR STRESS LOCATION AT END OF EXCAVATION TO OBSERVED DATA. b)COMPARISON OF PEAK MEASURED TO PREDICTED BAR STRESSES AT END OF EXCAVATION.



Failure Zone Developed in the C.E.B.T.P. Soil Nailed Wall

FIGURE 9. COMPARISON OF OBSERVED TO PREDICTED FAILURE PLANE LOCATION.

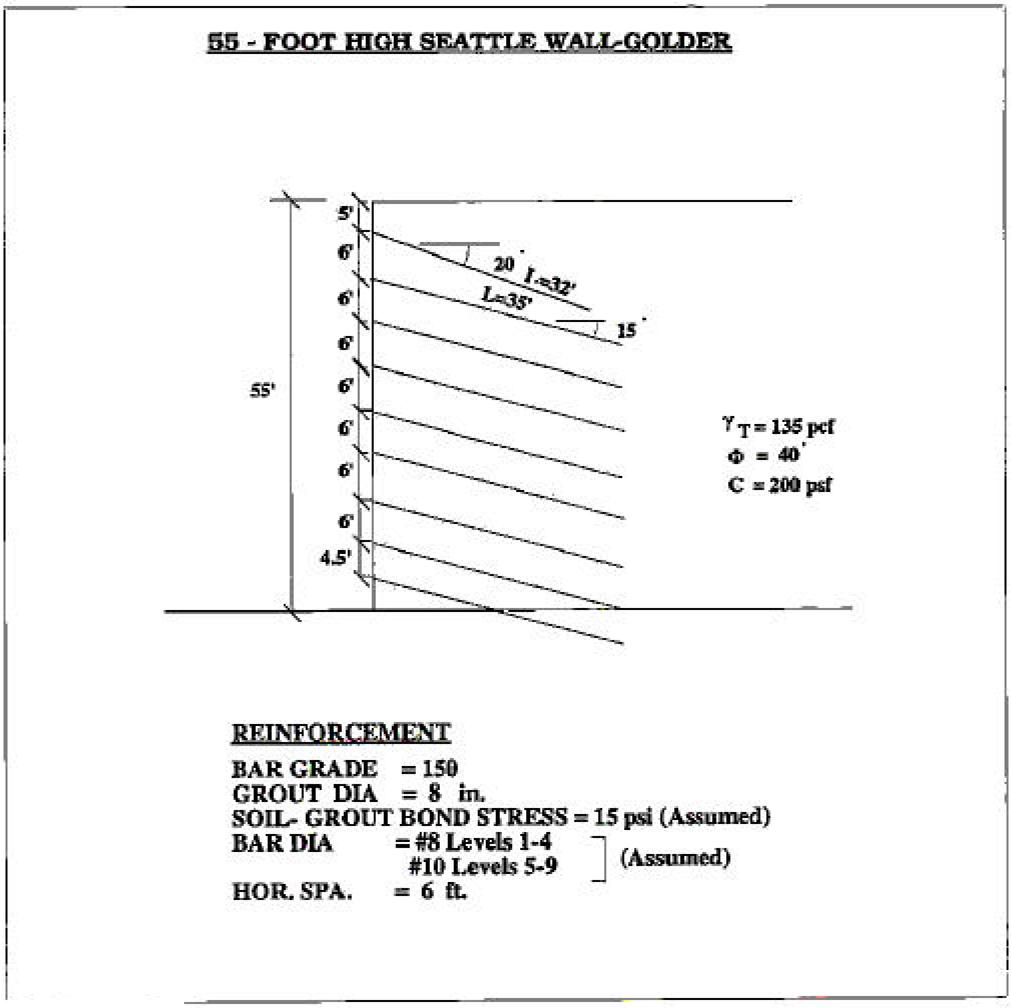
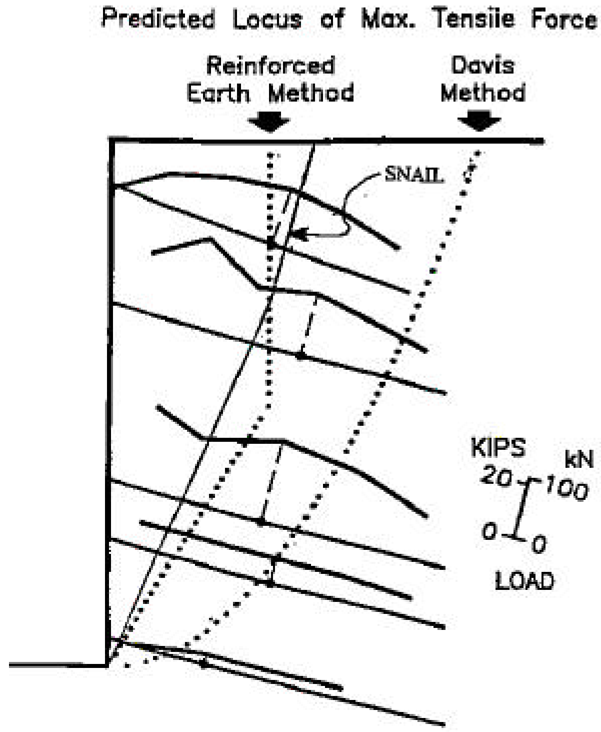


FIGURE 10. DESIGN, CONSTRUCTION AND PERFORMANCE OF A SOIL NAILED WALL IN SEATTLE, WASHINGTON FOR GOLDER ASSOCIATES. (DESIGN & PERFORMANCE OF EARTH RETAINING STRUCTURES', PP 629-643, GEOTECHNICAL SPECIAL PUBLICATION No. 25, CORNELL UNIVERSITY, ITHACA, NEW YORK, JUNE 18-21, 1990).



Load Distribution on Nails

55 - FOOT HIGH SEATTLE WALL-GOLDER

FIGURE 11. **COMPARISON OF PREDICTED LOCUS OF MAXIMUM TENSILE FORCE BY REINFORCED EARTH METHOD, DAVIS METHOD AND SNAIL.**

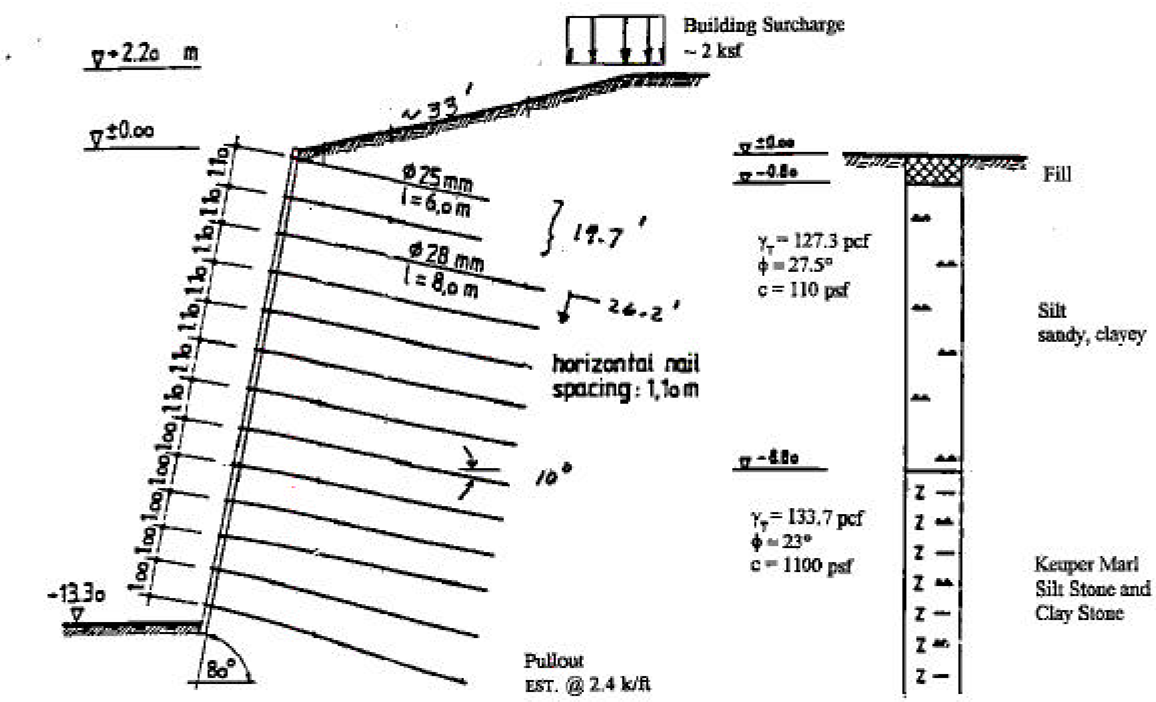


FIGURE 12. THE BEARING BEHAVIOR OF NAILED RETAINING STRUCTURES-GERMANY (DESIGN & PERFORMANCE OF EARTH RETAINING STRUCTURES', PP 629-643, GEOTECHNICAL SPECIAL PUBLICATION No. 25, CORNELL UNIVERSITY, ITHACA, NEW YORK, JUNE 18-21, 1990).

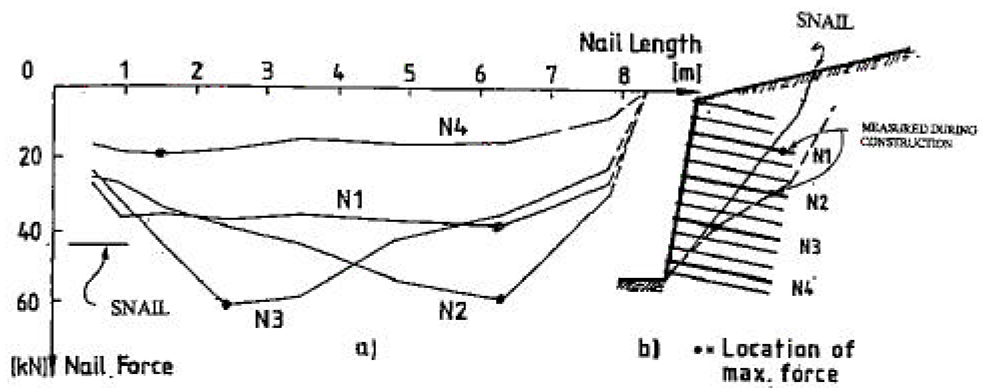


FIGURE 13. DISTRIBUTION OF THE NAIL FORCES AT CONTROL SECTION M3 FOR THE FINAL EXCAVATION STAGE.

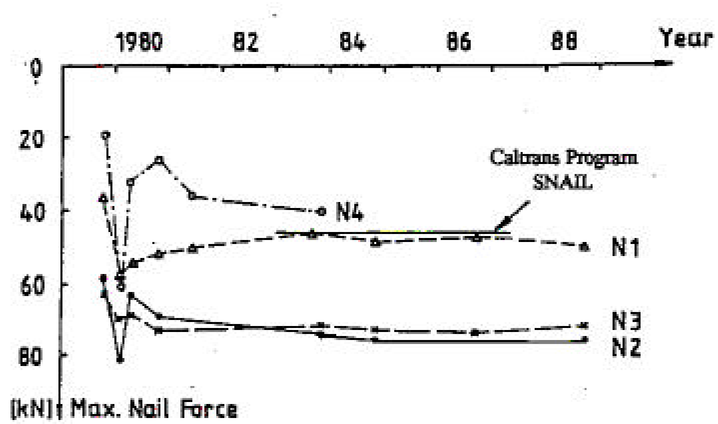
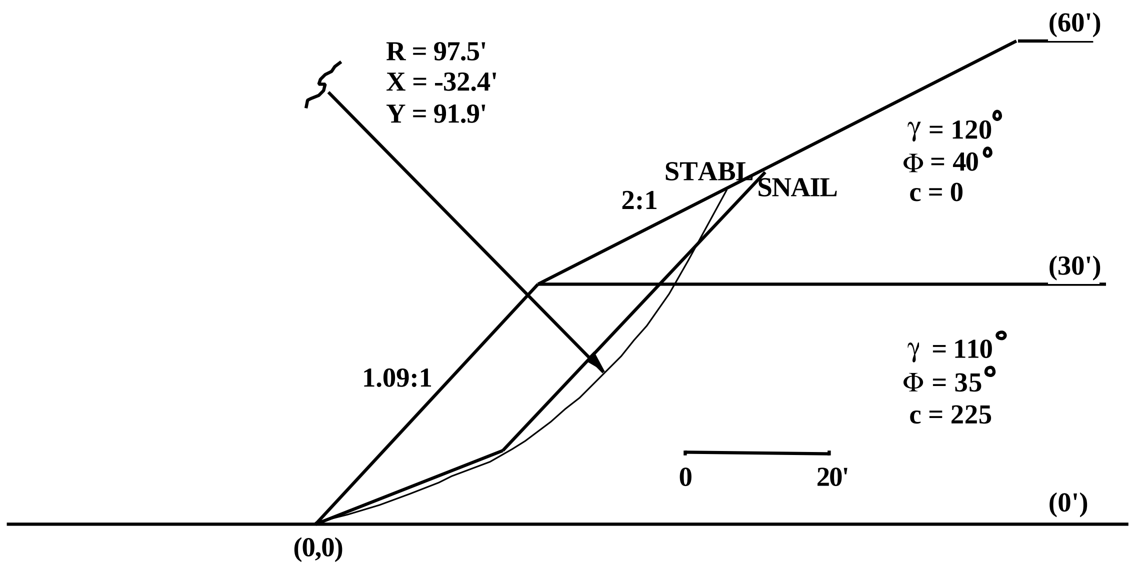
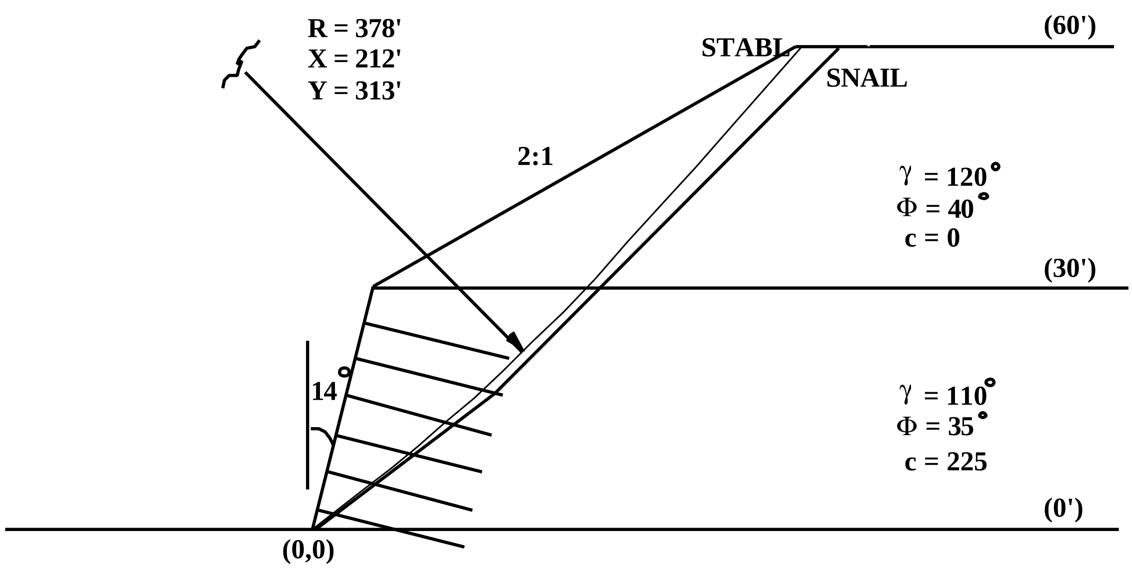


FIGURE 14. CHANGE OF NAIL FORCES WITH TIME.

SLOPE STABILITY FACTOR OF SAFETY COMPARISON PROGRAM STABL4 AND PROGRAM SNAIL



SEARCHED FAILURE PLANES - UNREINFORCED
STABL : F = 1.35
SNAIL : F = 1.39



SEARCHED FAILURE PLANES - REINFORCED SLOPE (PRESTRESSED
STABL : F = 1.53
SNAIL : F = 1.49

FIGURE 15.

BASIC COMPONENTS OF WEDGE ANALYSIS USED IN PROGRAM 'SNAIL' (HOMOGENEOUS SOIL)

W_1, W_2 = Wedge weight (Water table and surcharge included in programming)
θ_1, θ_2 = Failure plane angle of respective wedges with horizontal.
l_1, l_2 = Failure plane length at base of respective wedges.
L_{1W}, L_{2W} = Submerged length at base of respective wedges.
l_3 = Vertical interslice length.
E_1, E_2 = Earthquake forces on respective wedges, includes horizontal (K_H) and vertical (K_V) components.
Ψ = Angle EQ force makes with horizontal (ψ=0 for zero vertical component).
$T'N_1$, $T'N_2$ = Sum of mobilized reinforcement tension on respective wedges. *, **
α = Angle reinforcement makes with horizontal (Positive clockwise).
R_1, R_2 = Resultant friction forces at base of respective wedges.
R_3 = Resultant interslice friction force. ***
Φ' = Mobilized friction angle. *
C' = Mobilized Cohesion. *

* $T'N_{1,2} = (TN_{1,2}) / F$; (Tie-back walls, $T'N_{1,2} = TN_{1,2}$)
* $\Phi' = \text{Tan}^{-1}(\text{Tan}\,\Phi/F)$
* $C' = C/F$
$\delta_1 = \theta_1 + \Psi$
$\delta_2 = \theta_2 + \Psi$
** If Option 1 = 1, $T'N_{1,2} = TN_{1,2}$
*** Bar forces not considered in resultant interslice forces ($\therefore$ F.S. Conservative)
Earthquake loading (E_1 & E_2). E_1, $E_2 = W_{1,2}[K_H^2 + K_V^2]^{1/2}$
(Normal EQ components to failure plane in submerged zone neglected since pore pressure build up equal to normal EQ forces in that zone-cavitation not considered).

WEDGE SOLUTION

ACTIVE CASE

Wedge 2 :
$\Sigma F_N = 0$: $E_2(1-L_{2W}/l_2)\text{Sin}\,\delta_2 - T'N_2\text{Sin}(\alpha+\theta_2) - W_2\text{Cos}\theta_2 - C'l_3\text{Cos}\theta_2 - R_{32}\text{Sin}(\Phi'-\theta_2) + R_2\text{Cos}\Phi' = 0$ ----------(1)

$\Sigma\ F_T = 0 : - E_2 Cos\delta_2 + T'N_2 Cos(\alpha+\theta_2) - W_2 Sin\theta_2 + C'l_2 - C'l_3 Sin\theta_2 - R_{32} Cos(\Phi'-\theta_2) + R_2 Sin\Phi' = 0$ ----------(2)

From :

$R_2 = [R_{32} Sin(\Phi'-\theta_2)/Cos\Phi'] + [(C'l_3+W_2)Cos\theta_2/Cos\Phi'] + [(B_2-A_2)/Cos\Phi']$ ----------(3)

$R_2 = [R_{32} Cos(\Phi'-\theta_2)/Sin\Phi'] + [(C'l_3+W_2)Sin\theta_2/Sin\Phi'] - [C'l_2/Sin\Phi'] + [(A_{22}-B_{22})/Sin\Phi']$ (4)

$(3) = (4) \Rightarrow R_{32}[(Sin(\Phi'-\theta_2)/Cos\Phi')-(Cos(\Phi'-\theta_2)/Sin\Phi')] = [(C'l_3+W_2)Sin\theta_2/Sin\Phi'] - [(C'l_3+W_2)Cos\theta_2/Cos\Phi'] - [C'l_2/Sin\Phi'] + [(A_{22}-B_{22})/Sin\Phi'] - [(B_2-A_2)/Cos\Phi']$

Rearranging and reducing to a simpler form ;

$R_{32} = [(A_{22}-B_{22}) + (C'l_3+W_2)Sin\theta_2 - C'l_2 - [(B_2-A_2) + (C'l_3+W_2)Cos\theta_2]Tan\Phi'] / [Sin(\Phi' - \theta_2) Tan\Phi' - Cos(\Phi'-\theta_2)]$ ----------(5)

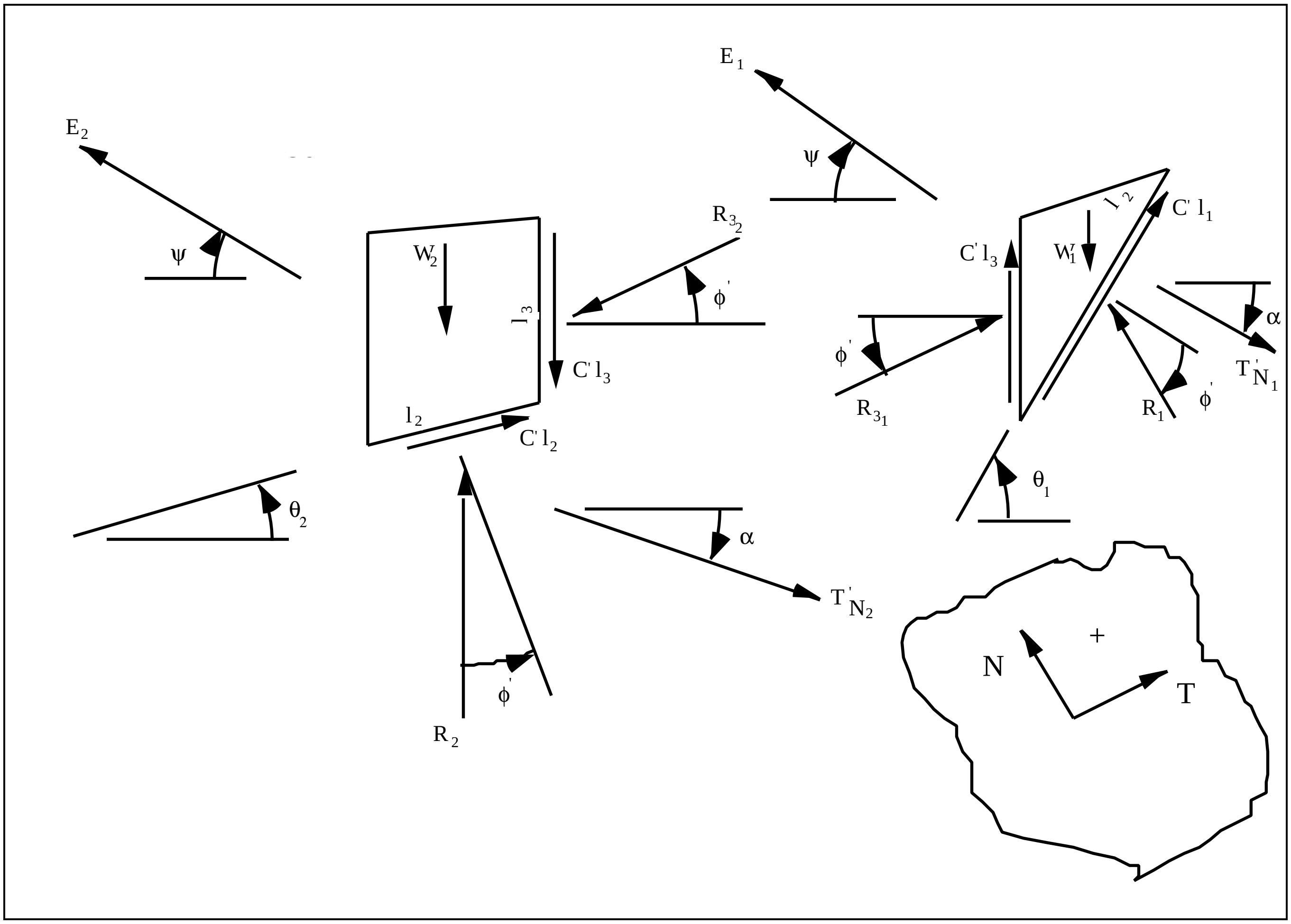


FIGURE 16. MAJOR FORCES AND DIRECTION ON A TWO PART WEDGE FOR ACTIVE CASE.

Wedge 1 :

$\Sigma F_N = 0$: $E_1(1-L_{1W}/l_1)\text{Sin } \delta_1 - T'N_1\text{Sin}(\alpha+\theta_1) - W_1\text{Cos}\theta_1 + C'l_3\text{Cos}\theta_1 + R_{31}\text{Sin}(\Phi'-\theta_1) + R_1\text{Cos}\Phi' = 0$ ----------(6)

$\Sigma F_T = 0$: $- E_1\text{Cos}\delta_1 + T'N_1\text{Cos}(\alpha+\theta_1) - W_1\text{Sin}\theta_1 + C'l_1 + C'l_3\text{Sin}\theta_1 + R_{31}\text{Cos}(\Phi'-\theta_1) + R_1\text{Sin}\Phi' = 0$ ----------(7)

From :

$R_1 = [(W_1-C'l_3)\text{Cos}\theta_1/\text{Cos}\Phi'] + [(B_1-A_1)/\text{Cos}\Phi'] - [R_{31}\text{Sin}(\Phi'-\theta_1)/\text{Cos}\Phi']$ ----------(8)

$R_1 = [(W_1-C'l_3)\text{Sin}\theta_1/\text{Sin}\Phi'] - [C'l_1/\text{Sin}\Phi'] + [(A_{11}-B_{11})/\text{Sin}\Phi'] - [R_{31}\text{Cos}(\Phi'-\theta_1)/\text{Sin}\Phi']$--(9)

(8) = (9) => $R_{31}[(\text{Cos}(\Phi'-\theta_1)) - (\text{Sin}(\Phi'-\theta_1)\text{Tan}\Phi')] = (A_{11}-B_{11}) + (W_1-C'l_3)\text{Sin}\theta_1 - (C'l_1) - [(B_1-A_1) + (W_1-C'l_3)\text{Cos}\theta_1]\text{Tan}\Phi'$

Rearranging and reducing to a simpler form ;

$R_{31} = \{(A_{11}-B_{11}) + (W_1-C'l_3)\text{Sin}\theta_1 - (C'l_1) - [(B_1-A_1) + (W_1-C'l_3)\text{Cos}\theta_1]\text{Tan}\Phi'\}/(\text{Cos}(\Phi'- \theta_1) - \text{Sin}(\Phi'-\theta_1)\text{Tan}\Phi')$ ----------(10)

Set 5) = 10) & remember that : 1 l

$A_1 = E_1(1-L_{1W}/l_1)\text{Sin } \delta_1$	$B_1 = T'N_1\text{Sin}(\alpha+\theta_1)$
$A_{11} = E_1\text{Cos}\delta_1$	$B_{11} = T'N_1\text{Cos}(\alpha+\theta_1)$
$A_2 = E_2(1-L_{2W}/l_2)\text{Sin } \delta_2$	$B_2 = T'N_2\text{Sin}(\alpha+\theta_2)$
$A_{22} = E_2\text{Cos}\delta_2$	$B_{22}= T'N_2\text{Cos}(\alpha+\theta_2)$

$R_{32} = \{(E_2\text{Cos}\delta_2-T'N_2\text{Cos}(\alpha+\theta_2)) + (W_2+C'l_3)\text{Sin}\theta_2 - (C'l_2) - [(T'N_2\text{Sin}(\alpha+\theta_2) - E_2(1 - L_{2W}/l_2)\text{Sin } \delta_2) + (W_2+C'l_3)\text{Cos}\theta_2]\text{Tan}\Phi') / [(\text{Cos}(2\Phi'-\theta_2))/\text{Cos}\Phi']$ ----------(11)

$R_{31}= \{(E_1\text{Cos}\delta_1-T'N_1\text{Cos}(\alpha+\theta_1)) + (W_1-C'l_3)\text{Sin}\theta_1 - (C'l_1) - [(T'N_1\text{Sin}(\alpha+\theta_1)-E_1(1 - L_{1W}/l_1)\text{Sin } \delta_1) + (W_1-C'l_3)\text{Cos}\theta_1]\text{Tan}\Phi'\}/[(\text{Cos}(2\Phi'-\theta_1))/\text{Cos}\Phi']$ ----------(12)

Iterate on F until

$|R_{32}- R_{31}| / [\ |R_{32}| + |R_{31}|\ ] \leq 0.01$

PASSIVE CASE

For passive case, the following assumption are made:

1 - There is no nail force.

2 - Only single failure plane is considered for homogenous soil.

3 - Soil friction angle and cohesion are fully mobilized.

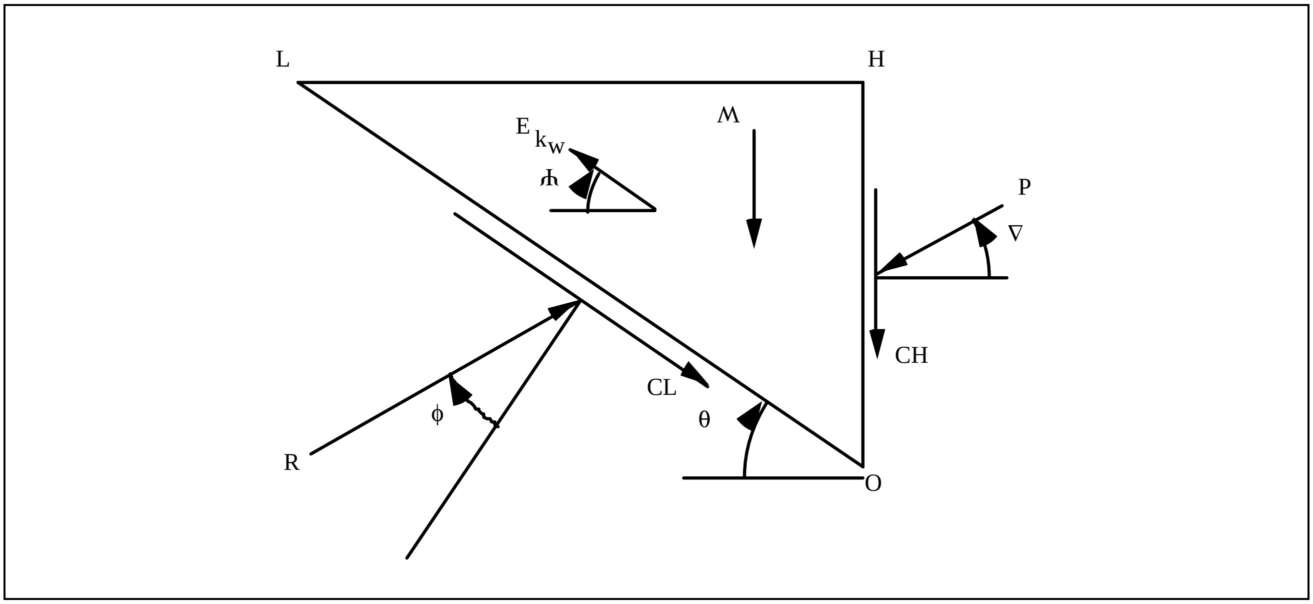


FIGURE 17. MAJOR FORCES AND DIRECTION FOR PASSIVE CASE.

where :

R, E, Ψ = as generally defined from the previous page

P = Passive Force

CH = OH*COH

CL = OL*COH

L = OL; L_W = Submerged length

$\Sigma F_N = 0$

$E(1-L_W/L)\mathrm{Sin}(\Psi-\theta) - (W+CH)\mathrm{Cos}\theta - P\mathrm{Sin}(\theta_1+\Delta) + R\ \mathrm{Cos}\Phi = 0$ ----------(13)

$\Sigma F_T = 0$

$E(1-L_W/L)\ \mathrm{Cos}(\Psi-\theta) - (W+CH)\mathrm{Sin}\theta - CL + P\mathrm{Cos}(\theta_1+\Delta) + R\mathrm{Sin}\Phi = 0$ ----------(14)

From (13) & (14) :

$P\mathrm{Cos}\ (\Delta+\theta_1+\Phi) - (W+CH)\mathrm{Sin}(\theta_1+\Phi) + E(1-L_W/L)\mathrm{Cos}(\Psi-\theta-\Phi) = CL\mathrm{Cos}\Phi$

$P = ((W+CH)\mathrm{Sin}(\theta_1+\Phi) + CL\mathrm{Cos}\Phi - E(1-L_W/L)\mathrm{Cos}(\Psi-\theta - \Phi))\ /\ \mathrm{Cos}\ (\theta_1+\Phi+\Delta)$

(θ varied incrementally to obtain minimum passive resistance).

MODIFICATION TO ALGORITHMS WHEN TWO OR MORE SOIL LAYER EXISTS

In case of multiple soil layers, the wedge is divided into sub wedges (shown below for a two layer system)

$Wi = Wi\ L + Wi\ R \quad (i=1,2)$

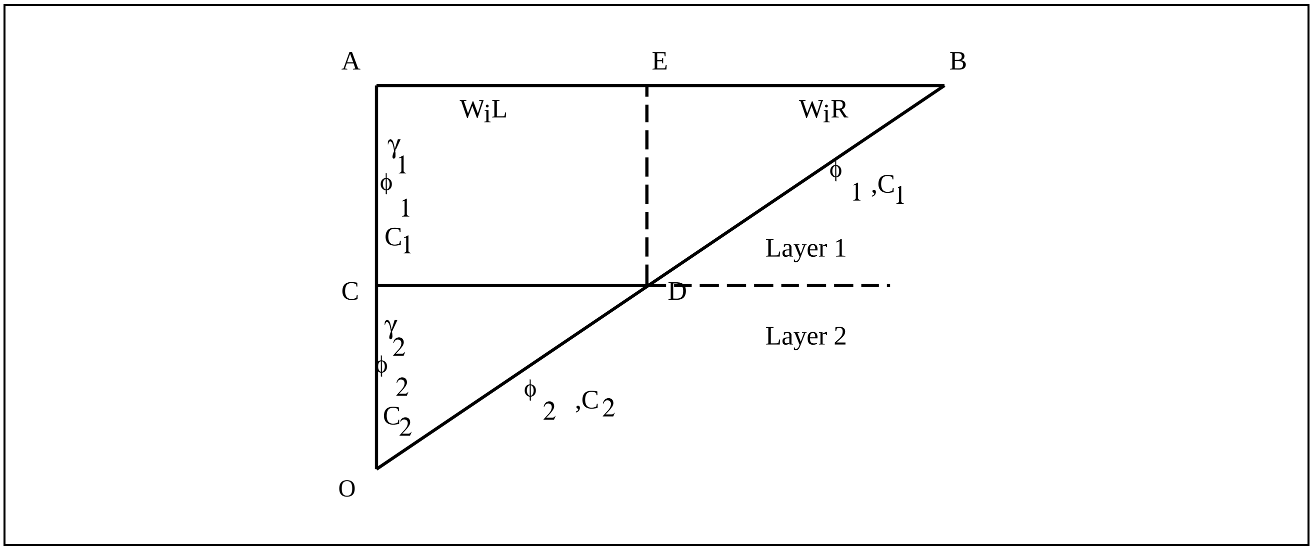


FIGURE 18. SOIL PROPERTIES FOR WEDGE IN TWO SOIL LAYER SYSTEM.

Soil cohesion and frictional angles along the failure plane OB for the subwedges are assigned as shown in the Figure. The interslice forces on vertical plane DE is based on equations (11) and (12). On the interslice plane OA the frictional angle and cohesion is approximated using the average method.

$$\Phi_3 = \tan^{-1}((CA*\tan(\Phi_1)+OC*\tan(\Phi_2))/OA)$$

and $$C_3 = (CA*C_1 + OC*C_2) / OA$$

DEFINITION OF TERMS ON PRINTED COPY

Distance along Toe of Slope	:	Daylight (exit) point of failure surface.
Minimum Factor of Safety	:	Minimum ratio of resisting forces to driving forces on searched failure planes (F).
Distance behind Wall Toe	:	Initiation point of failure plane on surface behind the wall toe.
Lower Failure Plane Angle	:	Angle from horizontal and length of the lower wedge failure plane (θ_2, L_2).
Upper Failure Plane Angle	:	Angle from horizontal and length of the upper wedge failure plane (θ_1, L_1).
Reinf. Stress at level	:	Called design stress (σ_d) and is the stress in the reinforcement at the indicated factor of safety. ($\sigma_d * F = \sigma_{ult.}$ where $\sigma_{ult.}$ is the ultimate capacity of the reinforcement used in evaluating system stability).
(Pullout Controls...)	:	Ultimate capacity of reinforcement is limited by pullout.
(Yield Stress Controls.)	:	Ultimate capacity of reinforcement is limited by bar rupture (FY).
(Punching Shear Controls..)	:	Ultimate capacity of reinforcement is limited by punching shear (PS) at face.
Maximum Horizontal Average Reinforcement Working Force	:	The maximum average working force for all failure planes searched. This information is useful for comparing to field observations. (Limit search to end of reinforcement for internal stability information). Printed value is the average force per member that must be mobilized to just provide system stability (F=1.0 or active state conditions). The force is determined by computing the equilibrium (active state) force and distributing this force equally to all members pierced by the failure plane. A force value of zero represents a stable system without reinforcement. No print out will occur if any portion of the search indicates an $F<1.0$.

ATTACHMENT

SNAILZ, Version 3.XX

An updated copy of Program SNAIL is enclosed for your use and called SNAILZ to differentiate from Ver 2.11. (If questions arise, e-mail to; Ken_Jackura@dot.ca.gov, or call 916-227-7165). The following corrections have been made over V2.11: Viewed metric conversion, and an error in the surcharge under the metric units. Also, iterations for convergence were increased for greater computational accuracy. For running SNAILZ Caps Lock and Num Lock key must be off to scroll through the input data screens. In the Project Description entry location, comma's (,) will not be accepted. Use colons or semi-colons instead. The new version of SNAILZ will no longer accept the old ***.dat** files. The new files are now saved as ***.inp** since changes in the input panel format are different from Version 2.11. The following additional features have been added over V2.11:

1. Seven soil layer system, with layer one starting at top. Layers can be inclined but cannot cross within prescribed search limits. Vertically scroll using arrow key.

2. Three additional slope angles.

3. Piezometric water input values.

4. Inclination to the PD external wall force.

NOTE: ITEMS 5 AND 6 BELOW NOT INCLUDED IN SNAILZ VERSION 3.XX

5. An option (opt. 1) to evaluate your design after initiating the 'run' mode (pressing 'Esc" key) with regard to the maximum design nail force, face pressure, punching shear, and factor of safety at each nail level. Input your design factor of safety. Below toe searches cannot be analyzed in this option, nor does the program evaluate the design without the bottom most nail.

   If Factor of Safety (FS) is insufficient to satisfy input FS, results (shown at end of report) will indicate nail levels and provide approximate punching shear and maximum bar force values using alternate bar diameters necessary to achieve the input FS. However, if bar lengths are insufficient, spacing and/or lengths must be redesigned. Either ultimate or factored bond stress, punching shear, and yield stress can be input (FLAGT=0 or 1). If ultimate values are used, all are divided by the indicated FS. When graphics appear, press B or F to view bar force vs. length. (For FS between 1.0 to 1.2, max. bar force is controlled by pullout in active zone resulting in lower values for bottom most nails; For FS > 1.1, bar forces controlled by system design; i.e., large values of punching shear will result in pullout in resisting zone controlling and large nail forces computed in bottom most nail levels).

6. An option (opt. 2) to have SNAILZ design the nail lengths for you after initiating the 'run' mode (pressing 'Esc' key). Input factor of safety you wish the program to design to, and all input parameters. Bar yield stress and bond stress must be input as prefactored values since this option executes only for FLAGT=1. Initial nail lengths do not have to be included. Minimum default design length for nails are 0.65H or 8 ft (2.4 m) whichever is greater, with lower 1/3 of the nail levels truncated, and minimum nail size = #6 bar or equivalent. Maximum nail length limited to 7H or 150-ft (46-m), whichever is greater. For this version, convergence is set to a tolerance of about 3% and thus, may require some nail length adjustment (primarily to the first level).

   Below toe searches cannot be analyzed in this option, nor does program evaluate design without bottom most nail. Output at end of the report indicates minimum recommended bar length, bar diameter, punching shear and factor of safety, and maximum bar force per level. The minimum punching shear per level is back calculated from location of the peak bar force using the input bond stress. However, always input the maximum punching shear shown on the output at the end of the report in subsequent analyses regardless of which level it is developed. When graphics appear, press B or F to view bar force vs. length.

'Below Toe' searches can only be used with option 3 and are the responsibility of user and require an independent check to satisfy any required FS. Thus, even though SNAILZ will truncate lower nail levels, in certain 'Below Toe' analysis situations this may result in unsatisfactory Factors of Safety and lengthening of the lower nail levels may be required.

Note: For options 1 and 2 under 'run' mode, the minimum permissible bond stress is 0.01 (your units). However, under option 3 in the 'run' mode, the normal computational routine for calculating stability, zero bond stress is permitted for any reinforcement level. Varying the search limits may alter nail forces and face pressures under options 1 and 2. (Program proportionately reduces search limits as it evaluates successively higher nail levels).

7. Under Option 1 in the input panel session, the following applies:

FLAGT=0; All strength parameters (ϕ, C, yield stress, bond stress, & punching shear) are automatically divided by the indicated Factor of Safety (FS).

FLAGT=1; User prefactors yield stress, bond stress, & punching shear. Program divides ϕ and C by indicated factor of safety. If user needs to prefactor ϕ and C also, the user should design system to FS=1.0.

FLAGT=2; Same as FLAGT=1 except vertical component of tie force eliminated due to presence of piles. Check results against FLAGT=1 and use GREATER of indicated factor of safety. If applicable, remember to input pile resistance (K/ft) as a PD force (option 4) of input panel.

8. Although not shown 'how to do it' on the screen, a particular failure plane can be easier to evaluate if you know joining coordinates (X, Y coordinate distances from toe) of the bi-linear wedges. Go to Option 2 and place a '3' in FSEARCH (even though not shown on the input panel): II and JJ are X and Y distances of the bi-linear point from toe, respectively (toe = 0,0), for searches at toe. Daylight point at top of slope can be easily specified by inputting LA = 10 and LB = 10 since search will only be at maximum search limit specified under, "3. SOIL PARAMETERS."

For 'Below Toe Searches,' all below toe search depths taken as y = 0.0, thus your JJ must be adjusted accordingly.

9. Converting data file from English to metric, or metric to English. When first starting up SNAILZ, and the first option screen appears where choice of;

1. From English to English measurement system.
2. From English to metric measurement system.
3. From metric to metric measurement system.

occurs, you can also convert the input file from English to an input file in metric by selecting '5,' or from metric to English by selecting '4' even though only 1, 2 or 3 is shown, by doing the following:

a) Call up or make data file that is in English units if '5' selected; metric units if '4' selected;

b) Save as new file after hitting 'ESC,'

c) Quit and restart SNAILZ but select ‘3’ (metric to metric) if ‘5’ originally selected; or ‘1’ (English to English) if ‘4’ originally selected, and call up the newly saved file.

.

PRINTING GRAPHICS

10. If running in Windows 3.1 or Windows 95 and Microsoft Office installed, a screen dump will not directly work and the following provides a number of choices of printing SNAILZ’s (or other programs) visual graphics.

A. Microsoft Office for the factory installed Windows 95 or later comes with several programs to print graphics after hitting the ‘Print Screen’ key; Powerpoint and Paint. Windows 3.1 comes only with Powerpoint V-4.2 or earlier versions.

1. **Windows 3.1 or Windows 95 upgrade using DOS 6.1 and Microsoft Office ver. 4.2 or earlier**. Execute SNAILZ and hit the ‘Print Screen’ key after the screen graphics appear. This saves the view in CLIPBOARD. Hit the Alt-Tab keys to get back to file manager (Windows 3.1), or DeskTop (Windows 95). If in Windows 3.1 call up POWERPOINT from the Microsoft Office ICON (or file manager). Go to Blank Presentation and choose any of the AutoLayout schemes after opening and hit OK. Go to Edit and select Paste. The view will be transferred to the AutoLayout. Size to fit through the mouse, or go to Draw and choose scale. Select Recolor under Tools, and change Black to White, White to Black if saved in the B/W mode while in SNAILZ; or change colors to suit your printer if view saved in color mode. (In certain PC configurations it is sometimes necessary to quit SNAILZ rather than getting back to DeskTop through the Alt-Tab keys for some of the original colors in the color view to be saved. **Make sure Display Settings under Control Panal is set on 256 colors**).

2. **Factory installed Windows 95 and later with DOS 7.0, and Microsoft Office 95 and later**. Microsoft Office’ POWERPOINT will not support the recolor option and Microsoft’s Photo Shop program will be required for recoloring. However, the image can be printed directly through the Microsoft program PAINT that comes with these versions of Windows 95. Create a shortcut icon for PAINT and open. On the menu bar at the top of the screen, click on Image, go to Attributes and click defaults for Units, and B/W for Color. After clicking OK and YES, go to Edit and hit Paste. After the screen image appears, go to Image and click on ‘Invert Colors’ (provided the SNAILZ screen image was saved in the B/W mode). A dashed line will boarder the image and while in this mode use the mouse (double arrows) to grab the upper left hand corner and move the image horizontally and vertically to center before printing.

(Note: Reinstalling the POWERPOINT ver 4.2 into a new subdirectory within the existing directory through the ‘Custom Install’ feature will provide benefits of both versions. Create the new sub directory (different name than what exists) prior to the ‘Custom Install’ execution, and install only the ver 4.2 files for POWERPOINT. Operation than becomes the same as in ‘1’ above.)

3. **Windows NT with Microsoft Office’s Photo Editor (ver. 3.0)**

Search for the Photo Editor through your find command and bring out the shortcut icon unto your Desktop and execute. Execute SNAILZ and bring up the image (Color or B/W). Press hard several times on the ‘Prn Scrn’ key otherwise garbage symbols or nothing is captured (why this is necessary is a mystery but it might be due to a Microsoft programming problem), hit the alt-tab key to get back to the photo editor and click on ‘Paste Special’ under edit in the menu bar. If not highlighted go back to SNAILZ through the alt-tab buttons and press hard several times on the ‘prn scrn’ key again and than back into photo editor as above. To reverse the colors for printing click on ‘negative’ under effects in the menu bar, than ok for the colors. Edit or size while here and click on ‘copy’ under edit, than click on ‘new’ under file (or its icon) and ‘paste’ the recently copied image. Once highlighted, the image can be centered by dragging to the appropriate position. Print using only the print icon symbol (print option under file generally brings an error - another probable programming error). You can also save the image as a *.? file right after the image is reversed after bringing into photo editor and then opened into Microsoft Word or Powerpoint for printing.

B. **Alternative 'Print Screen' software programs**.

1. SnagIt from Techsmith Corporation is made especially for Windows 95-98 to screen capture your image and can be downloaded from the internet for a free 45 day trial. Cost is $39.95. Internet address is http://www.techsmith.com. Download and keep open on Desktop to load image. On menu bar for snagit under input check 'Full Screen DOS'; under filters check 'Custom Color Resolution' and 'Invert Colors', and under tools 'Image Capture'. When SNAILZ image appears hit the Prn Scrn key and the image immediately shows up. Scaling or other changes can easily be made or customized for your print output in color or B/W.

2. Another program available for supporting a screen dump is "SCREENPRINT Gold 2.5". Purchase price is $39.95 and most computer software outlet stores carry it. (If not write the company; The Software Labs, Inc., P.O. Box 692, Redmond, Wa 98073). This program has the advantage of storing many images for later editing or printing and is quite useful in supporting the sending of graphics by e-mail. If purchased, make sure the configure setting under 'Setup' is correct (Capture Only, Negative, and Capture DOS Graphics Screen labels are checked). After executing SNAILZ and changing the screen image to B/W, hit the 'Print Screen' key and, most important, the Ctrl-Alt-P key to save the image to a thumbnail. Each image must be selected in this same way for full screen DOS based program images (the manual doesn't tell you this). Printing can then be normally executed

C. **Developing a 'Start-Up Disc' for the "A" drive using DOS 6.1 commands**. A little more basic, but tricky method that works quite well (and speeds up computational time 2-3 fold) is to make a systems disc for the "A" drive using another PC with DOS 6.1 still resident, and use the disc for booting off the "A" drive in the PC that's running the Windows 95-98 operating system. Add the following files to the system disc from the DOS directory after the system disc is made: Drvspace.bin; Edit.com; Graphics.com; Ansi.sys. Also needed are the Autoexec.bat and the Config.sys files. The following works well for these two files on a DELL PC, 266mhz, Pentium II math co-processor and factory loaded Windows 95 operating system. For the Autoexec.bat the following was written:

```
SET BLASTER=A220 I5 D1 T4
SET MSINPUT=C:\MSINPUT
SET WIN32DMIPATH=C:\DMI\
PATH=C:\DESKJET;C:\MOUSE
SET NWLANGUAGE=ENGLISH
GRAPHICS DESKJET
MOUSE
```

and the following for the Config.sys:

```
FILES=20
BUFFERS=20
DOS=HIGH, UMB
DEVICE=A:\ANSI.SYS
```

Reboot and after the "A:\" prompt sign appears, change to the "C" drive and call up the directory SNAILZ is resident in and execute. If your printer is not a deskjet, consult your old DOS manual for the proper call name specific to the printer you are using. With this setup, not only are computional time reduced, but graphics and text can be directly printed by striking the 'Print Screen' key.

(NOTE: If booting off the "A" drive is undesirable, the following greatly helps in reducing computational time; remark out the DEVICE or

DEVICEHIGH=.....\EMM386.EXE NOEMS command from your config.sys file and reboot if running in Windows 3.1.
NOTE: If running in Windows 95-98, quit and restart in DOS mode by hitting the F8 key during restart and choose option 6. Use DOS commands to take you to the directory where SNAILZ resides and execute. This also will speed up execution time.)

NOTE: THIS PROGRAM WILL BE PERIODICALLY UPDATED UNTIL ALL OPTIONS ARE COMPLETED. PLEASE ACCESS FOLLOWING INTERNET ADDRESS FOR UPDATES AND/OR CORRECTIONS.

INTERNET ADDRESS: http://www.dot.ca.gov/hq/esc/geotech