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16. Abstract

Swelling and shrinkage of sub-grade soils are critical factors contributing to increases in roughness and degradation of serviceability of highway pavements. Existing procedures for predicting swell are largely based on the potential vertical rise (PVR) procedure developed by McDowell in 1956. While the PVR procedure represents a major development in the design of pavements on expansive soils, instances of apparently over-conservative PVR predictions have led some designers to suggest revision or replacement of the existing procedure. This project reviews the basic assumptions of the existing PVR procedure and identifies the likely sources of the questionable predictions that have arisen in the past. An alternative procedure is presented that features rigorous modeling of both the moisture diffusion process that induces changes in suction within a soil mass and the deformations that occur in response to changes in suction. This alternative procedure includes provisions for measuring and/or estimating soil and environmental input parameters necessary for the predictions. A procedure for predicting the impact of soil deformations on pavement performance is also presented. The proposed procedure is applied to three study sections involving Texas roadways on expansive soils, and parametric studies are presented evaluating the effectiveness of various design measures including moisture barriers, lime treatment, and replacement of in situ sub-grade soils with "inert" soils.

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DESIGN PROCEDURE FOR PAVEMENTS ON EXPANSIVE SOILS: VOLUME 3

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DISCLAIMER

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WINPRES

USER MANUAL

Version 1.0

1. INTRODUCTION

This manual is a guide to using WinPRES, which is the developed Windows® version of the program PRES. The Appendix of this manual includes some examples to show the user how to input data and how to get output answers.

A simple model was developed to estimate the vertical movement at any point in a pavement in order to correlate the vertical movement to the roughness measurements made in different wheel paths of the pavement sections. Another model was developed to predict the pavement roughness in terms of serviceability index (SI) and international roughness index (IRI) by correlating regression constants obtained from the roughness analysis to the vertical movement estimated from the vertical movement model.

The vertical movement model and the roughness model developed were then assembled in the program PRES written in the Fortran language. The input data are entered to the program through a Windows graphical user interface developed using a Visual Basic tool. PRES is a model to estimate the development of pavement roughness on expansive soil subgrades, including the effects of the depth of a vertical moisture barrier and the thickness of inert and stabilized soil, if desired.

2. MAIN DIALOG WINDOW

When you launch WinPRES, the main dialog box (Fig. 1) appears, which has a logo and toolbar menu. These menus are displayed across the top of the screen as: File, Run, and Help.

Figure 1. Main Dialog Box.

2.1 The File Menu

The File menu is universally used to start a new project, open an existing project, save, save as, print, and exit (Fig. 2).

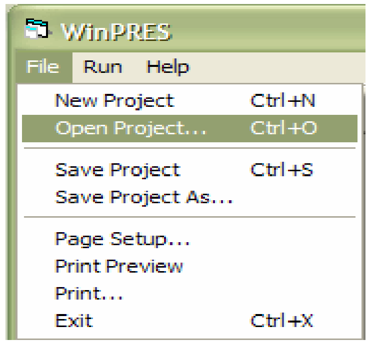


Figure 2. File Menu.

2.2 The Run Menu

The Run menu runs PRES.exe, which is the executable file written in the Fortran language (Fig. 3).

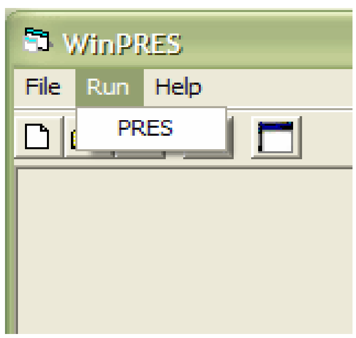


Figure 3. Run Menu.

2.3 The Help Menu

The Help menu (Fig. 4) is used only to look at the About WinPRES dialog box (Fig. 5). The program and system information are presented in this box.

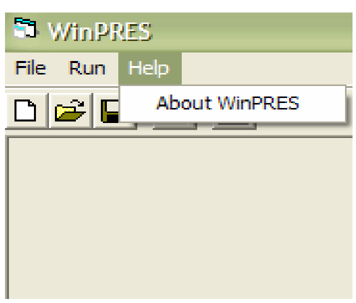


Figure 4. Help Menu.

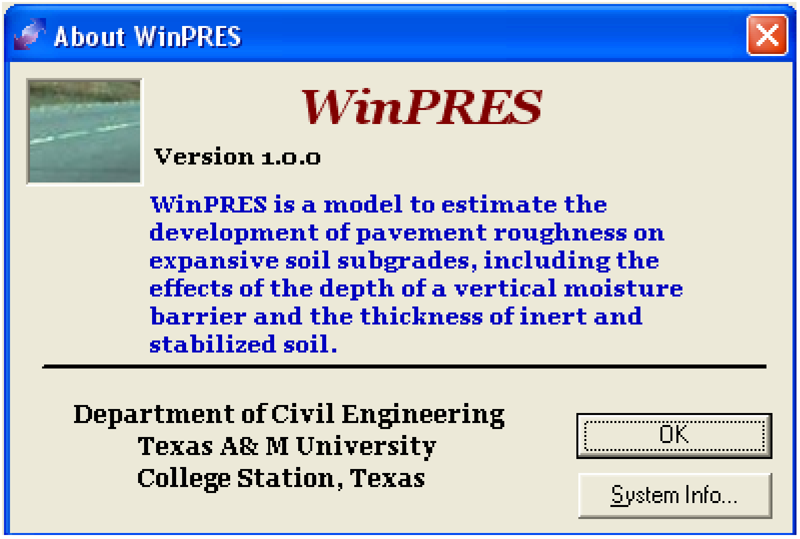


Figure 5. About WinPRES.

3. INPUT DIALOG BOX

The INPUT dialog box has eight tabs: Project Information, Units and Pavement Types, Environmental and Geometric Conditions, Soil Properties, Barrier and Wheel Path, Structural Properties of Pavement, Traffic and Reliability, and Roughness (Fig. 6).

To gain experience in using this program, the user is encouraged to modify one of the existing example problems.

3.1 Project Information

This screen is used to specify or modify the project name, date, CSJ number, and Project Engineer (Fig. 6).

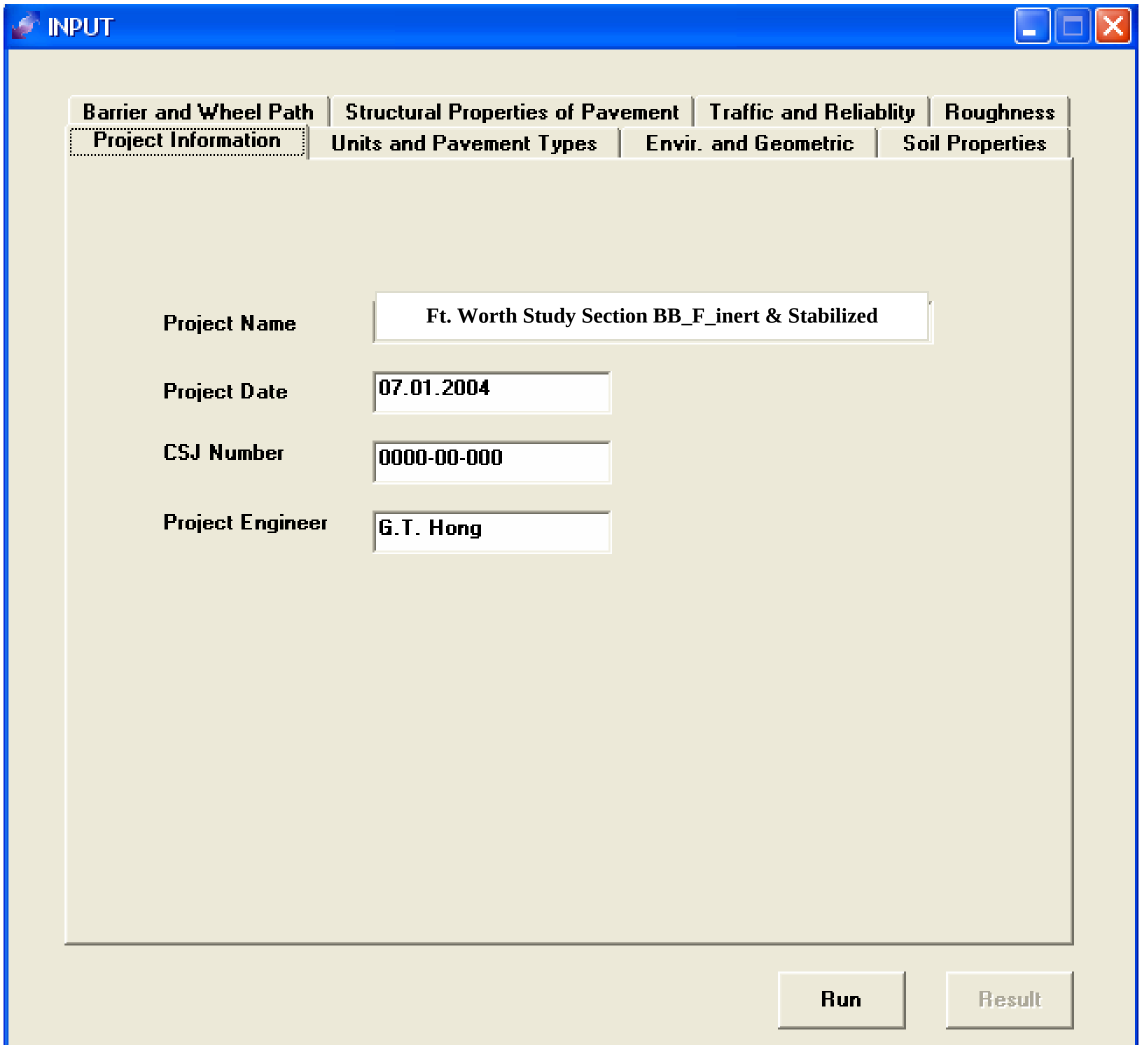


Figure 6. INPUT Dialog Box.

3.2 Units and Pavement Types

This screen allows the selection of the units of measurement and pavement types (Fig. 7).

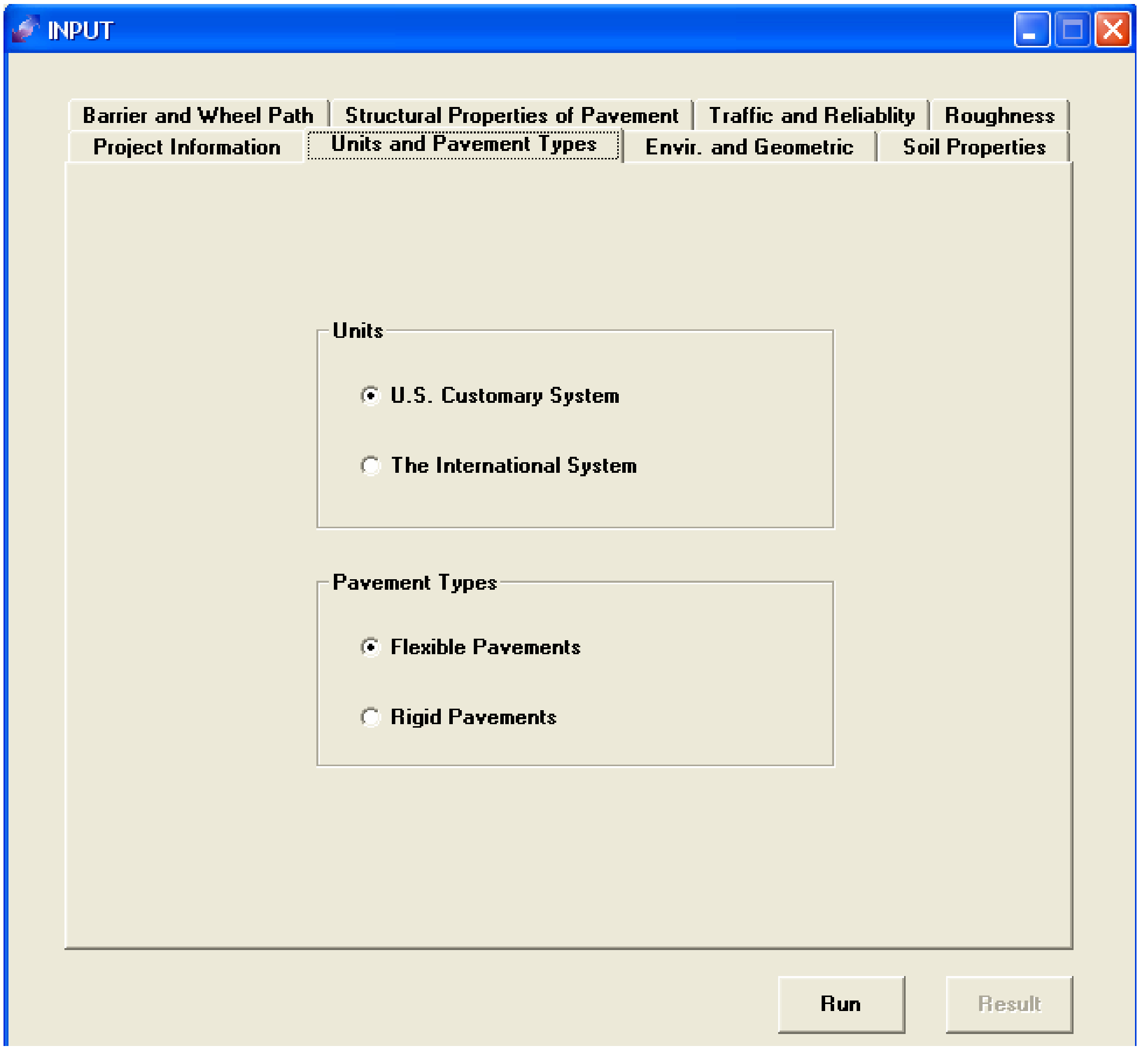


Figure 7. Units and Pavement Types.

3.3 Environmental and Geometric Conditions

This screen is used to enter the climatic data, drainage condition, and field conditions for a project (Fig. 8).

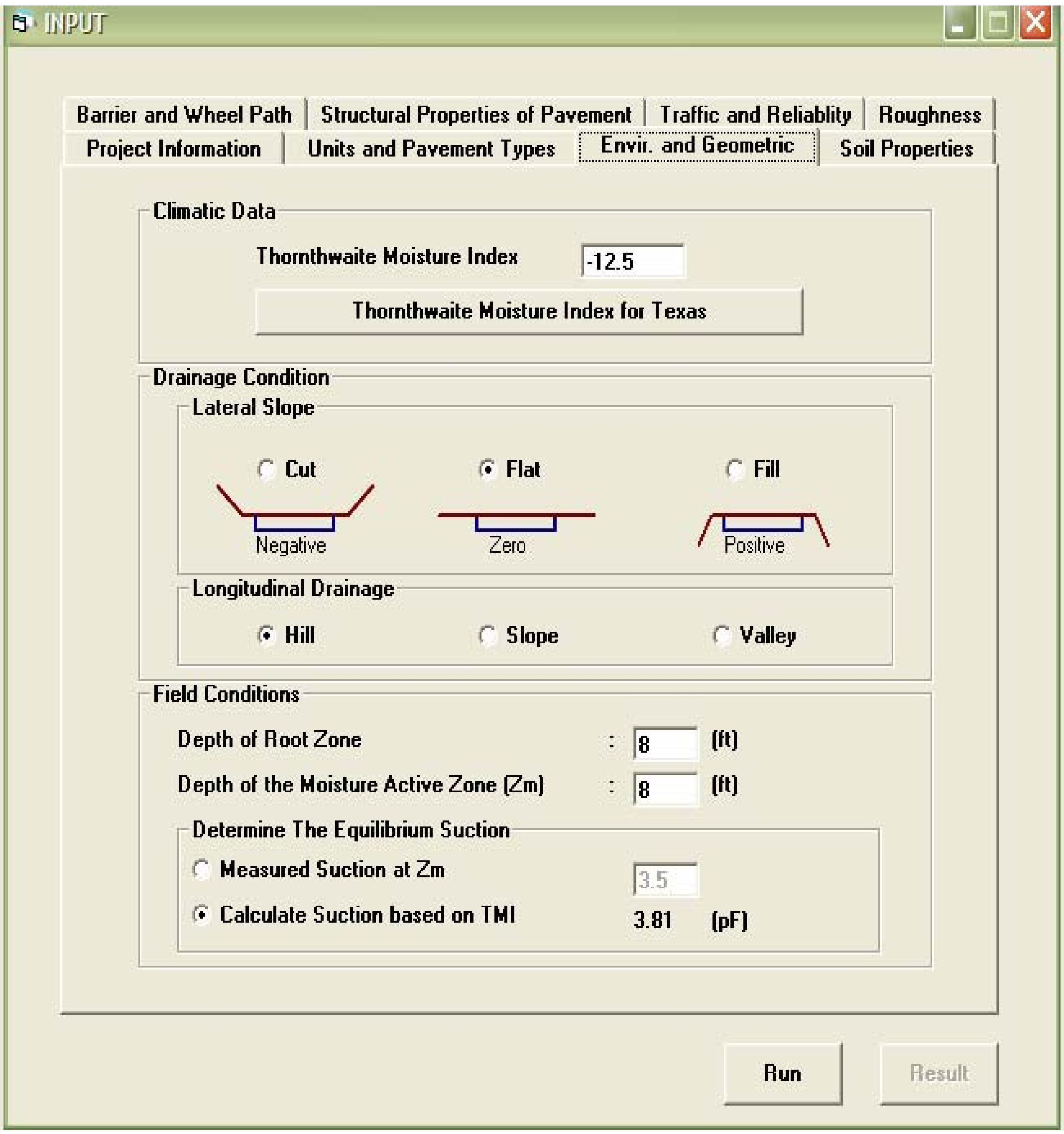


Figure 8. Environmental and Geometric Conditions.

Step 1 – Enter the Thornthwaite Moisture Index (TMI) based on the values shown on the map of Texas (Fig. 9) by clicking the button 

(Fig. 8). Thornthwaite Moisture Index is used to characterize the climate in the project site. Historical mean of TMI is available through maps containing spatial distributions of TMI. The TMI map of Texas was taken from the dissertation Development of a Design Procedure for

Residential & Light Commercial Slabs-On-Ground Constructed over Expansive Soils by W. K. Wray (1978).

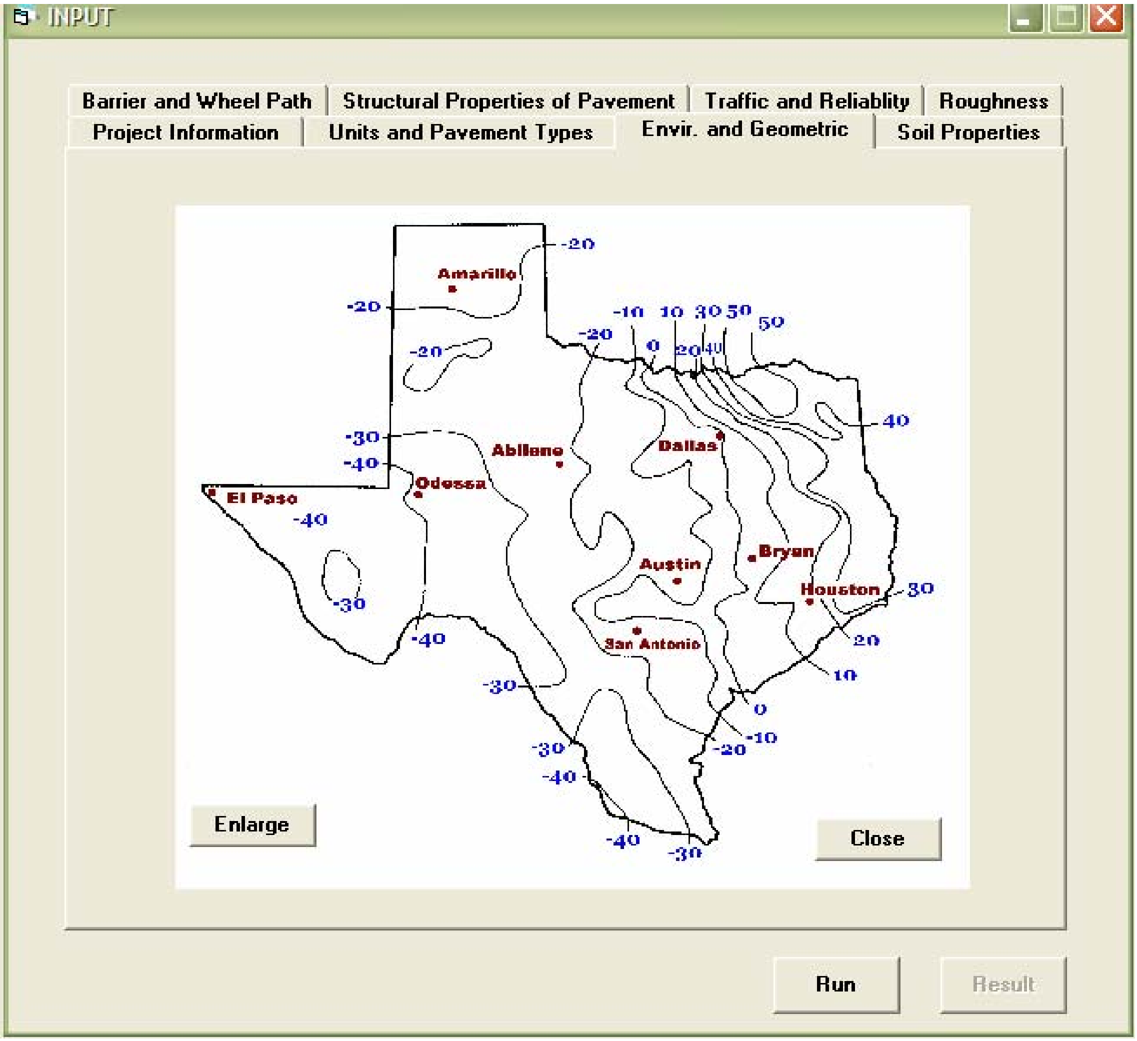


Figure 9. Thornthwaite Moisture Index Map of Texas.

Step 2 – Select the roadway drainage condition for both the lateral slope and longitudinal drainage (Fig. 8).

Generally, the minimum and maximum suction (pF) at the surface of a site is considered as the suction at the field capacity (wettest soil in the field), 2.0 pF and wilting point, 4.5 pF, respectively. The pF is defined as:

$$pF = \log_{10} |h| \qquad (1)$$

where $|h|$ is the magnitude of suction in cm of water.

The suction at the field capacity should be adjusted with lateral slope and longitudinal drainage conditions of the pavement. The lateral slope conditions used are cut, flat, and fill as shown in Figure 8. The longitudinal drainage conditions used are hill, slope, and valley. The minimum suction at the surface for different drainage and slope conditions are given in Table 1. As a minimum suction determined corresponding to the drainage conditions at a site is lower, potential swelling is greater.

Table 1. Minimum Suction (pF) for Different Slope and Drainage Conditions.

Longitudinal Drainage	Lateral Slope		
	Cut	Flat	Fill
Hill	2.3	2.5	2.6
Slope	2.0	2.2	2.3
Valley	2.0	2.2	2.3

Note : For Thornthwaite Moisture Index (TMI) greater than +10.0, the values in the table are used. For $-20.0 \leq TMI < 10.0$, 0.2 is added to the values in the table. For TMI less than -20.0, 0.4 is added to the values in the table.

Step 3 – Enter values for the depth of root zone and depth of the moisture active zone (Zm). The equilibrium suction, Ue, can be determined by selecting the option Measured Suction at Zm or Calculate Suction based on TMI, which is an approximated suction value based on the regression equation (Eq. 2) for the relation between field data and TMI.

$$Ue = 3.5633 \exp(-0.0051 TMI) \quad (2)$$

Depth of root zone is needed at the site that has some trees near the edge of the pavement. Depth of the moisture active zone (Zm), the deepest depth for possible moisture flow, is assumed as a point where equilibrium suction begins. Maximum suction at the site should be the wilting point 4.5 (pF) up to the depth of the root zone. The value of equilibrium suction at the site can be measured or considered as a calculated suction based on TMI, which is an approximated suction value based on the regression equation for the relation between field data and TMI.

3.4 Soil Properties

This screen is used to specify the individual soil layer data acquired from testing field samples (Fig. 10). Type of soil layer, thickness, dry unit weight, liquid limit (LL), plasticity index (PI), % passing less than #200 sieve, and % passing less than 2μm are required. Lime or cement as a stabilizing material should be added when adding a stabilized soil layer.

Inert soil can typically be described as a soil borrowed and brought in from an offsite location that has much less expansive properties than the existing subgrade. Typically this would mean a soil with a PI of less than 15. The input values of the stabilized soil are the values of the untreated soil. The algorithm within the design program will alter the LL and PI based upon the percent of stabilizing agent (lime or cement) that is used.

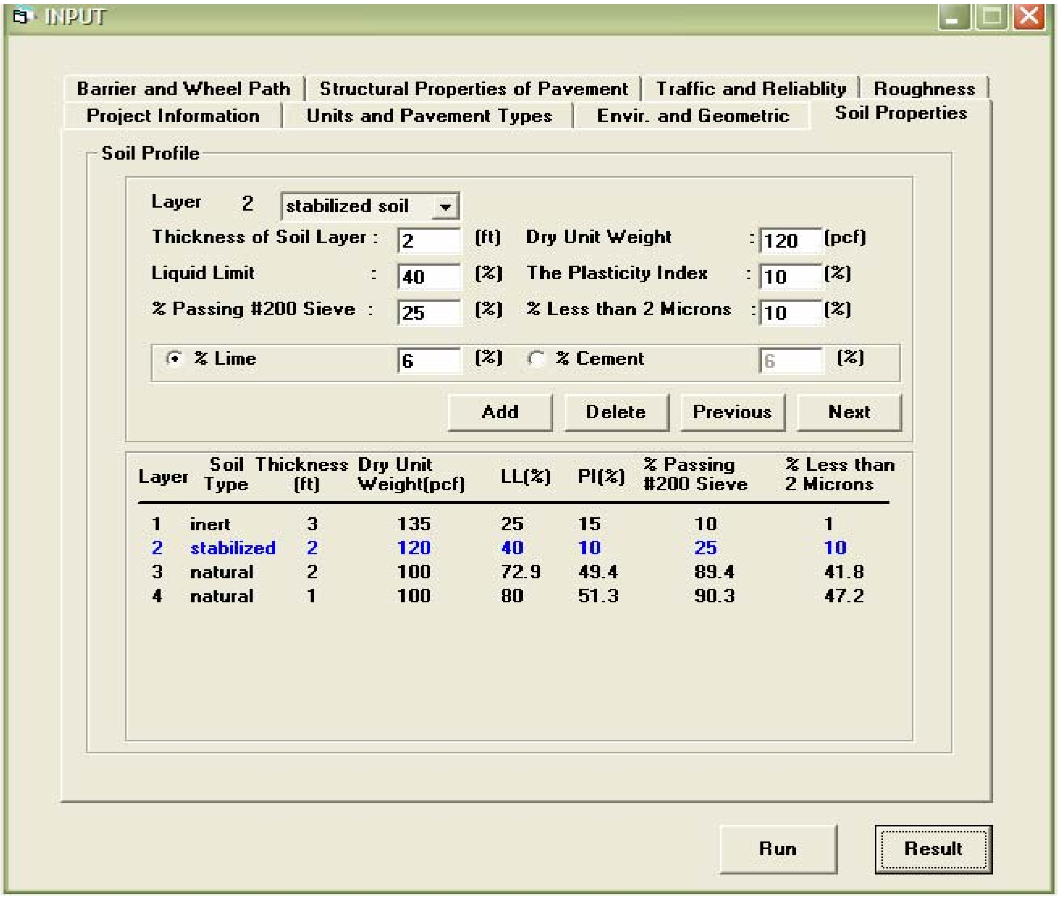


Figure 10. Soil Properties.

Step 1 – Specify or modify the soil properties of each layer by entering the test data in each text box. Move into the previous or next layer by using these buttons 

and add or delete a layer by using these buttons 

.

Step 2 – If stabilizing a layer, select the options for lime or cement as an additional stabilizing material and enter the percent by weight of the material for stabilization of a subgrade soil.

Step 3 – Review the input data displayed in the bottom half of the screen and correct if needed.

3.5 Barrier and Wheel Path

This screen is used to specify the depth of vertical moisture barrier if used and a vehicle wheel path of most concern (Fig. 11).

The Texas Department of Transportation has been using vertical moisture barrier for several years in pavement sections where repeated maintenance work due to expansive clay activity has been reported. A typical value of 8.0 ft can be used for the vertical moisture barrier in the state of Texas.

Depth of vertical moisture barrier recommended does not exceed the depth of moisture active zone, if used. Width of pavement and the distance from the center of pavement to the wheel path of most concern are required.

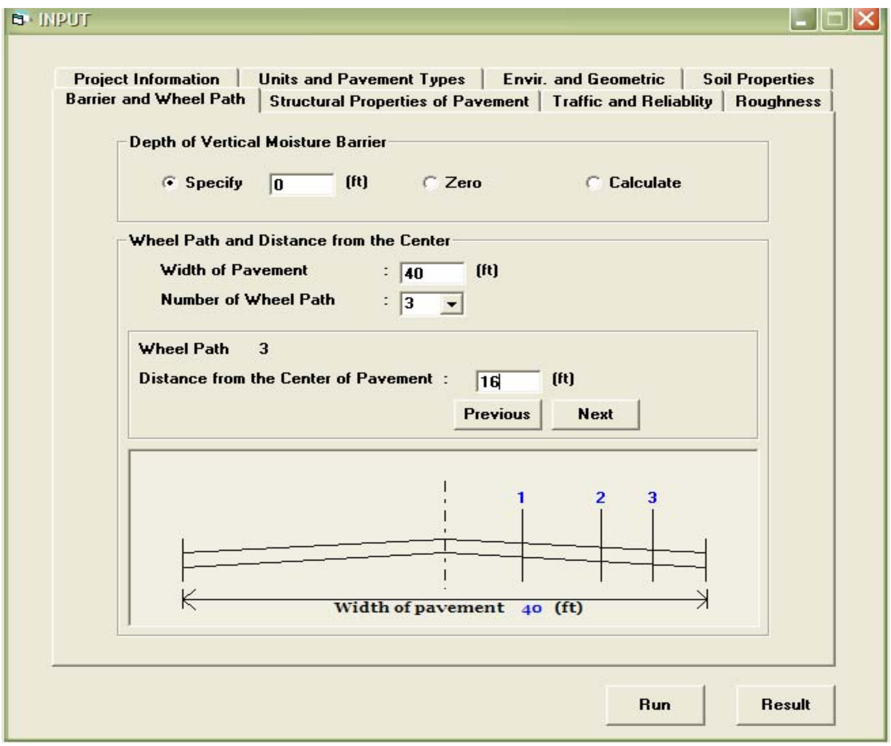


Figure 11. Barrier and Wheel Path.

Step 1 – Select one of the options, Specify, Zero, or Calculate for the depth of vertical moisture barrier. Enter a number in the text box (Fig. 11) when selecting the option Specify. Input the terminal roughness information on the Roughness tab when selecting the option Calculate.

Step 2 – Enter the width of pavement and determine the number of wheel paths by using the input box 3 . Input the distance from the roadway centerline for each wheel path. Check each distance input from the diagram, which automatically plots the wheel paths.

3.6 Structural Properties of Pavement

These screens require the input of pavement specific data.

3.6.1 Flexible Pavements

The structural number (SN) and falling weight deflectometer (FWD) modulus of subgrade soil (from the drop weight closest to the 9k load) are needed.

Step 1 – Select the options Specify or Input Thickness of the Surface, Base, and Subbase to input the structural number of pavement (Fig. 12).

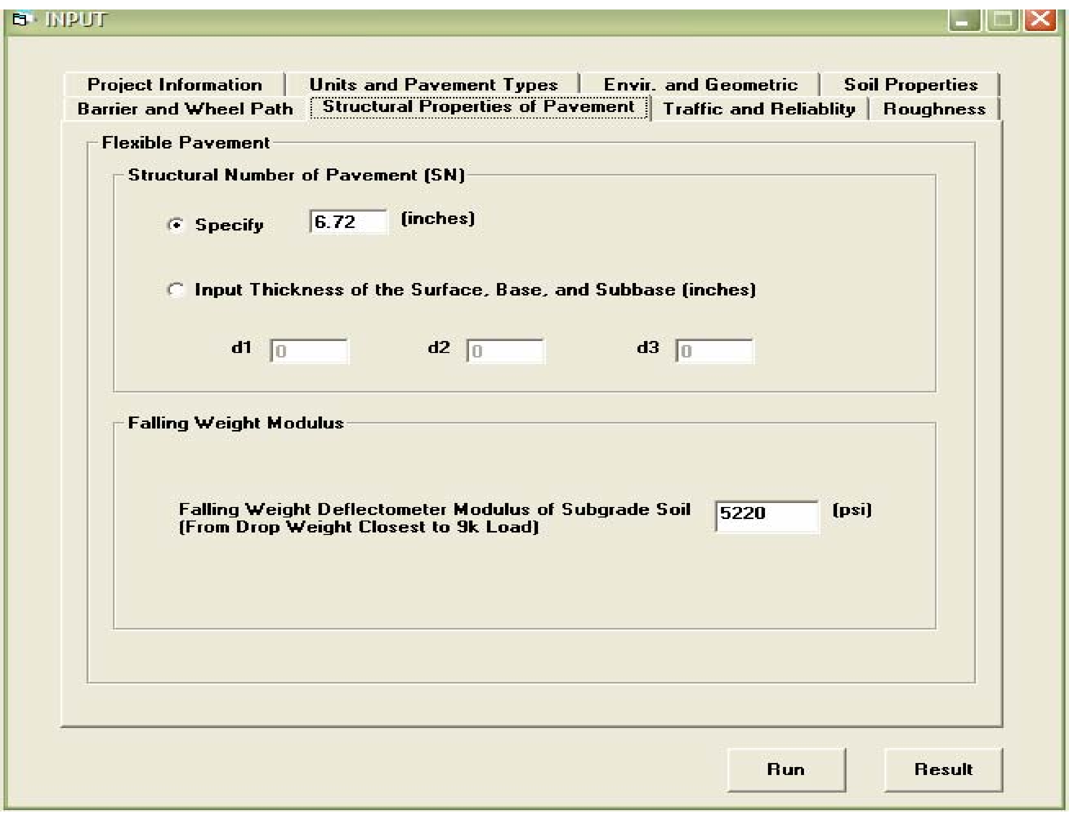


Figure 12. Structural Properties of Flexible Pavements.

Structural number of flexible pavement is computed by:

$$SN = a_1 D_1 + a_2 D_2 + a_3 D_3 \qquad (3)$$

where

a_1, a_2, a_3 = layer coefficients for the surface, base, and subbase, respectively

D_1, D_2, D_3 = the thickness of the surface, base, and subbase, respectively.

Step 2 – Enter the FWD modulus of subgrade soil (from the drop weight closest to the 9k load).

3.6.2 Rigid Pavements

For the case of rigid pavements, there are six input parameters: the slab thickness, 28-day compressive strength of concrete, mean modulus of rupture of concrete, falling weight deflectometer modulus of subgrade soil (from the drop weight closest to the 9k load), drainage coefficient, load transfer coefficient, and terminal serviceability index (Fig. 13).

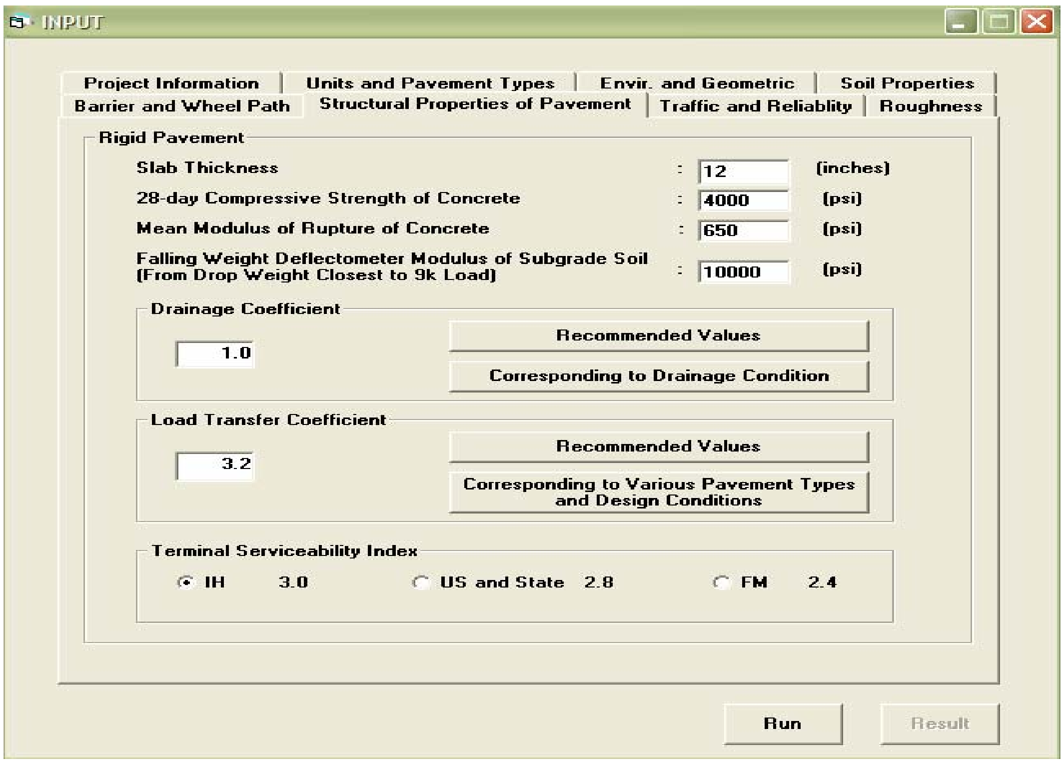


Figure 13. Structural Properties of Rigid Pavements.

Step 1 – Enter the slab thickness, 28-day compressive strength of concrete, mean modulus of rupture of concrete, and falling weight deflectometer modulus of subgrade soil (from the drop weight closest to the 9k load).

The following explanation of modulus for rigid pavement was taken from the textbook pavement Analysis and Design by Y. H. Huang (Prentice Hall) 2nd Edition, p. 573:

> "The property of roadbed soil to be used for rigid pavement design is the modulus of subgrade reaction k, rather than the resilient modulus M_R. If the slab is placed directly on the subgrade without a subbase, AASHTO (American Association of State Highway and Transportation Officials) suggested the use of the following theoretical relationship based on an analysis of plate bearing test: "

$$k = \frac{M_R}{19.4} \quad (k \text{ is in pci and } M_R \text{ is in psi}) \qquad (4)$$

Step 2 – Enter the drainage coefficient by selecting the recommend values (Fig. 14) by clicking Recommended Values or determining the value corresponding to drainage conditions (Fig. 15) by clicking Corresponding to Drainage Condition

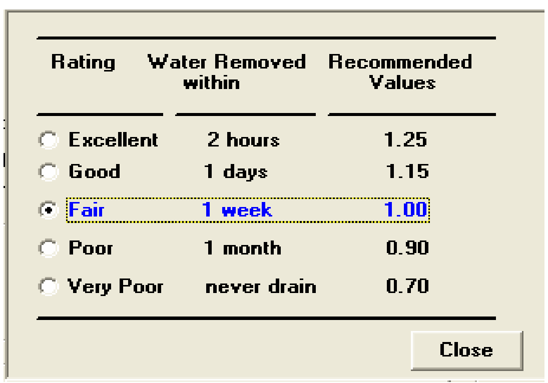


Figure 14. Recommended Values for Drainage Coefficient in Rigid Pavements.

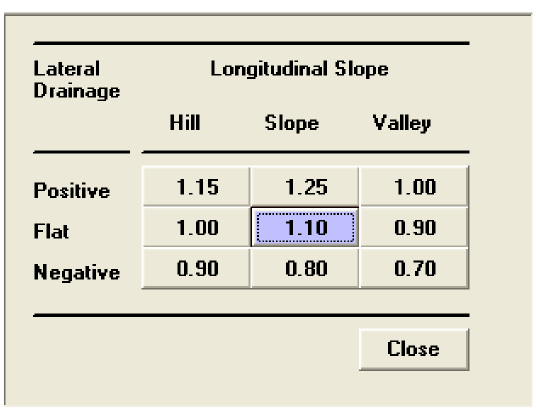
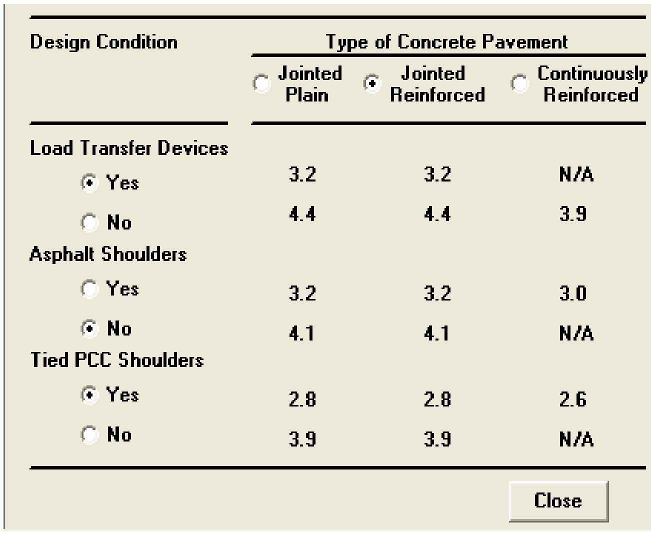


Figure 15. Drainage Coefficient Corresponding to Drainage Conditions.

Step 3 – Enter the load transfer coefficient by selecting the recommended values (Fig. 16) by clicking Recommended Values or determining the value corresponding to various pavement types and design conditions (Fig. 17) by clicking the button Corresponding to Various Pavements Types and Design Conditions.

Rating	Recommended Values
Excellent	2.3
Good	2.9
Fair	3.2
Poor	3.8
Very Poor	4.4

Figure 16. Recommended Values for Load Transfer Coefficient in Rigid Pavement.



Design Condition	Type of Concrete Pavement: Jointed Plain	Jointed Reinforced	Continuously Reinforced
Load Transfer Devices			
Yes	3.2	3.2	N/A
No	4.4	4.4	3.9
Asphalt Shoulders			
Yes	3.2	3.2	3.0
No	4.1	4.1	N/A
Tied PCC Shoulders			
Yes	2.8	2.8	2.6
No	3.9	3.9	N/A

Figure 17. Load Transfer Coefficient Corresponding to Various Pavement Types and Design Conditions in Rigid Pavements.

Step 4 – Select the roadway type option, IH, US and State, or FM, as a terminal serviceability index (Fig. 13).

3.7 Traffic and Reliability

Traffic analysis and reliability data are used to calculate serviceability index and international roughness index loss for a traffic analysis period.

Step 1 – Enter the traffic analysis period (C), average daily traffic in one direction T_k =0 (r_0) and average daily traffic in one direction T_k =C (r_c), and 18 kip single axles T_k =C (N_c) for each wheel path (Fig. 18).

The 18 kip single-axle load applications (W_{18}) can be calculated from the following traffic equation used by the Texas Department of Transportation.

$$W_{18} = \frac{N_c}{C\left(r_0 + r_c\right)}\left[2r_0 t_k + \left(\frac{r_c - r_0}{C}\right)t_k^{\ 2}\right] \qquad (5)$$

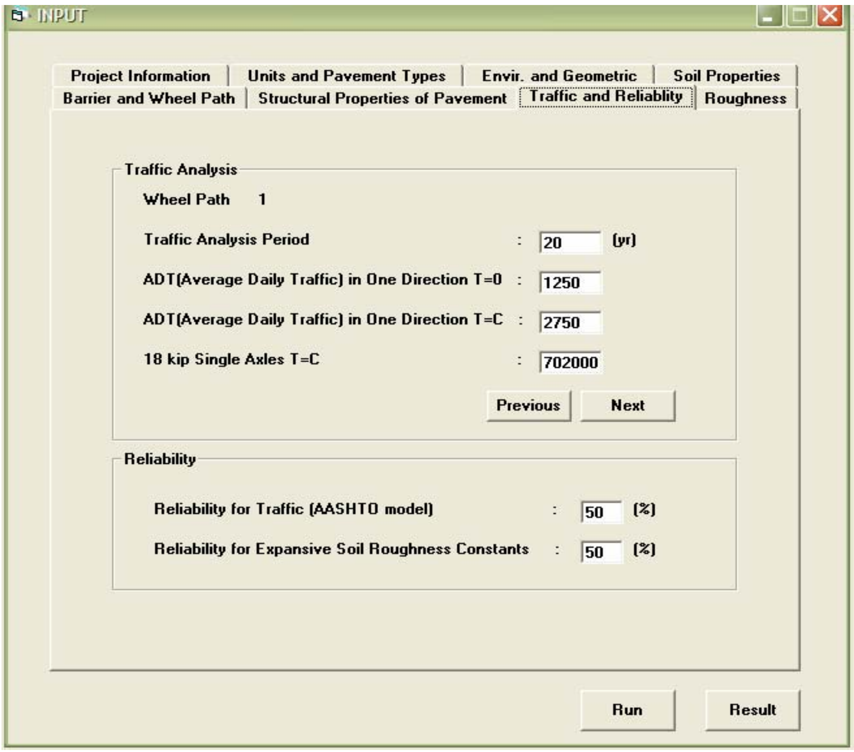


Figure 18. Traffic Analysis and Reliability.

Step 2 – Enter the reliability for traffic and expansive soil roughness constants.

The following explanation of reliability was taken from the textbook Pavement Analysis and Design by Y. H. Huang (Prentice Hall) 2nd Edition, pp 507-508:

> "Reliability is a means of incorporating some degree of certainty into the design process to ensure that the various design alternatives will last the analysis period. The levels of reliability to be used for design should increase as the volume of traffic, and public expectation of availability increase".

The following table presents recommended level of reliability for various functional classes.

Table 2. Suggested Levels of Reliability for Various Functional Classifications.

Functional Classification	Recommended Level of Reliability	
	Traffic (After AASHTO, 1986)	Expansive Soil
for prediction	50%	50%
for design		
Interstate and other freeways	85 – 99.9 %	80 – 99.9 %
Principal arterials	80 – 99.0 %	75 – 95.0 %
Collectors	80 – 95.0 %	75 – 95.0 %
Local	50 – 80.0 %	50 – 80.0 %

* AASHTO, 1986. Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials.

The 50 percent reliability level that is used for prediction uses the formula in predicting the expected value of the ride quality or roughness, without taking into account the variability of the input data.

3.8 Roughness

The initial and terminal roughness are required on this screen (Fig. 19). The serviceability index and the international roughness index are widely used to estimate the roughness of pavement. The serviceability performance concept in the design of pavements emerged from the AASHTO road test. In the AASHTO road test, the serviceability of pavements was rated subjectively by a panel made up of individuals selected to represent many important groups of highway users. The mean of the individual ratings was defined as the present serviceability rating (PSI), and it was a number between zero and five. The international roughness index emerged from the International Road Roughness Experiment (IRRE) held in Brasilia, Brazil in 1982. The IRI is based on the roadmeter measure, and has units of slope such as m/km or in/mile. The IRI is influenced by wavelengths ranging from 4.0 ft (1.2 m) to 100 ft (30 m) and is linearly proportional to roughness.

Terminal roughness information is required if the user wants to calculate the depth of vertical moisture barrier required.

Step 1– Enter the initial serviceability index and international roughness index and years roughness calculation required for each wheel path (Fig. 19).

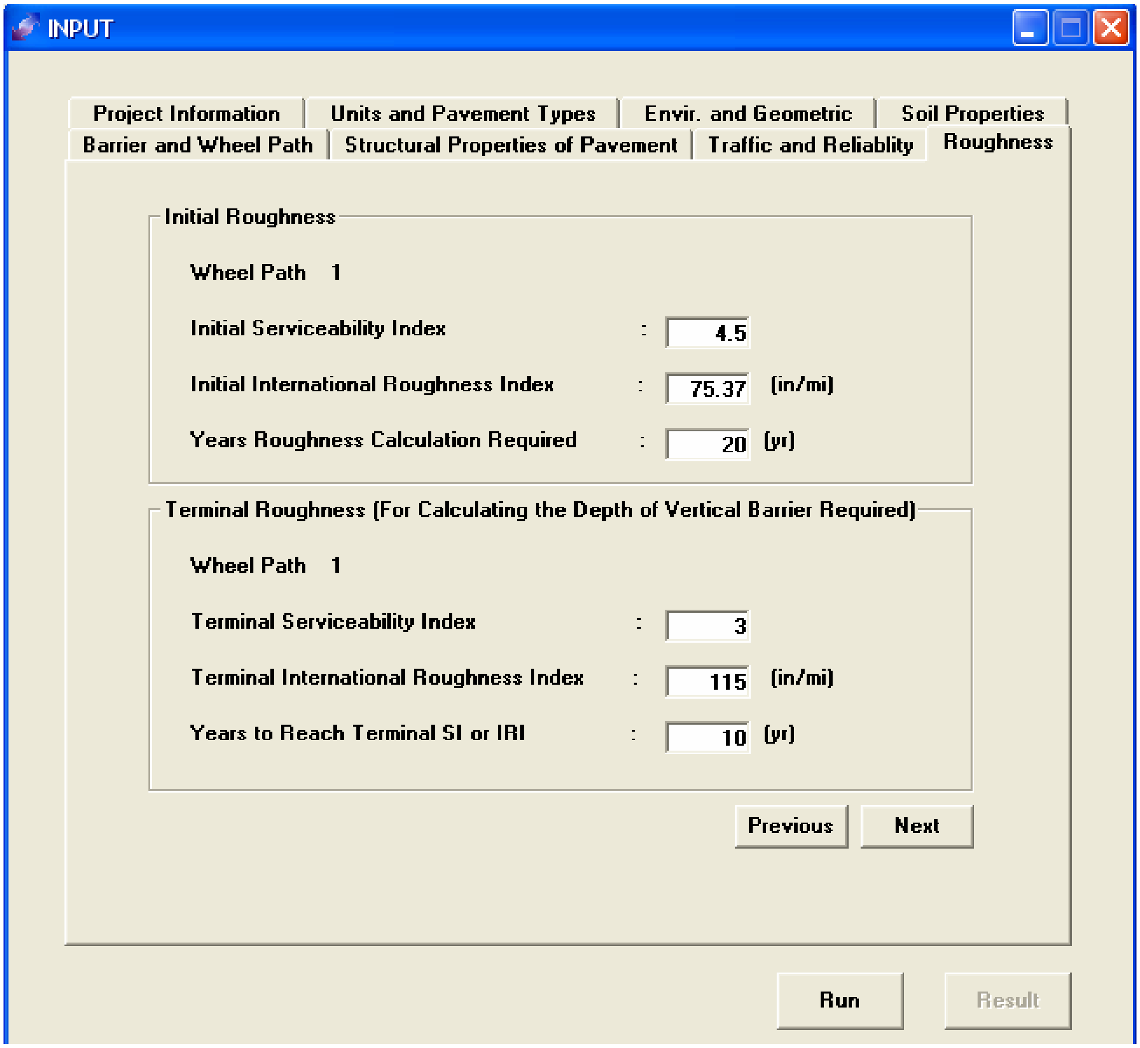


Figure 19. Initial and Terminal Roughness.

Step 2– Terminal roughness information (Fig. 19) is required if the user has previously selected the option Calculate the Depth of Vertical Moisture Barrier Required on the dialog box (Fig. 11).

This ends the Input portion of the program.

4. PROGRAM EXECUTION

To execute the program, click the button Run on the Input dialog box, click the icon on the toolbar (Fig. 1), or click the Run option (Fig. 3) on the menu bar.

Several error message boxes (Fig. 20) will appear if a mistake has been made with the input data.

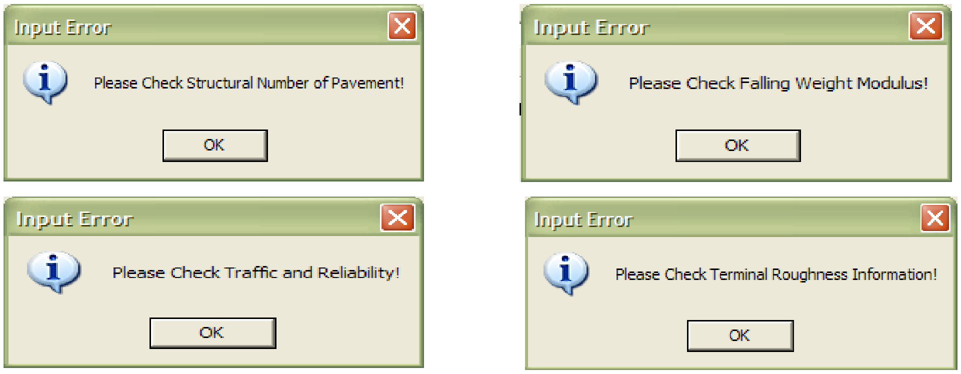


Figure 20. Several Error Message Boxes.

When all input data are correct, a dark execute window will appear as in Fig. 21 when the program is running. It will take a few minutes to complete it. To show results, click the button

. 

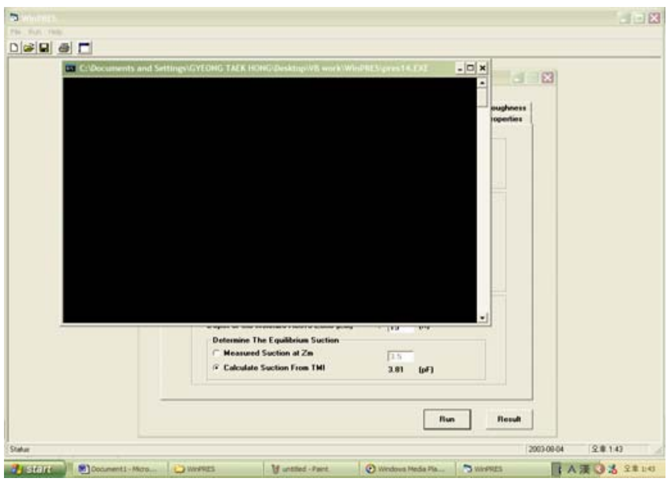


Figure 21. Execute Window.

5. OUTPUT DIALOG WINDOW

The Output Dialog window displays five small window boxes related to the results: Calculated Vertical Movement, Output, Suction Profile versus Depth, Serviceability Index versus Time, and International Roughness Index versus Time (Fig. 22).

After running the program, a message box may appear that informs the designer that the expansive clay roughness will increase too rapidly (Fig. 23). In this case, the roughness with time will not be calculated. To determine this information for a less extreme condition, use a vertical moisture barrier (Fig. 11), a lower reliability (Fig. 18), or inert or stabilized soil properties (Fig. 10).

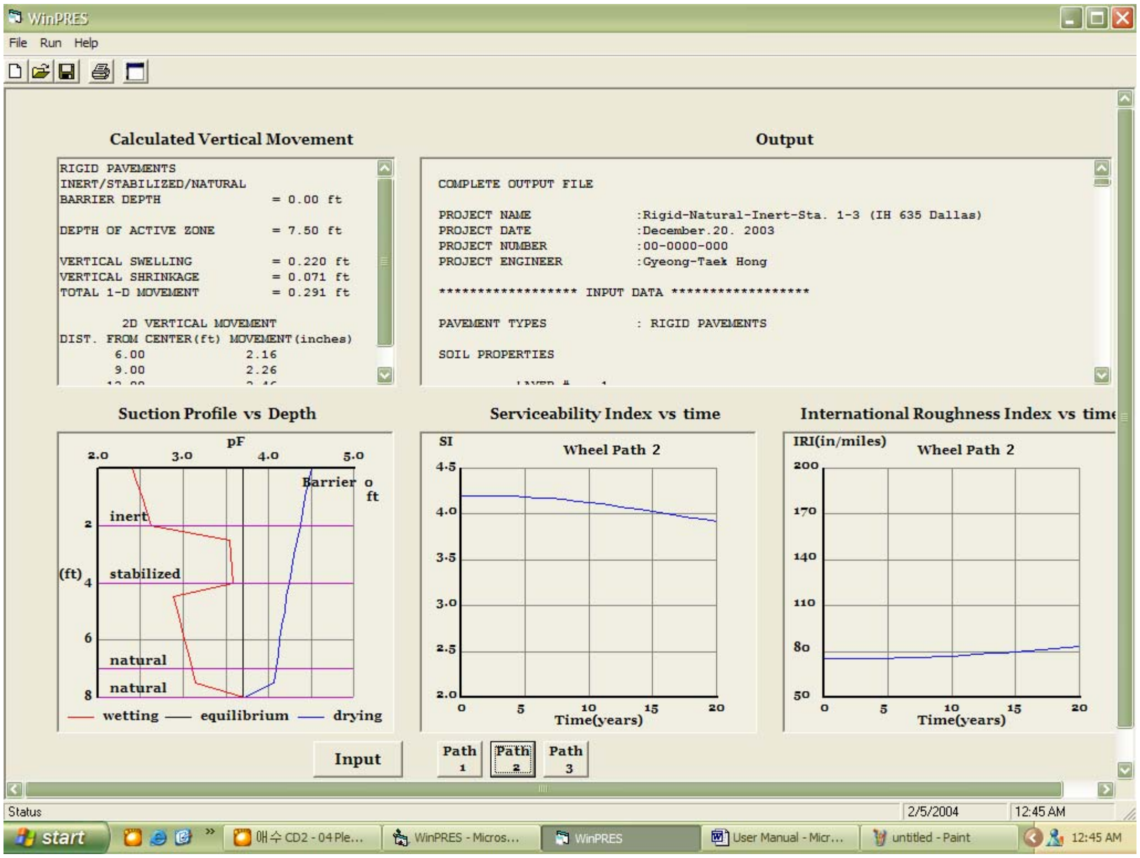


Figure 22. Output Dialog Window.

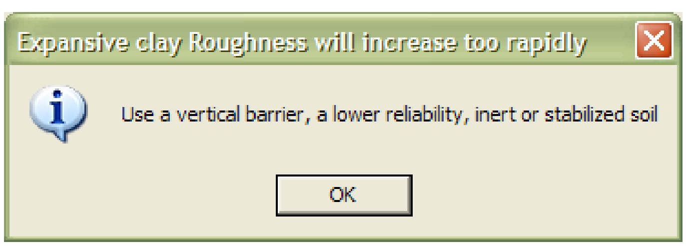


Figure 23. Information Message Box for the Roughness.

After executing the program, the five output files suction.dat, SI.dat, IRI.dat, summary.dat, and outputfull.dat will appear in the folder that has an execute file winpres.exe. The suction.dat file includes the suction profile with depth. The SI.dat and IRI.dat files have serviceability index and international roughness index versus time, respectively. The summary.dat file includes the vertical movement at the edge of pavement and in the wheel path of interest. The outputfull.dat file has all input and output data.

5.1 Calculated Vertical Movement

This window shows the summary of results calculated for total one-dimensional vertical movement at the edge of pavement by summing the swelling and shrinkage and for two-dimensional vertical movement at the wheel path (Fig. 24).

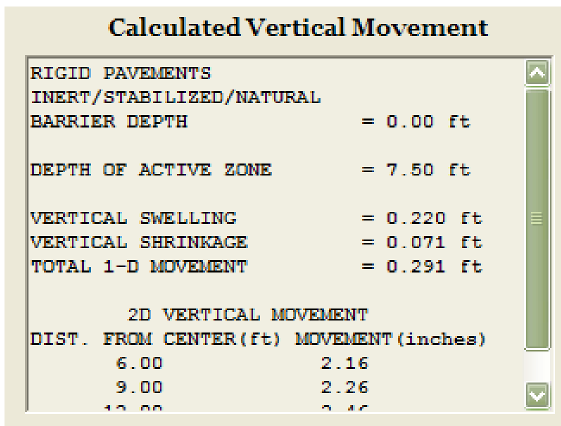


Figure 24. Calculated Vertical Movement.

5.2 Output

The user can view the full results of the data by moving the right scrollbar up or down (Fig. 25).

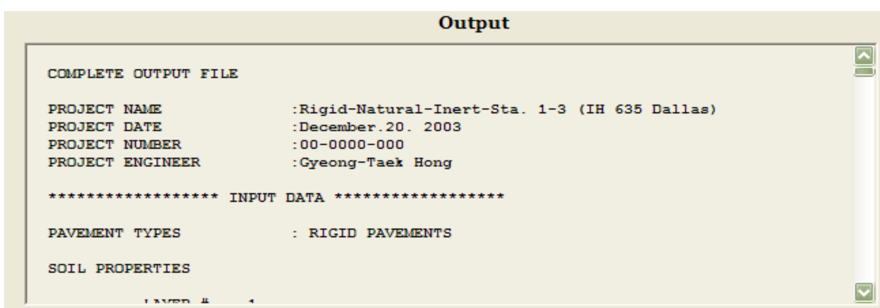


Figure 25. Complete Output.

5.3 Suction Profile versus Depth

This window shows graphically the suction values of the wetting envelope, equilibrium, and drying envelope conditions with depth. The graph shows the soil type such as inert, stabilized, and natural soil in each layer and the depth of a vertical moisture barrier if used (Fig. 26).

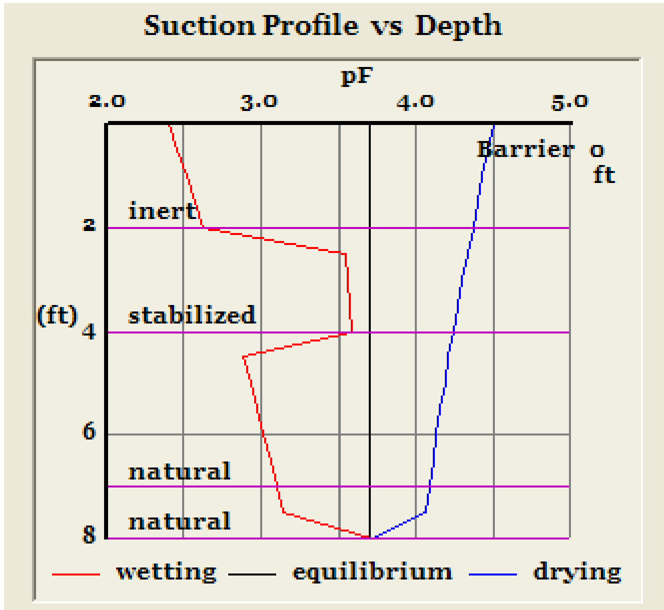
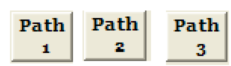


Figure 26. Suction Profile versus Depth.

5.4 Roughness with Time

The two graphs, serviceability index and international roughness index versus time in each wheel path can be displayed by clicking these buttons 

(Fig. 27).

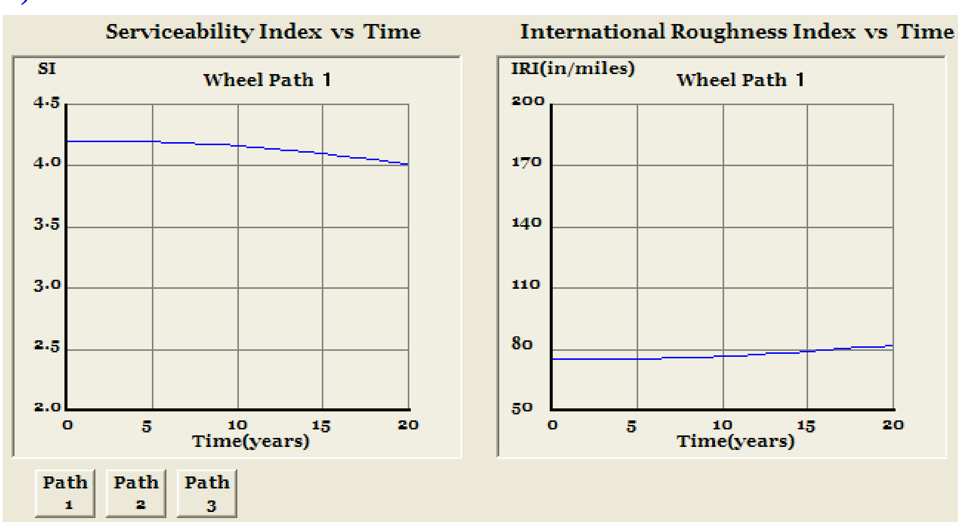


Figure 27. Roughness with Time.

APPENDIX A

(EXAMPLES)

```
FILE NAME : TarrantAAFs.DAT
COMPLETE OUTPUT FILE

 PROJECT NAME             :Fort Worth Study Section AA_F_Stabilized
 PROJECT DATE             :07.01.2004
 CSJ     NUMBER           :0000-00-000
 PROJECT ENGINEER         :G.T. Hong

 ****************** INPUT DATA ******************

 PAVEMENT TYPES           : FLEXIBLE PAVEMENTS

 SOIL PROPERTIES

           LAYER #    1
 SOIL TYPE                           =  STABILIZED SOIL
 THICKNESS (ft)                      =     2.50
 LIQUID LIMIT (%)                    =    60.00
 PLASTICITY INDEX (%)                =    28.00
 PERCENT PASSING # 200 (%)           =    80.00
 LESS THAN 2 MICRONS (%)             =    25.00
 DRY UNIT WEIGHT (lb/ft3)            =   115.00
 PERCENT OF LIME (%)                 =   8.00

           LAYER #    2
 SOIL TYPE                           =  NATURAL SOIL
 THICKNESS (ft)                      =     0.50
 LIQUID LIMIT (%)                    =    60.00
 PLASTICITY INDEX (%)                =    28.00
 PERCENT PASSING # 200 (%)           =    80.00
 LESS THAN 2 MICRONS (%)             =    25.00
 DRY UNIT WEIGHT (lb/ft3)            =   100.00

           LAYER #    3
 SOIL TYPE                           =  NATURAL SOIL
 THICKNESS (ft)                      =     4.20
 LIQUID LIMIT (%)                    =    60.00
 PLASTICITY INDEX (%)                =    25.00
 PERCENT PASSING # 200 (%)           =    80.00
 LESS THAN 2 MICRONS (%)             =    23.00
 DRY UNIT WEIGHT (lb/ft3)            =   100.00

           LAYER #    4
 SOIL TYPE                           =  NATURAL SOIL
 THICKNESS (ft)                      =     1.30
 LIQUID LIMIT (%)                    =    30.00
 PLASTICITY INDEX (%)                =    15.00
 PERCENT PASSING # 200 (%)           =    35.00
 LESS THAN 2 MICRONS (%)             =    10.00
 DRY UNIT WEIGHT (lb/ft3)            =   115.00

           LAYER #    5
 SOIL TYPE                           =  NATURAL SOIL
 THICKNESS (ft)                      =     0.50
 LIQUID LIMIT (%)                    =    20.00
 PLASTICITY INDEX (%)                =    10.00
 PERCENT PASSING # 200 (%)           =    25.00
 LESS THAN 2 MICRONS (%)             =    10.00
 DRY UNIT WEIGHT (lb/ft3)            =   130.00
```

```
          LAYER #    6
SOIL TYPE                           =  NATURAL SOIL
THICKNESS (ft)                      =     3.50
LIQUID LIMIT (%)                    =    65.00
PLASTICITY INDEX (%)                =    35.00
PERCENT PASSING # 200 (%)           =    85.00
LESS THAN 2 MICRONS (%)             =    30.00
DRY UNIT WEIGHT (lb/ft3)            =   100.00

          LAYER #    7
SOIL TYPE                           =  NATURAL SOIL
THICKNESS (ft)                      =     2.50
LIQUID LIMIT (%)                    =    65.00
PLASTICITY INDEX (%)                =    35.00
PERCENT PASSING # 200 (%)           =    85.00
LESS THAN 2 MICRONS (%)             =    35.00
DRY UNIT WEIGHT (lb/ft3)            =   100.00


ELEMENT DATA

LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
    1           2.50                20
    2           0.50                 6
    3           4.20                20
    4           1.30                14
    5           0.50                 6
    6           3.50                20
    7           2.50                20

ENVIRONMENTAL AND GEOMETRIC CONDITON

MEAN THORNTHWAITE MOISTURE INDEX             =   -10.00
ROOT DEPTH,ZR (ft)                           =     0.00
DEPTH OF MOISTURE ACTIVE ZONE,ZM (ft)        =    15.00
WIDTH OF PAVEMENT (ft)                       =    83.00
LONGITUDINAL SLOP                            =  SLOPE
LATERAL DRAINAGE                             =  FILL


WHEEL PATH DATA
NO.   DISTANCE FROM THE CENTER OF PAVEMENT (ft)
  1             27.00

INITIAL ROUGHNESS
WHEEL PATH NO.      SI          IRI (in/mi)
    1             4.20        75.20

DEPTH OF VERTICAL BARRIER (ft)               =    0.00


STRUCTURAL PROPERTIES OF PAVEMENT

STRUCTURAL NUMBER (ft)                       =   0.42
FALLING WEIGHT DEFLECTOMETER MODULUS
OF SUBGRADE SOIL (FROM DROP WEIGHT
CLOSEST TO 9K LOAD) (psi)                    = 10000.00


TRAFFIC DATA

                  WHEEL PATH NO.   1
```

```
TRAFFIC ANALYSIS PERIOD (Years)              =     30.0
ADT IN ONE DIRECTION WHEN T=0                =  42850.0
ADT IN ONE DIRECTION WHEN T=C                =  67950.0
18 kip SINGLE AXLES  WHEN T=C                =  8415520.0

RELIABILITY
FOR TRAFFIC                                  = 90.0
FOR ROUGHNESS CONSTANTS Bs AND Bi            = 90.0
```

```
*********************** RESULTS ***********************
```

SUCTION COMPRESSION INDEX (SCI)

LAYER NO.	ZONE	SCI
1	4	0.0156
2	4	0.0313
3	4	0.0288
4	2	0.0257
5	1	0.0180
6	3	0.0529
7	3	0.0576

SUCTION PROFILE

DEPTH(ft)	h(EQUILIBRIUM)	h(WET)	h(DRY)
0.0	2.58	2.50	4.50
0.1	2.58	2.58	4.48
0.3	2.58	2.58	4.45
0.4	2.58	2.58	4.43
0.5	2.58	2.58	4.41
0.6	2.58	2.58	4.38
0.8	2.58	2.58	4.36
0.9	2.58	2.58	4.34
1.0	2.58	2.58	4.32
1.1	2.58	2.58	4.30
1.3	2.58	2.58	4.28
1.4	2.58	2.58	4.25
1.5	2.58	2.58	4.23
1.6	2.58	2.58	4.21
1.8	2.58	2.58	4.19
1.9	2.58	2.58	4.17
2.0	2.58	2.58	4.15
2.1	2.58	2.58	4.13
2.3	2.58	2.58	4.12
2.4	2.58	2.58	4.10
2.5	2.58	2.58	4.08
2.6	2.58	2.52	4.06
2.7	2.58	2.52	4.05
2.8	2.58	2.52	4.04
2.8	2.58	2.52	4.02
2.9	2.58	2.52	4.01
3.0	2.58	2.52	4.00
3.2	2.58	2.52	3.97
3.4	2.58	2.52	3.93
3.6	2.58	2.52	3.90
3.8	2.58	2.53	3.87
4.1	2.58	2.53	3.85
4.3	2.58	2.53	3.82
4.5	2.58	2.53	3.79
4.7	2.58	2.53	3.76
4.9	2.58	2.53	3.73
5.1	2.58	2.53	3.71
5.3	2.58	2.53	3.68
5.5	2.58	2.54	3.66

5.7	2.58	2.54	3.63
5.9	2.58	2.54	3.61
6.2	2.58	2.54	3.59
6.4	2.58	2.54	3.56
6.6	2.58	2.54	3.54
6.8	2.58	2.54	3.52
7.0	2.58	2.54	3.50
7.2	2.58	2.54	3.48
7.3	2.58	2.54	3.47
7.4	2.58	2.54	3.46
7.5	2.58	2.54	3.45
7.6	2.58	2.54	3.45
7.7	2.58	2.54	3.44
7.8	2.58	2.54	3.43
7.9	2.58	2.54	3.42
7.9	2.58	2.55	3.42
8.0	2.58	2.55	3.41
8.1	2.58	2.55	3.40
8.2	2.58	2.55	3.39
8.3	2.58	2.55	3.39
8.4	2.58	2.55	3.38
8.5	2.58	2.55	3.37
8.6	2.58	2.55	3.37
8.7	2.58	2.55	3.36
8.8	2.58	2.55	3.35
8.8	2.58	2.55	3.35
8.9	2.58	2.55	3.34
9.0	2.58	2.55	3.34
9.2	2.58	2.55	3.32
9.4	2.58	2.55	3.31
9.5	2.58	2.55	3.29
9.7	2.58	2.55	3.28
9.9	2.58	2.55	3.27
10.1	2.58	2.55	3.25
10.2	2.58	2.55	3.24
10.4	2.58	2.55	3.23
10.6	2.58	2.55	3.21
10.8	2.58	2.55	3.20
10.9	2.58	2.55	3.19
11.1	2.58	2.56	3.18
11.3	2.58	2.56	3.17
11.5	2.58	2.56	3.15
11.6	2.58	2.56	3.14
11.8	2.58	2.56	3.13
12.0	2.58	2.56	3.12
12.2	2.58	2.56	3.11
12.3	2.58	2.56	3.10
12.5	2.58	2.56	3.09
12.6	2.58	2.56	3.08
12.8	2.58	2.56	3.08
12.9	2.58	2.56	3.07
13.0	2.58	2.56	3.06
13.1	2.58	2.56	3.05
13.3	2.58	2.56	3.05
13.4	2.58	2.56	3.04
13.5	2.58	2.56	3.03
13.6	2.58	2.56	3.03
13.8	2.58	2.56	3.02
13.9	2.58	2.56	3.02
14.0	2.58	2.56	3.01
14.1	2.58	2.56	3.00
14.3	2.58	2.56	3.00
14.4	2.58	2.56	2.99

```
   14.5          2.58         2.56       2.99
   14.6          2.58         2.56       2.98
   14.8          2.58         2.56       2.97
   14.9          2.58         2.56       2.97
   15.0          2.58         2.58       2.58

TOTAL POTENTIAL VERTICAL SWELLING           = 0.002 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE          = 0.095 ft
TOTAL 1-D VERTICAL MOVEMENT                 = 0.097 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST =  4.05 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST = 12.15 ft


DEPTH OF VERTICAL BARRIER                     =  0.00ft

DEPTH OF AVAILABLE MOISTURE  dam (ft)         =   1.30
PARAMETERS FOR VERTICAL MOVEMENT
   XI-1    =   0.3755
   XI-2    =   0.7384
   XI-3    =   6.3718

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 11.14 * EXP((  0.7384 * d/D) **   6.3718) mm

VERTICAL MOVEMENT
DISTANCE FROM CENTER ,d, (ft)    VERTICAL MOVEMENT,VM,(inches)
           27.00                              0.44


    WHEEL PATH NO.   1
DISTANCE FROM CENTER OF THE PAVEMENT (ft)     =  27.00

ROUGHNESS CONSTANTS
THE COEFFICIENT ,As                         =  332.4111
THE COEFFICIENT ,Bs                         =   23.3367
THE COEFFICIENT ,Rhos                       =   70.0102
THE COEFFICIENT ,Ai                         =  651.3207
THE COEFFICIENT ,Bi                         =   46.2731
THE COEFFICIENT ,Rhoi                       =  131.0206
```

ESTIMATED ROUGHNESS WITH TIME

YEAR	PSI	IRI(in/mi)	dPSI(SOILS)	dPSI(TRAFFIC)	dIRI(SOILS)	dIRI(TRAFFIC)
0	4.20	75.20	0.00	0.00	0.00	0.00
1	4.09	79.41	0.11	0.00	4.20	0.02
2	3.84	89.57	0.35	0.01	14.03	0.33
3	3.63	99.50	0.54	0.04	23.09	1.21
4	3.45	108.22	0.67	0.07	30.45	2.57
5	3.31	115.78	0.77	0.12	36.31	4.26
6	3.19	122.36	0.84	0.17	40.99	6.17
7	3.09	128.14	0.89	0.23	44.75	8.19
8	3.00	133.26	0.92	0.28	47.79	10.28
9	2.93	137.85	0.94	0.33	50.26	12.39
10	2.86	141.98	0.96	0.38	52.29	14.49
11	2.80	145.73	0.97	0.43	53.96	16.56
12	2.75	149.15	0.98	0.48	55.34	18.61
13	2.70	152.29	0.98	0.52	56.48	20.61
14	2.66	155.18	0.98	0.56	57.42	22.56
15	2.62	157.86	0.98	0.60	58.20	24.46
16	2.58	160.35	0.97	0.64	58.84	26.31
17	2.55	162.68	0.97	0.68	59.37	28.11
18	2.52	164.86	0.96	0.71	59.80	29.86

19	2.49	166.90	0.96	0.75	60.15	31.56
20	2.47	168.83	0.95	0.78	60.42	33.21
21	2.44	170.64	0.94	0.81	60.63	34.81
22	2.42	172.36	0.94	0.84	60.79	36.37
23	2.40	173.98	0.93	0.87	60.90	37.88
24	2.38	175.53	0.92	0.90	60.98	39.35
25	2.36	177.00	0.92	0.93	61.02	40.78
26	2.34	178.40	0.91	0.95	61.03	42.17
27	2.32	179.74	0.90	0.98	61.01	43.52
28	2.31	181.01	0.89	1.00	60.97	44.84
29	2.29	182.23	0.89	1.02	60.91	46.12
30	2.28	183.41	0.88	1.05	60.83	47.37

```
 FILE NAME : TarrantBBFsi.DAT
COMPLETE OUTPUT FILE

  PROJECT NAME             :Fort Worth Study Section BB_Fsi
  PROJECT DATE             :09.01.2004
  CSJ     NUMBER           :0000-00-000
  PROJECT ENGINEER         :G.T. Hong

  ****************** INPUT DATA ******************

  PAVEMENT TYPES           : FLEXIBLE PAVEMENTS

  SOIL PROPERTIES

            LAYER #    1
  SOIL TYPE                           =  STABILIZED SOIL
  THICKNESS (ft)                      =     2.50
  LIQUID LIMIT (%)                    =    60.00
  PLASTICITY INDEX (%)                =    36.00
  PERCENT PASSING # 200 (%)           =    85.00
  LESS THAN 2 MICRONS (%)             =    30.00
  DRY UNIT WEIGHT (lb/ft3)            =   120.00
  PERCENT OF LIME (%)                 =   8.00

            LAYER #    2
  SOIL TYPE                           =  INERT SOIL
  THICKNESS (ft)                      =     1.50
  LIQUID LIMIT (%)                    =    25.00
  PLASTICITY INDEX (%)                =     5.00
  PERCENT PASSING # 200 (%)           =    10.00
  LESS THAN 2 MICRONS (%)             =     1.00
  DRY UNIT WEIGHT (lb/ft3)            =   100.00

            LAYER #    3
  SOIL TYPE                           =  NATURAL SOIL
  THICKNESS (ft)                      =     1.00
  LIQUID LIMIT (%)                    =    55.00
  PLASTICITY INDEX (%)                =    30.00
  PERCENT PASSING # 200 (%)           =    80.00
  LESS THAN 2 MICRONS (%)             =    25.00
  DRY UNIT WEIGHT (lb/ft3)            =   100.00

            LAYER #    4
```

```
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     4.00
LIQUID LIMIT (%)                   =    65.00
PLASTICITY INDEX (%)               =    38.00
PERCENT PASSING # 200 (%)          =    85.00
LESS THAN 2 MICRONS (%)            =    30.00
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    5
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     0.50
LIQUID LIMIT (%)                   =    30.00
PLASTICITY INDEX (%)               =    15.00
PERCENT PASSING # 200 (%)          =    35.00
LESS THAN 2 MICRONS (%)            =    10.00
DRY UNIT WEIGHT (lb/ft3)           =   115.00

          LAYER #    6
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     1.50
LIQUID LIMIT (%)                   =    53.00
PLASTICITY INDEX (%)               =    32.00
PERCENT PASSING # 200 (%)          =    80.00
LESS THAN 2 MICRONS (%)            =    25.00
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    7
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     4.00
LIQUID LIMIT (%)                   =    45.00
PLASTICITY INDEX (%)               =    15.00
PERCENT PASSING # 200 (%)          =    99.40
LESS THAN 2 MICRONS (%)            =    37.00
DRY UNIT WEIGHT (lb/ft3)           =   100.00


ELEMENT DATA

LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
    1            2.50                20
    2            1.50                16
    3            1.00                11
    4            4.00                20
    5            0.50                 6
    6            1.50                16
    7            4.00                20

ENVIRONMENTAL AND GEOMETRIC CONDITON

MEAN THORNTHWAITE MOISTURE INDEX                  =   -10.00
ROOT DEPTH,ZR (ft)                                =     0.00
DEPTH OF MOISTURE ACTIVE ZONE,ZM (ft)      =    15.00
WIDTH OF PAVEMENT (ft)                     =    83.00
LONGITUDINAL SLOP                          =  SLOPE
LATERAL DRAINAGE                           =  FILL


WHEEL PATH DATA
NO.   DISTANCE FROM THE CENTER OF PAVEMENT (ft)
  1            27.00

INITIAL ROUGHNESS
WHEEL PATH NO.      SI          IRI (in/mi)
```

```
   1              4.20        75.20

 DEPTH OF VERTICAL BARRIER (ft)               =    0.00


 STRUCTURAL PROPERTIES OF PAVEMENT

 STRUCTURAL NUMBER (ft)                       =   0.44
 FALLING WEIGHT DEFLECTOMETER MODULUS
 OF SUBGRADE SOIL (FROM DROP WEIGHT
 CLOSEST TO 9K LOAD) (psi)                           = 10000.00


 TRAFFIC DATA

                   WHEEL PATH NO.   1
 TRAFFIC ANALYSIS PERIOD (Years)              =     30.0
 ADT IN ONE DIRECTION WHEN T=0                =  42850.0
 ADT IN ONE DIRECTION WHEN T=C                =  67950.0
 18 kip SINGLE AXLES  WHEN T=C                =  8415520.0

 RELIABILITY
 FOR TRAFFIC                                  = 90.0
 FOR ROUGHNESS CONSTANTS Bs AND Bi            = 90.0



************************ RESULTS ************************

 SUCTION COMPRESSION INDEX (SCI)
 LAYER NO.   ZONE        SCI
      1        3       0.0176
      2        5       0.0100
      3        3       0.0469
      4        3       0.0565
      5        2       0.0257
      6        2       0.0547
      7        4       0.0261

 SUCTION PROFILE
 DEPTH(ft)  h(EQUILIBRIUM)   h(WET)     h(DRY)
     0.0          3.45         2.50       4.50
     0.1          3.45         3.45       4.49
     0.3          3.45         3.45       4.47
     0.4          3.45         3.45       4.46
     0.5          3.45         3.45       4.45
     0.6          3.45         3.45       4.44
     0.8          3.45         3.45       4.42
     0.9          3.45         3.45       4.41
     1.0          3.45         3.45       4.40
     1.1          3.45         3.45       4.39
     1.3          3.45         3.45       4.38
     1.4          3.45         3.45       4.37
     1.5          3.45         3.45       4.35
     1.6          3.45         3.45       4.34
     1.8          3.45         3.45       4.33
     1.9          3.45         3.45       4.32
     2.0          3.45         3.45       4.31
     2.1          3.45         3.45       4.30
     2.3          3.45         3.45       4.29
     2.4          3.45         3.45       4.28
     2.5          3.45         3.45       4.27
```

2.6	3.45	2.72	4.26
2.7	3.45	2.72	4.25
2.8	3.45	2.73	4.25
2.9	3.45	2.74	4.24
3.0	3.45	2.74	4.23
3.1	3.45	2.75	4.23
3.2	3.45	2.75	4.22
3.3	3.45	2.76	4.21
3.3	3.45	2.77	4.21
3.4	3.45	2.77	4.20
3.5	3.45	2.78	4.19
3.6	3.45	2.78	4.19
3.7	3.45	2.79	4.18
3.8	3.45	2.79	4.17
3.9	3.45	2.80	4.17
4.0	3.45	2.81	4.16
4.1	3.45	2.81	4.15
4.2	3.45	2.82	4.15
4.3	3.45	2.82	4.14
4.4	3.45	2.83	4.13
4.5	3.45	2.84	4.13
4.5	3.45	2.84	4.12
4.6	3.45	2.85	4.11
4.7	3.45	2.86	4.11
4.8	3.45	2.86	4.10
4.9	3.45	2.87	4.09
5.0	3.45	2.87	4.09
5.2	3.45	2.89	4.07
5.4	3.45	2.90	4.06
5.6	3.45	2.91	4.05
5.8	3.45	2.92	4.03
6.0	3.45	2.93	4.02
6.2	3.45	2.95	4.01
6.4	3.45	2.96	4.00
6.6	3.45	2.97	3.98
6.8	3.45	2.98	3.97
7.0	3.45	2.99	3.96
7.2	3.45	3.00	3.95
7.4	3.45	3.01	3.94
7.6	3.45	3.02	3.93
7.8	3.45	3.03	3.92
8.0	3.45	3.04	3.91
8.2	3.45	3.05	3.89
8.4	3.45	3.06	3.88
8.6	3.45	3.07	3.88
8.8	3.45	3.07	3.87
9.0	3.45	3.08	3.86
9.1	3.45	3.09	3.85
9.2	3.45	3.09	3.85
9.3	3.45	3.09	3.85
9.3	3.45	3.09	3.84
9.4	3.45	3.10	3.84
9.5	3.45	3.10	3.84
9.6	3.45	3.10	3.83
9.7	3.45	3.11	3.83
9.8	3.45	3.11	3.83
9.9	3.45	3.11	3.82
10.0	3.45	3.12	3.82
10.1	3.45	3.12	3.81
10.2	3.45	3.12	3.81
10.3	3.45	3.13	3.81
10.3	3.45	3.13	3.80
10.4	3.45	3.13	3.80

10.5	3.45	3.14	3.80
10.6	3.45	3.14	3.79
10.7	3.45	3.14	3.79
10.8	3.45	3.15	3.79
10.9	3.45	3.15	3.78
11.0	3.45	3.15	3.78
11.2	3.45	3.16	3.77
11.4	3.45	3.16	3.77
11.6	3.45	3.17	3.76
11.8	3.45	3.18	3.75
12.0	3.45	3.18	3.75
12.2	3.45	3.19	3.74
12.4	3.45	3.19	3.73
12.6	3.45	3.20	3.73
12.8	3.45	3.21	3.72
13.0	3.45	3.21	3.71
13.2	3.45	3.22	3.71
13.4	3.45	3.22	3.70
13.6	3.45	3.23	3.70
13.8	3.45	3.23	3.69
14.0	3.45	3.24	3.69
14.2	3.45	3.24	3.68
14.4	3.45	3.24	3.68
14.6	3.45	3.25	3.67
14.8	3.45	3.25	3.67
15.0	3.45	3.45	3.45

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TOTAL POTENTIAL VERTICAL SWELLING            = 0.068 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE           = 0.062 ft
TOTAL 1-D VERTICAL MOVEMENT                  = 0.130 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST =  8.20 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST =  9.42 ft


DEPTH OF VERTICAL BARRIER                             =  0.00ft

DEPTH OF AVAILABLE MOISTURE  dam (ft)         =   1.12
PARAMETERS FOR VERTICAL MOVEMENT
   XI-1    =   0.3633
   XI-2    =   0.8491
   XI-3    =   3.5303

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 14.38 * EXP((  0.8491 * d/D) **   3.5303) mm

VERTICAL MOVEMENT
DISTANCE FROM CENTER ,d, (ft)    VERTICAL MOVEMENT,VM,(inches)
          27.00                                0.64


    WHEEL PATH NO.   1
DISTANCE FROM CENTER OF THE PAVEMENT (ft)     =  27.00

 ROUGHNESS CONSTANTS
 THE COEFFICIENT ,As                          =  422.4005
 THE COEFFICIENT ,Bs                          =   23.3367
 THE COEFFICIENT ,Rhos                        =   42.7775
 THE COEFFICIENT ,Ai                          =  832.0126
 THE COEFFICIENT ,Bi                          =   46.2731
 THE COEFFICIENT ,Rhoi                        =   79.2791

ESTIMATED ROUGHNESS WITH TIME
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YEAR	PSI	IRI(in/mi)	dPSI(SOILS)	dPSI(TRAFFIC)	dIRI(SOILS)	dIRI(TRAFFIC)
0	4.20	75.20	0.00	0.00	0.00	0.00
1	3.93	85.93	0.27	0.00	10.73	0.00
2	3.58	102.29	0.62	0.00	26.96	0.13
3	3.32	115.48	0.86	0.02	39.70	0.58
4	3.13	125.97	1.03	0.04	49.41	1.37
5	2.99	134.52	1.14	0.07	56.88	2.44
6	2.87	141.65	1.22	0.11	62.72	3.72
7	2.78	147.71	1.27	0.15	67.35	5.16
8	2.70	152.95	1.31	0.19	71.06	6.69
9	2.63	157.53	1.34	0.23	74.05	8.29
10	2.57	161.60	1.36	0.27	76.48	9.92
11	2.52	165.23	1.37	0.31	78.47	11.57
12	2.48	168.51	1.37	0.35	80.09	13.21
13	2.44	171.48	1.37	0.39	81.43	14.86
14	2.40	174.20	1.37	0.43	82.52	16.48
15	2.37	176.70	1.37	0.47	83.41	18.08
16	2.34	179.00	1.36	0.50	84.14	19.66
17	2.31	181.13	1.35	0.54	84.72	21.21
18	2.28	183.11	1.35	0.57	85.18	22.73
19	2.26	184.97	1.34	0.60	85.54	24.22
20	2.24	186.70	1.33	0.63	85.82	25.68
21	2.22	188.33	1.32	0.66	86.02	27.11
22	2.20	189.86	1.31	0.69	86.16	28.50
23	2.18	191.31	1.30	0.72	86.24	29.87
24	2.17	192.67	1.29	0.75	86.27	31.20
25	2.15	193.97	1.28	0.77	86.27	32.50
26	2.14	195.20	1.27	0.80	86.22	33.78
27	2.12	196.37	1.26	0.82	86.15	35.02
28	2.11	197.49	1.25	0.84	86.05	36.24
29	2.10	198.55	1.23	0.87	85.92	37.43
30	2.09	199.57	1.22	0.89	85.77	38.60

```
FILE NAME : AtlantaBBFn.DAT
COMPLETE OUTPUT FILE
PROJECT NAME            :Atlanta US 271 study_F_natural
PROJECT DATE            :09.01.2004
CSJ     NUMBER          :0000-00-000
PROJECT ENGINEER        :G.T. Hong

****************** INPUT DATA ******************

PAVEMENT TYPES          : FLEXIBLE PAVEMENTS

SOIL PROPERTIES

          LAYER #    1
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     5.00
LIQUID LIMIT (%)                   =    48.00
PLASTICITY INDEX (%)               =    26.00
PERCENT PASSING # 200 (%)          =    90.00
LESS THAN 2 MICRONS (%)            =    14.00
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    2
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SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     3.00
LIQUID LIMIT (%)                   =    37.00
PLASTICITY INDEX (%)               =    17.00
PERCENT PASSING # 200 (%)          =    92.00
LESS THAN 2 MICRONS (%)            =     8.70
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    3
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     4.00
LIQUID LIMIT (%)                   =    40.00
PLASTICITY INDEX (%)               =    25.00
PERCENT PASSING # 200 (%)          =    93.40
LESS THAN 2 MICRONS (%)            =     8.60
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    4
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     5.00
LIQUID LIMIT (%)                   =    37.00
PLASTICITY INDEX (%)               =    15.00
PERCENT PASSING # 200 (%)          =    93.30
LESS THAN 2 MICRONS (%)            =     7.70
DRY UNIT WEIGHT (lb/ft3)           =   100.00


ELEMENT DATA

LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
    1           5.00                20
    2           3.00                20
    3           4.00                20
    4           5.00                20

ENVIRONMENTAL AND GEOMETRIC CONDITON

MEAN THORNTHWAITE MOISTURE INDEX            =    30.00
ROOT DEPTH,ZR (ft)                          =    11.00
DEPTH OF MOISTURE ACTIVE ZONE,ZM (ft)       =    17.00
WIDTH OF PAVEMENT (ft)                      =    44.00
LONGITUDINAL SLOP                           =  SLOPE
LATERAL DRAINAGE                            =  FILL


WHEEL PATH DATA
NO.   DISTANCE FROM THE CENTER OF PAVEMENT (ft)
  1             9.00

INITIAL ROUGHNESS
WHEEL PATH NO.      SI          IRI (in/mi)
    1             4.20        75.20

DEPTH OF VERTICAL BARRIER (ft)              =    8.00


STRUCTURAL PROPERTIES OF PAVEMENT

STRUCTURAL NUMBER (ft)                      =   0.31
FALLING WEIGHT DEFLECTOMETER MODULUS
OF SUBGRADE SOIL (FROM DROP WEIGHT
CLOSEST TO 9K LOAD) (psi)                   = 10000.00
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TRAFFIC DATA

                  WHEEL PATH NO.   1
TRAFFIC ANALYSIS PERIOD (Years)               =     30.0
ADT IN ONE DIRECTION WHEN T=0                 =  10000.0
ADT IN ONE DIRECTION WHEN T=C                 =  20000.0
18 kip SINGLE AXLES  WHEN T=C                 =  2500000.0

RELIABILITY
FOR TRAFFIC                                   = 50.0
FOR ROUGHNESS CONSTANTS Bs AND Bi             = 50.0


*********************** RESULTS ***********************

SUCTION COMPRESSION INDEX (SCI)
LAYER NO.   ZONE         SCI
     1        3        0.0156
     2        3        0.0118
     3        1        0.0350
     4        3        0.0058

SUCTION PROFILE
DEPTH(ft)  h(EQUILIBRIUM)   h(WET)     h(DRY)
    0.0          3.09         2.30       4.50
    0.3          3.09         2.32       4.50
    0.5          3.09         2.34       4.50
    0.8          3.09         2.36       4.50
    1.0          3.09         2.38       4.50
    1.3          3.09         2.40       4.50
    1.5          3.09         2.41       4.50
    1.8          3.09         2.43       4.50
    2.0          3.09         2.45       4.50
    2.3          3.09         2.46       4.50
    2.5          3.09         2.48       4.50
    2.8          3.09         2.50       4.50
    3.0          3.09         2.51       4.50
    3.3          3.09         2.53       4.50
    3.5          3.09         2.54       4.50
    3.8          3.09         2.56       4.50
    4.0          3.09         2.57       4.50
    4.3          3.09         2.58       4.50
    4.5          3.09         2.60       4.50
    4.8          3.09         2.61       4.50
    5.0          3.09         2.62       4.50
    5.2          3.09         2.63       4.50
    5.3          3.09         2.63       4.50
    5.5          3.09         2.64       4.50
    5.6          3.09         2.65       4.50
    5.8          3.09         2.66       4.50
    5.9          3.09         2.66       4.50
    6.1          3.09         2.67       4.50
    6.2          3.09         2.67       4.50
    6.4          3.09         2.68       4.50
    6.5          3.09         2.69       4.50
    6.7          3.09         2.69       4.50
    6.8          3.09         2.70       4.50
    7.0          3.09         2.71       4.50
    7.1          3.09         2.71       4.50
    7.3          3.09         2.72       4.50
    7.4          3.09         2.72       4.50
    7.6          3.09         2.73       4.50
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7.7	3.09	2.73	4.50
7.9	3.09	2.74	4.50
8.0	3.09	2.74	4.50
8.2	3.09	2.75	4.50
8.4	3.09	2.76	4.50
8.6	3.09	2.77	4.50
8.8	3.09	2.77	4.50
9.0	3.09	2.78	4.50
9.2	3.09	2.79	4.50
9.4	3.09	2.79	4.50
9.6	3.09	2.80	4.50
9.8	3.09	2.80	4.50
10.0	3.09	2.81	4.50
10.2	3.09	2.82	4.50
10.4	3.09	2.82	4.50
10.6	3.09	2.83	4.50
10.8	3.09	2.83	4.50
11.0	3.09	2.84	3.53
11.2	3.09	2.84	3.52
11.4	3.09	2.85	3.52
11.6	3.09	2.85	3.51
11.8	3.09	2.86	3.50
12.0	3.09	2.86	3.49
12.3	3.09	2.87	3.48
12.5	3.09	2.87	3.47
12.8	3.09	2.88	3.46
13.0	3.09	2.89	3.45
13.3	3.09	2.89	3.44
13.5	3.09	2.90	3.43
13.8	3.09	2.90	3.42
14.0	3.09	2.91	3.42
14.3	3.09	2.91	3.41
14.5	3.09	2.91	3.40
14.8	3.09	2.92	3.39
15.0	3.09	2.92	3.38
15.3	3.09	2.93	3.38
15.5	3.09	2.93	3.37
15.8	3.09	2.94	3.36
16.0	3.09	2.94	3.36
16.3	3.09	2.94	3.35
16.5	3.09	2.95	3.34
16.8	3.09	2.95	3.34
17.0	3.09	3.09	3.09

TOTAL POTENTIAL VERTICAL SWELLING = 0.047 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE = 0.086 ft
TOTAL 1-D VERTICAL MOVEMENT = 0.133 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST = 7.85 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST = 10.80 ft

DEPTH OF VERTICAL BARRIER = 8.00ft

DEPTH OF AVAILABLE MOISTURE dam (ft) = 1.64
PARAMETERS FOR VERTICAL MOVEMENT
XI-1 = 0.6005
XI-2 = 0.4984
XI-3 = 1.5838

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 24.31 * EXP((0.4984 * d/D) ** 1.5838) mm

VERTICAL MOVEMENT

DISTANCE FROM CENTER ,d, (ft)	VERTICAL MOVEMENT,VM,(inches)
9.00	1.04

WHEEL PATH NO. 1

DISTANCE FROM CENTER OF THE PAVEMENT (ft) = 9.00

ROUGHNESS CONSTANTS

THE COEFFICIENT ,As	=	706.3068
THE COEFFICIENT ,Bs	=	17.9600
THE COEFFICIENT ,Rhos	=	233.0982
THE COEFFICIENT ,Ai	=	1395.0005
THE COEFFICIENT ,Bi	=	35.8170
THE COEFFICIENT ,Rhoi	=	451.2970

ESTIMATED ROUGHNESS WITH TIME

YEAR	PSI	IRI(in/mi)	dPSI(SOILS)	dPSI(TRAFFIC)	dIRI(SOILS)	dIRI(TRAFFIC)
0	4.20	75.20	0.00	0.00	0.00	0.00
1	4.20	75.29	0.00	0.00	0.09	0.00
2	4.17	76.28	0.03	0.00	1.07	0.01
3	4.11	78.30	0.09	0.00	3.02	0.08
4	4.04	80.92	0.15	0.01	5.46	0.26
5	3.97	83.84	0.22	0.02	8.07	0.56
6	3.89	86.87	0.28	0.03	10.67	0.99
7	3.82	89.90	0.33	0.05	13.17	1.53
8	3.75	92.88	0.38	0.06	15.51	2.17
9	3.69	95.78	0.43	0.09	17.69	2.89
10	3.63	98.59	0.47	0.11	19.71	3.68
11	3.57	101.28	0.50	0.13	21.57	4.51
12	3.52	103.87	0.53	0.16	23.28	5.39
13	3.47	106.36	0.55	0.18	24.85	6.31
14	3.42	108.74	0.58	0.20	26.30	7.24
15	3.38	111.02	0.60	0.23	27.63	8.20
16	3.33	113.22	0.61	0.25	28.85	9.17
17	3.29	115.32	0.63	0.28	29.97	10.15
18	3.26	117.34	0.64	0.30	31.01	11.13
19	3.22	119.28	0.65	0.33	31.97	12.11
20	3.19	121.15	0.66	0.35	32.85	13.10
21	3.16	122.95	0.67	0.37	33.67	14.08
22	3.13	124.68	0.68	0.40	34.43	15.05
23	3.10	126.35	0.68	0.42	35.13	16.02
24	3.07	127.96	0.69	0.44	35.78	16.99
25	3.04	129.52	0.69	0.46	36.38	17.94
26	3.02	131.02	0.70	0.49	36.94	18.89
27	2.99	132.48	0.70	0.51	37.45	19.82
28	2.97	133.88	0.70	0.53	37.93	20.75
29	2.95	135.25	0.71	0.55	38.38	21.67
30	2.93	136.57	0.71	0.57	38.80	22.57

FILE NAME : AustinMRs.DAT

COMPLETE OUTPUT FILE

PROJECT NAME	:Austin Loop 1, (Main Road)_R_stabilized
PROJECT DATE	:09.01.2004
CSJ NUMBER	:0000-00-000
PROJECT ENGINEER	:G.T. Hong

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****************** INPUT DATA ******************

PAVEMENT TYPES           : RIGID PAVEMENTS

SOIL PROPERTIES

          LAYER #    1
SOIL TYPE                          =  STABILIZED SOIL
THICKNESS (ft)                     =     2.00
LIQUID LIMIT (%)                   =    49.00
PLASTICITY INDEX (%)               =    29.00
PERCENT PASSING # 200 (%)          =    84.90
LESS THAN 2 MICRONS (%)            =    42.00
DRY UNIT WEIGHT (lb/ft3)           =   120.00
PERCENT OF LIME (%)                =   8.00

          LAYER #    2
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     3.00
LIQUID LIMIT (%)                   =    49.00
PLASTICITY INDEX (%)               =    29.00
PERCENT PASSING # 200 (%)          =    84.90
LESS THAN 2 MICRONS (%)            =    42.00
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    3
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     3.00
LIQUID LIMIT (%)                   =    68.00
PLASTICITY INDEX (%)               =    33.00
PERCENT PASSING # 200 (%)          =    91.80
LESS THAN 2 MICRONS (%)            =    30.00
DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    4
SOIL TYPE                          =  NATURAL SOIL
THICKNESS (ft)                     =     6.00
LIQUID LIMIT (%)                   =    68.00
PLASTICITY INDEX (%)               =    35.00
PERCENT PASSING # 200 (%)          =    90.00
LESS THAN 2 MICRONS (%)            =    18.00
DRY UNIT WEIGHT (lb/ft3)           =   105.00


ELEMENT DATA

LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
    1           2.00                 20
    2           3.00                 20
    3           3.00                 20
    4           6.00                 20

ENVIRONMENTAL AND GEOMETRIC CONDITON

MEAN THORNTHWAITE MOISTURE INDEX            =   -15.00
ROOT DEPTH,ZR (ft)                          =     0.00
DEPTH OF MOISTURE ACTIVE ZONE,ZM (ft)       =    14.00
WIDTH OF PAVEMENT (ft)                      =    62.00
LONGITUDINAL SLOP                           =  SLOPE
LATERAL DRAINAGE                            =  FILL
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WHEEL PATH DATA
NO.   DISTANCE FROM THE CENTER OF PAVEMENT (ft)
  1            21.00

INITIAL ROUGHNESS
WHEEL PATH NO.      SI          IRI (in/mi)
    1              4.20        75.20

DEPTH OF VERTICAL BARRIER (ft)               =    0.00


STRUCTURAL PROPERTIES OF PAVEMENT

CONCRETE PAVEMENT LAYER THICKENESS (ft)      =   1.00
FALLING WEIGHT DEFLECTOMETER MODULUS
OF SUBGRADE SOIL FOR LOAD NEAR 9000lb        = 10000.00

DESIGN VARIABLES FOR RIGID PAVEMENT

28-DAY COMPRESSIVE STRENGTH OF CONCRETE (psi)      =  4000.00
ELASTIC MODULUS OF CONCRETE (psi)            = 3604996.53
MEAN MODULUS OF RUPTURE OF CONCRETE (psi)    =   650.00
DRAINAGE COEFFICIENT                         =     1.00
LOAD TRANSFER COEFFICIENT                          =     3.20
TERMINAL SERVICEABILITY INDEX FOR THE CONCRETE
PAVEMENT                                     =     0.00


TRAFFIC DATA

                  WHEEL PATH NO.   1
TRAFFIC ANALYSIS PERIOD (Years)              =     30.0
ADT IN ONE DIRECTION WHEN T=0                =  42850.0
ADT IN ONE DIRECTION WHEN T=C                =  67950.0
18 kip SINGLE AXLES  WHEN T=C                =  9993430.0

RELIABILITY
FOR TRAFFIC                                  = 95.0
FOR ROUGHNESS CONSTANTS Bs AND Bi            = 95.0


************************ RESULTS ************************

SUCTION COMPRESSION INDEX (SCI)
LAYER NO.   ZONE         SCI
     1        2       0.0099
     2        2       0.0420
     3        4       0.0327
     4        4       0.0260

SUCTION PROFILE
DEPTH(ft)  h(EQUILIBRIUM)   h(WET)     h(DRY)
    0.0          3.45         2.50       4.50
    0.1          3.45         3.45       4.49
    0.2          3.45         3.45       4.48
    0.3          3.45         3.45       4.47
    0.4          3.45         3.45       4.46
    0.5          3.45         3.45       4.45
    0.6          3.45         3.45       4.44
    0.7          3.45         3.45       4.43
    0.8          3.45         3.45       4.42
    0.9          3.45         3.45       4.41
    1.0          3.45         3.45       4.40
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1.1	3.45	3.45	4.39
1.2	3.45	3.45	4.38
1.3	3.45	3.45	4.37
1.4	3.45	3.45	4.37
1.5	3.45	3.45	4.36
1.6	3.45	3.45	4.35
1.7	3.45	3.45	4.34
1.8	3.45	3.45	4.33
1.9	3.45	3.45	4.32
2.0	3.45	3.45	4.31
2.2	3.45	2.68	4.30
2.3	3.45	2.69	4.29
2.5	3.45	2.71	4.27
2.6	3.45	2.72	4.26
2.8	3.45	2.73	4.25
2.9	3.45	2.74	4.23
3.1	3.45	2.75	4.22
3.2	3.45	2.76	4.21
3.4	3.45	2.77	4.20
3.5	3.45	2.78	4.19
3.7	3.45	2.79	4.17
3.8	3.45	2.81	4.16
4.0	3.45	2.82	4.15
4.1	3.45	2.83	4.14
4.3	3.45	2.84	4.13
4.4	3.45	2.85	4.12
4.6	3.45	2.86	4.11
4.7	3.45	2.86	4.10
4.9	3.45	2.87	4.09
5.0	3.45	2.88	4.08
5.2	3.45	2.89	4.07
5.3	3.45	2.90	4.06
5.5	3.45	2.91	4.05
5.6	3.45	2.92	4.04
5.8	3.45	2.93	4.03
5.9	3.45	2.94	4.02
6.1	3.45	2.95	4.01
6.2	3.45	2.95	4.00
6.4	3.45	2.96	3.99
6.5	3.45	2.97	3.98
6.7	3.45	2.98	3.97
6.8	3.45	2.99	3.96
7.0	3.45	2.99	3.95
7.1	3.45	3.00	3.95
7.3	3.45	3.01	3.94
7.4	3.45	3.02	3.93
7.6	3.45	3.02	3.92
7.7	3.45	3.03	3.91
7.9	3.45	3.04	3.91
8.0	3.45	3.04	3.90
8.3	3.45	3.06	3.88
8.6	3.45	3.07	3.87
8.9	3.45	3.08	3.86
9.2	3.45	3.10	3.84
9.5	3.45	3.11	3.83
9.8	3.45	3.12	3.82
10.1	3.45	3.13	3.81
10.4	3.45	3.14	3.79
10.7	3.45	3.15	3.78
11.0	3.45	3.16	3.77
11.3	3.45	3.17	3.76
11.6	3.45	3.18	3.75
11.9	3.45	3.19	3.74

```
    12.2          3.45         3.19       3.73
    12.5          3.45         3.20       3.72
    12.8          3.45         3.21       3.71
    13.1          3.45         3.22       3.71
    13.4          3.45         3.23       3.70
    13.7          3.45         3.23       3.69
    14.0          3.45         3.45       3.45

 TOTAL POTENTIAL VERTICAL SWELLING           = 0.091 ft
 TOTAL POTENTIAL VERTICAL SHRINKAGE          = 0.062 ft
 TOTAL 1-D VERTICAL MOVEMENT                 = 0.153 ft

 THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST =  8.00 ft
 THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST =  8.90 ft


 DEPTH OF VERTICAL BARRIER                     =  0.00ft

 DEPTH OF AVAILABLE MOISTURE  dam (ft)        =   1.36
 PARAMETERS FOR VERTICAL MOVEMENT
    XI-1    =   0.5537
    XI-2    =   0.9186
    XI-3    =   3.9892

 EQUATION FOR 2D VERTICAL MOVEMENT
 VM = 25.75 * EXP((  0.9186 * d/D) **   3.9892) mm

 VERTICAL MOVEMENT
 DISTANCE FROM CENTER ,d, (ft)    VERTICAL MOVEMENT,VM,(inches)
           21.00                              1.18


     WHEEL PATH NO.   1
DISTANCE FROM CENTER OF THE PAVEMENT (ft)     =  21.00

 ROUGHNESS CONSTANTS
 THE COEFFICIENT ,As                         =  861.1995
 THE COEFFICIENT ,Bs                         =   24.8608
 THE COEFFICIENT ,Rhos                       =  116.7587
 THE COEFFICIENT ,Ai                         = 1791.2784
 THE COEFFICIENT ,Bi                         =   49.2369
 THE COEFFICIENT ,Rhoi                       =  316.9089

ESTIMATED ROUGHNESS WITH TIME
```

YEAR	PSI	IRI(in/mi)	dPSI(SOILS)	dPSI(TRAFFIC)	dIRI(SOILS)	dIRI(TRAFFIC)
0	4.20	75.20	0.00	0.00	0.00	0.00
1	4.17	75.57	0.03	0.00	0.37	0.00
2	4.04	77.94	0.16	0.00	2.74	0.00
3	3.89	81.70	0.31	0.00	6.47	0.03
4	3.75	85.94	0.44	0.00	10.65	0.10
5	3.63	90.26	0.56	0.01	14.83	0.24
6	3.52	94.47	0.67	0.02	18.82	0.45
7	3.42	98.50	0.75	0.03	22.56	0.74
8	3.33	102.31	0.83	0.04	26.00	1.11
9	3.26	105.91	0.89	0.05	29.17	1.54
10	3.19	109.30	0.94	0.07	32.07	2.03
11	3.13	112.49	0.99	0.09	34.72	2.57
12	3.07	115.50	1.03	0.10	37.15	3.15
13	3.02	118.35	1.06	0.12	39.37	3.78
14	2.97	121.04	1.09	0.14	41.41	4.43
15	2.93	123.58	1.11	0.16	43.27	5.11
16	2.89	126.00	1.13	0.18	44.99	5.81

17	2.85	128.29	1.15	0.20	46.57	6.53
18	2.81	130.48	1.16	0.22	48.02	7.26
19	2.78	132.56	1.18	0.24	49.36	8.00
20	2.75	134.55	1.19	0.26	50.59	8.76
21	2.72	136.44	1.19	0.28	51.73	9.51
22	2.69	138.26	1.20	0.30	52.78	10.28
23	2.67	140.00	1.21	0.32	53.76	11.04
24	2.64	141.67	1.21	0.34	54.66	11.81
25	2.62	143.28	1.22	0.36	55.50	12.58
26	2.60	144.82	1.22	0.38	56.28	13.34
27	2.58	146.30	1.22	0.40	57.00	14.10
28	2.56	147.73	1.22	0.42	57.67	14.86
29	2.54	149.11	1.22	0.44	58.29	15.62
30	2.52	150.44	1.22	0.46	58.87	16.37

```
FILE NAME : AustinFFsi.DAT
 COMPLETE OUTPUT FILE
 PROJECT NAME            :Austine Loop 1 (Front) Study_F_Fsi
 PROJECT DATE            :07.01.2004
 CSJ     NUMBER          :0000-00-000
 PROJECT ENGINEER        :G.T. Hong

 ****************** INPUT DATA ******************

 PAVEMENT TYPES          : FLEXIBLE PAVEMENTS

 SOIL PROPERTIES

           LAYER #    1
 SOIL TYPE                          =  STABILIZED SOIL
 THICKNESS (ft)                     =     2.00
 LIQUID LIMIT (%)                   =    49.00
 PLASTICITY INDEX (%)               =    29.00
 PERCENT PASSING # 200 (%)          =    84.90
 LESS THAN 2 MICRONS (%)            =    42.00
 DRY UNIT WEIGHT (lb/ft3)           =   120.00
 PERCENT OF LIME (%)                =   8.00

           LAYER #    2
 SOIL TYPE                          =  INERT SOIL
 THICKNESS (ft)                     =     3.00
 LIQUID LIMIT (%)                   =    25.00
 PLASTICITY INDEX (%)               =    10.00
 PERCENT PASSING # 200 (%)          =    10.00
 LESS THAN 2 MICRONS (%)            =     1.00
 DRY UNIT WEIGHT (lb/ft3)           =   130.00

           LAYER #    3
 SOIL TYPE                          =  NATURAL SOIL
 THICKNESS (ft)                     =     2.50
 LIQUID LIMIT (%)                   =    68.00
 PLASTICITY INDEX (%)               =    33.00
 PERCENT PASSING # 200 (%)          =    91.80
 LESS THAN 2 MICRONS (%)            =    30.00
 DRY UNIT WEIGHT (lb/ft3)           =   100.00

           LAYER #    4
 SOIL TYPE                          =  NATURAL SOIL
 THICKNESS (ft)                     =     6.00
 LIQUID LIMIT (%)                   =    68.00
 PLASTICITY INDEX (%)               =    35.00
 PERCENT PASSING # 200 (%)          =    90.60
```

```
  LESS THAN 2 MICRONS (%)             =    18.00
  DRY UNIT WEIGHT (lb/ft3)            =   105.00

  ELEMENT DATA

  LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
      1           2.00                20
      2           3.00                20
      3           2.50                20
      4           6.00                20

  ENVIRONMENTAL AND GEOMETRIC CONDITON

  MEAN THORNTHWAITE MOISTURE INDEX             =   -15.00
  ROOT DEPTH,ZR (ft)                           =     0.00
  DEPTH OF MOISTURE ACTIVE ZONE,ZM (ft)        =    14.00
  WIDTH OF PAVEMENT (ft)                       =    50.00
  LONGITUDINAL SLOP                            =  SLOPE
  LATERAL DRAINAGE                             =  FILL


  WHEEL PATH DATA
  NO.   DISTANCE FROM THE CENTER OF PAVEMENT (ft)
    1            15.00

  INITIAL ROUGHNESS
  WHEEL PATH NO.      SI          IRI (in/mi)
      1             4.20        75.37

  DEPTH OF VERTICAL BARRIER (ft)               =    0.00


  STRUCTURAL PROPERTIES OF PAVEMENT

  STRUCTURAL NUMBER (ft)                       =   0.37
  FALLING WEIGHT DEFLECTOMETER MODULUS
  OF SUBGRADE SOIL (FROM DROP WEIGHT
  CLOSEST TO 9K LOAD) (psi)                    = 10000.00

  TRAFFIC DATA

                    WHEEL PATH NO.   1
  TRAFFIC ANALYSIS PERIOD (Years)              =     30.0
  ADT IN ONE DIRECTION WHEN T=0                =   4285.0
  ADT IN ONE DIRECTION WHEN T=C                =   6795.0
  18 kip SINGLE AXLES  WHEN T=C                =  2472059.0

  RELIABILITY
  FOR TRAFFIC                                  = 90.0
  FOR ROUGHNESS CONSTANTS Bs AND Bi            = 90.0

************************ RESULTS ************************

  SUCTION COMPRESSION INDEX (SCI)
  LAYER NO.   ZONE         SCI
       1        2       0.0099
       2        2       0.0120
       3        4       0.0327
       4        4       0.0258

  SUCTION PROFILE
  DEPTH(ft)  h(EQUILIBRIUM)   h(WET)     h(DRY)
      0.0          3.45         2.50       4.50
```

0.1	3.45	3.45	4.49
0.2	3.45	3.45	4.48
0.3	3.45	3.45	4.47
0.4	3.45	3.45	4.46
0.5	3.45	3.45	4.45
0.6	3.45	3.45	4.44
0.7	3.45	3.45	4.43
0.8	3.45	3.45	4.42
0.9	3.45	3.45	4.41
1.0	3.45	3.45	4.40
1.1	3.45	3.45	4.39
1.2	3.45	3.45	4.38
1.3	3.45	3.45	4.37
1.4	3.45	3.45	4.37
1.5	3.45	3.45	4.36
1.6	3.45	3.45	4.35
1.7	3.45	3.45	4.34
1.8	3.45	3.45	4.33
1.9	3.45	3.45	4.32
2.0	3.45	3.45	4.31
2.2	3.45	2.68	4.30
2.3	3.45	2.69	4.29
2.5	3.45	2.70	4.28
2.6	3.45	2.71	4.27
2.8	3.45	2.72	4.26
2.9	3.45	2.73	4.25
3.1	3.45	2.74	4.23
3.2	3.45	2.75	4.22
3.4	3.45	2.76	4.21
3.5	3.45	2.77	4.20
3.7	3.45	2.78	4.19
3.8	3.45	2.79	4.18
4.0	3.45	2.80	4.17
4.1	3.45	2.81	4.16
4.3	3.45	2.81	4.15
4.4	3.45	2.82	4.14
4.6	3.45	2.83	4.13
4.7	3.45	2.84	4.12
4.9	3.45	2.85	4.11
5.0	3.45	2.86	4.11
5.1	3.45	2.86	4.10
5.3	3.45	2.87	4.09
5.4	3.45	2.88	4.08
5.5	3.45	2.89	4.07
5.6	3.45	2.90	4.06
5.8	3.45	2.90	4.05
5.9	3.45	2.91	4.04
6.0	3.45	2.92	4.04
6.1	3.45	2.93	4.03
6.3	3.45	2.93	4.02
6.4	3.45	2.94	4.01
6.5	3.45	2.95	4.00
6.6	3.45	2.96	4.00
6.8	3.45	2.96	3.99
6.9	3.45	2.97	3.98
7.0	3.45	2.98	3.97
7.1	3.45	2.98	3.97
7.3	3.45	2.99	3.96
7.4	3.45	3.00	3.95
7.5	3.45	3.00	3.95
7.8	3.45	3.02	3.93
8.1	3.45	3.03	3.91
8.4	3.45	3.04	3.90

```
      8.7          3.45         3.06       3.88
      9.0          3.45         3.07       3.87
      9.3          3.45         3.08       3.86
      9.6          3.45         3.09       3.84
      9.9          3.45         3.11       3.83
     10.2          3.45         3.12       3.82
     10.5          3.45         3.13       3.81
     10.8          3.45         3.14       3.79
     11.1          3.45         3.15       3.78
     11.4          3.45         3.16       3.77
     11.7          3.45         3.17       3.76
     12.0          3.45         3.18       3.75
     12.3          3.45         3.19       3.74
     12.6          3.45         3.19       3.73
     12.9          3.45         3.20       3.72
     13.2          3.45         3.21       3.71
     13.5          3.45         3.45       3.45

  TOTAL POTENTIAL VERTICAL SWELLING            = 0.042 ft
  TOTAL POTENTIAL VERTICAL SHRINKAGE           = 0.036 ft
  TOTAL 1-D VERTICAL MOVEMENT                  = 0.078 ft

  THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST =  8.10 ft
  THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST =  9.30 ft


  DEPTH OF VERTICAL BARRIER                     =  0.00ft

  DEPTH OF AVAILABLE MOISTURE  dam (ft)         =   1.30
  PARAMETERS FOR VERTICAL MOVEMENT
     XI-1    =   0.6613
     XI-2    =   0.8692
     XI-3    =   3.6574

  EQUATION FOR 2D VERTICAL MOVEMENT
  VM = 15.70 * EXP((  0.8692 * d/D) **   3.6574) mm

  VERTICAL MOVEMENT
  DISTANCE FROM CENTER ,d, (ft)    VERTICAL MOVEMENT,VM,(inches)
           15.00                               0.68

      WHEEL PATH NO.   1
 DISTANCE FROM CENTER OF THE PAVEMENT (ft)     =  15.00

  ROUGHNESS CONSTANTS
  THE COEFFICIENT ,As                          =  473.9041
  THE COEFFICIENT ,Bs                          =   23.3367
  THE COEFFICIENT ,Rhos                        =   72.0082
  THE COEFFICIENT ,Ai                          =  934.9209
  THE COEFFICIENT ,Bi                          =   46.2731
  THE COEFFICIENT ,Rhoi                        =  138.0238

 ESTIMATED ROUGHNESS WITH TIME
YEAR    PSI   IRI(in/mi)  dPSI(SOILS)   dPSI(TRAFFIC)   dIRI(SOILS)   dIRI(TRAFFIC)

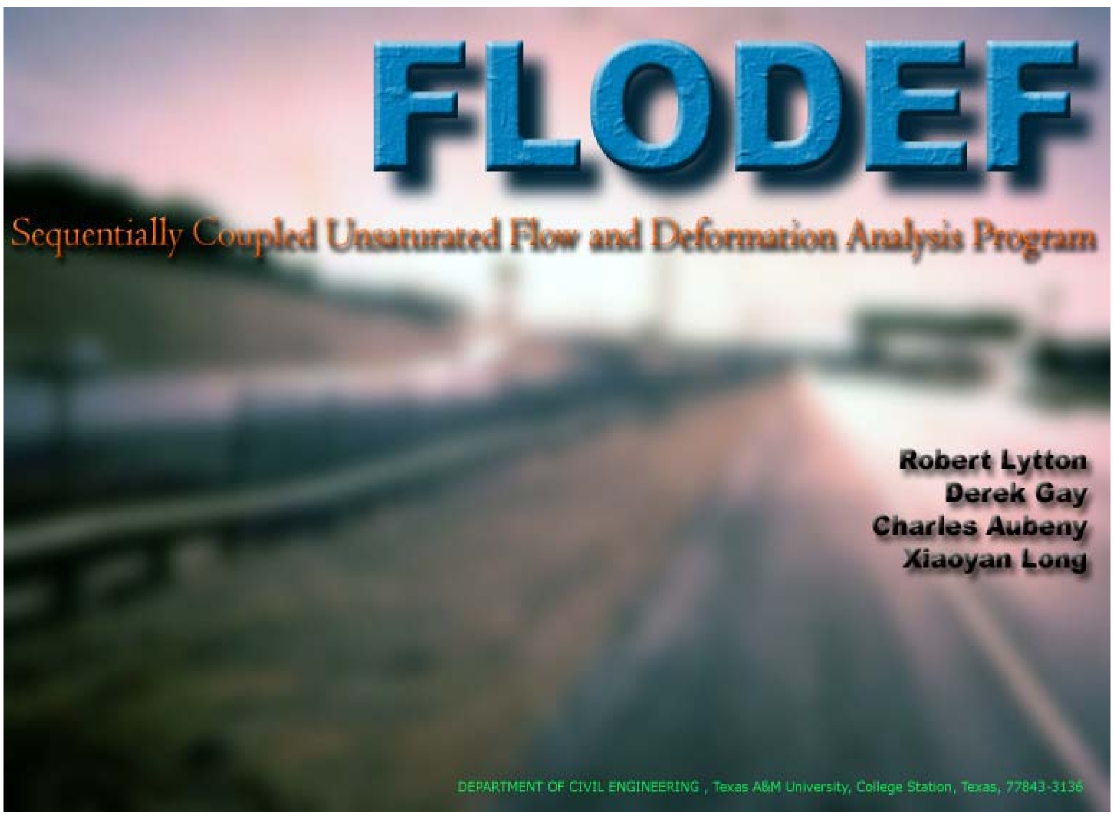
  0     4.20    75.37        0.00            0.00           0.00          0.00
  1     4.10    79.13        0.10            0.00           3.76          0.00
  2     3.86    88.67        0.34            0.00          13.22          0.08
  3     3.64    98.21        0.54            0.01          22.45          0.39
  4     3.47   106.69        0.70            0.03          30.34          0.98
  5     3.33   114.09        0.82            0.05          36.91          1.82
  6     3.21   120.58        0.91            0.08          42.35          2.85
  7     3.11   126.29        0.98            0.12          46.88          4.04
```

8	3.02	131.38	1.03	0.15	50.67	5.33
9	2.94	135.93	1.07	0.19	53.86	6.70
10	2.88	140.05	1.10	0.23	56.56	8.12
11	2.82	143.79	1.12	0.26	58.85	9.56
12	2.77	147.21	1.13	0.30	60.81	11.03
13	2.72	150.35	1.14	0.34	62.48	12.49
14	2.68	153.25	1.15	0.37	63.92	13.96
15	2.64	155.94	1.16	0.41	65.16	15.41
16	2.60	158.44	1.16	0.44	66.22	16.85
17	2.57	160.78	1.16	0.47	67.13	18.27
18	2.54	162.97	1.16	0.50	67.92	19.67
19	2.51	165.02	1.16	0.53	68.60	21.05
20	2.48	166.96	1.16	0.56	69.18	22.41
21	2.46	168.79	1.15	0.59	69.68	23.74
22	2.43	170.52	1.15	0.62	70.10	25.05
23	2.41	172.16	1.14	0.65	70.46	26.33
24	2.39	173.72	1.14	0.67	70.76	27.59
25	2.37	175.20	1.13	0.70	71.02	28.82
26	2.35	176.62	1.12	0.72	71.22	30.03
27	2.34	177.97	1.12	0.75	71.39	31.21
28	2.32	179.26	1.11	0.77	71.52	32.37
29	2.30	180.49	1.10	0.79	71.62	33.51
30	2.29	181.68	1.10	0.81	71.69	34.62

APPENDIX B:

FLODEF
USER MANUAL

Version 1.0



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1. INTRODUCTION

FLODEF is a sequentially coupled unsaturated flow and deformation finite element method (FEM) analysis program. Originally developed by Dr. Robert Lytton and Dr. Derek Gay in 1993, the program computes the transient unsaturated moisture flow and movement in an expansive clay domain. Unsaturated moisture flow is analyzed through Mitchell's model by converting the nonlinear partial differential equation given in the modified Darcy's law into an ordinary partial differential equation.

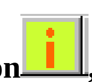
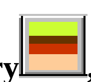
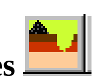
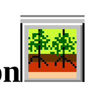
The program has provided a friendly graphic user interface (GUI). The input part is composed of four sections: **site information, pavement section geometry, layer properties, and vegetation**. For the post-processing part, the user can have the options of viewing surface deformation plot, contour plots, time history plots, and vertical profile plots to check the analysis results.

2. PROGRAM INSTALLATION

It is recommended that the user's computer screen resolution be set to 1024 by 768 pixels. If the current computer monitor setting is not compatible with this requirement, adjust the setting by pressing the mouse's right button at the window screen to enter the "**Properties**" option, "**Settings**" tab, then change the screen resolution to 1024 by 768 pixels and select the "**Apply**" button.

To install the program, the user just inserts the attached CD in the computer drive and clicks the file "**Flodef_setup.exe**". Then the program **winflow** can be automatically installed in any user-defined destination path.

3. INPUT

For the purpose of executing the program, the user needs to fill in the data for **site information**, **pavement section geometry**, **layer properties**  and **vegetation** screens. The user can click the associated icon or menu toolbar to enter each input screen.

3.1 Site Information

The program provides choices of seasonal weather data at nine different locations in Texas (west Texas, central Texas, and east Texas): **El Paso**, **Snyder, Wichita Falls, Converse, Seguin, Dallas, Ennis, Houston,** and **Port Arthur**. If the actual field site is not located near any of these nine cities, select the region for analysis based on the TMI value and geological location (Fig. 28).

Initial moisture conditions at the beginning of analysis fall into three categories: **wet condition** (winter season), **equilibrium condition** (spring/fall season), and **dry condition** (summer season). Select the season most appropriate for the roadway during its expected lifespan.

Based on the user's requirement, the analysis period of 5 years, 10 years, 15 years, or 20 years can be selected. The program has the capability to compute the effects of vertical embedded moisture barrier, horizontal moisture barrier, median condition and drainage condition. The information of special geological formation such as a tinted limestone layer can be input in the "Special Soil Layer" box. The existences of one format of geological formation in different locations are accounted for more than one type of special subgrade layers.

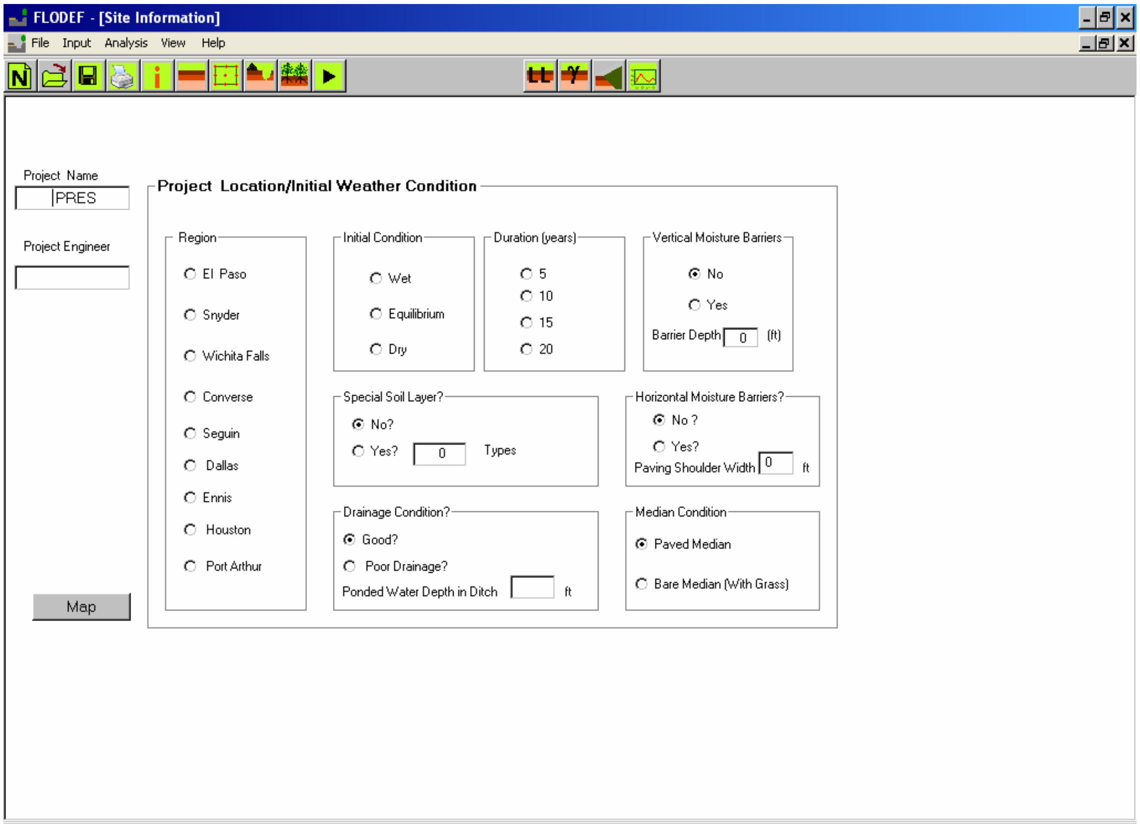


Figure 28. Site Information Screen.

Click the “map” button on this screen to view a Texas map with indicated TMI values (Fig. 29).

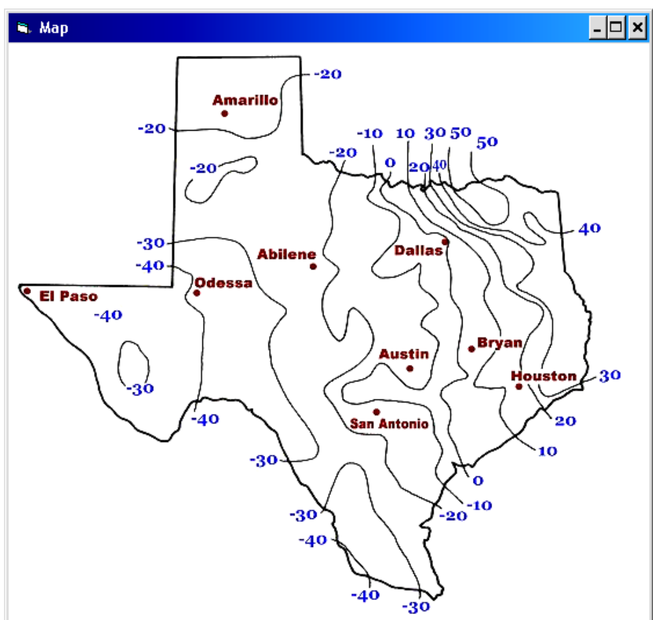


Figure 29. Texas Map with TMI Value Indicated.

3.2 Pavement Section Geometry

This section requires the user to input the roadway geometry dimensions (surface, base, subbase, and subgrade layer thicknesses plus pavement cross section information). Normally, the moisture active zone depth z_m is around 20 ft. If the sum of individual subgrade layers is not less than 20 ft, the mesh analysis depth is set to 20ft by the program. Where the total depth of the subgrade layers is less than 20 ft, for instance, in the situation that bedrock is encountered at shallow depth, the mesh depth is equal to the bedrock depth.

If the number of total subgrade layers is less than four, the user must split the deepest individual subgrade layer into two layers with duplicate data. The depth of the two layers does not have to be exactly equal but can be rounded to the nearest foot to make the sum of the two equal the total. (Example: The Drill Log only shows three subgrade layers. Subgrade layer 2 is nine feet thick. Split this into subgrade layers 2 and 3 with depths of five feet and four feet respectively and make the previous subgrade layer 3, subgrade layer 4.

The unit for thicknesses of the surface, base, and subbase courses is inches, while the depth of each subgrade layer is counted in ft. The side slopes S1, S2, R3, S4, R5, R6 and S7 are unitless and given by common slope designations used in construction, such as 2 to 1 or 10 to 1. It should be emphasized that none of the parameters (S2, S4, S7, Z4, Z5, Z6, Z7, X3, X4, X5 and X6) can receive an input value of zero. The minimum value that can be used is 0.01. The physical meanings of these parameters are illustrated in Figure 30.

FLODEF

The manual provides examples of several types of mesh dimension combinations from the **Fort Worth Loop 820, Atlanta US 271, Austin Loop 1** field conditions used in the initial research:

1) If the shoulder slope S1 is not equal to zero (**Atlanta US 271 type**), then the input pavement dimension parameters should agree with the following two requirements: a) the sum of the surface and base course thickness equals the elevation difference of two sides of the shoulder ($(Z1+Z2)/12.0=(-1)*X4/S1$,where Z1, Z2 have units in inches, and X4 has units in ft); b) the total sum of surface, base course and subbase course thickness plus the subgrade layer 1 depth equals the value of elevation difference from the surface course to the ditch bottom $(Z1+Z2+Z3)/12+Z4=(-1)*X4/S1+(-1)*X5/S2$, where Z1, Z2 have units in inches, and X4, X5 have units in ft). The slope is negative when it goes clockwise and positive when rotating counterclockwise.

2) If the shoulder slope S1 is equal to zero and the elevation difference from the surface course to the ditch bottom is very small (around 1 ft) (**Fort Worth study Section B type**), then the input pavement dimension parameters should conform to the following restriction: adjust the input value of surface course thickness Z1, and make Z1 equal to the elevation difference from the surface course to the ditch bottom ($Z1/12.0=(-1)*X5/S2$, where Z1 has the unit of inch, X5 has the unit of ft). If the shoulder slope S1 is equal to zero and the elevation difference from the surface course to the ditch bottom is not small (greater than 1 ft) (**Fort Worth study Section A type, Austin Loop 360 type**), then the input pavement dimension parameters should be input as follows: the total sum of surface course thickness Z1, base course thickness Z2, subbase course thickness Z3, and subgrade layer 1 thickness Z4 should equal the elevation difference from the surface course to the ditch bottom ($(Z1+Z2+Z3/12.0)+Z4=(-1)*X5/S2$, where Z1, Z2, Z3 have the unit of inch and Z4 has the unit of ft).

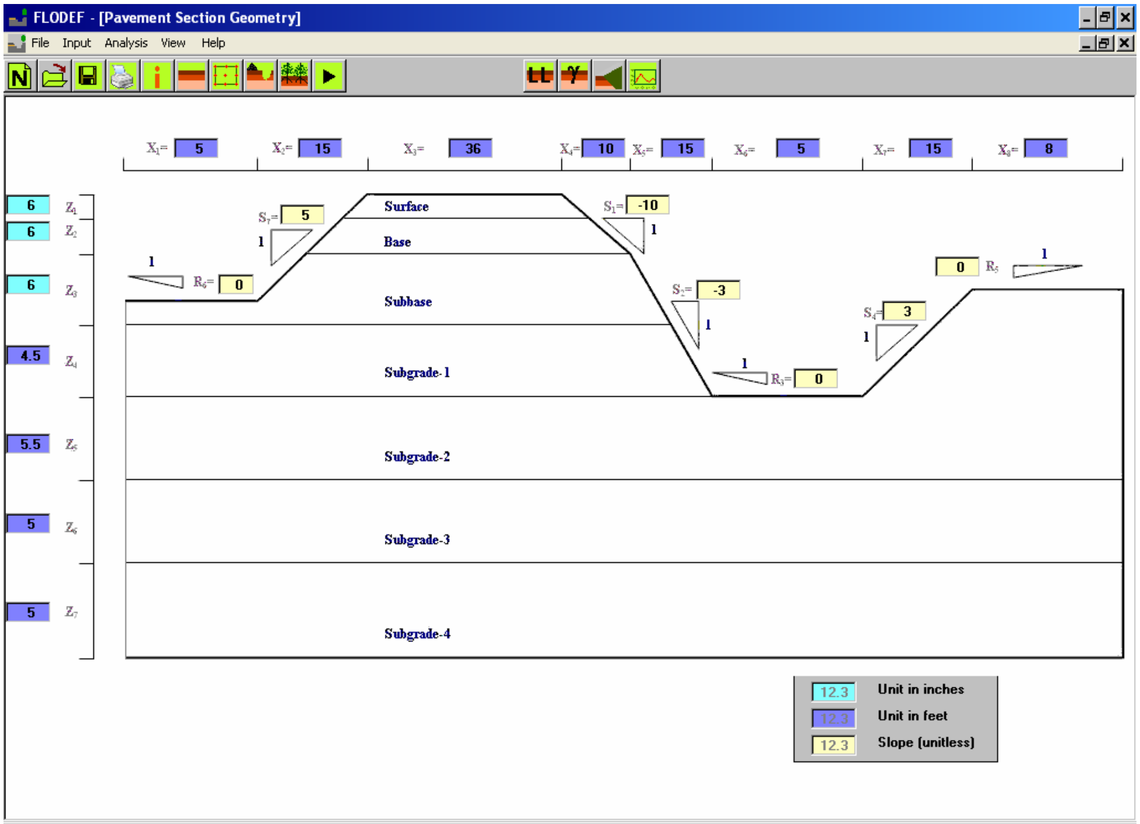
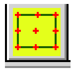


Figure 30. Pavement Section Geometry Screen.

3.3 Mesh View

After the user inputs the pavement section dimension values, the user should click the "mesh view" icon  to review the mesh automatically generated by the program. The element types in the mesh are 8 nodes quadratic element and 6 nodes bilinear triangle element. The user can click the element to view the global node numbers for each element in the upper right window.

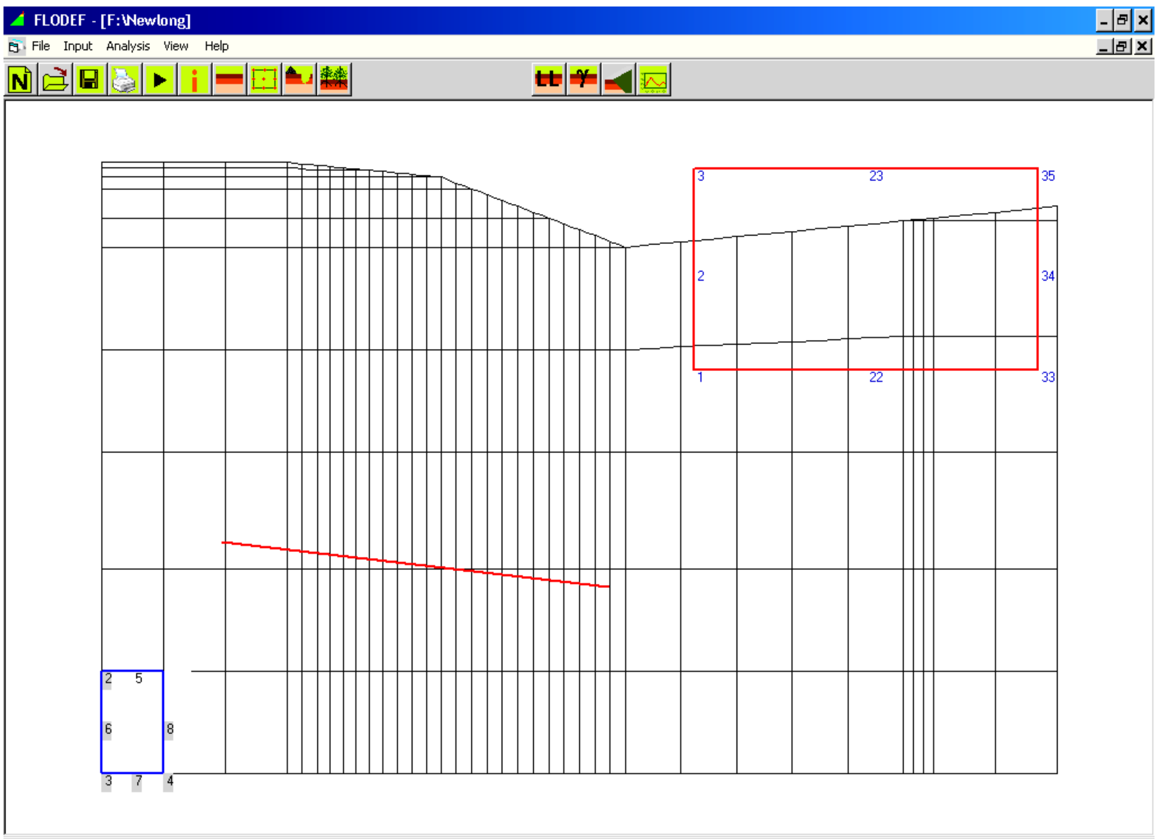


Figure 31. Automatic Mesh View Screen.

The user needs to input the pavement dimensions to satisfy the listed requirements in the manual. If the input data does not satisfy the requirements, when the "Mesh View" button is clicked, the program will give an error message and ask for new input of pavement dimensions which conform to the described restrictions above.

3.4 Layer Properties

In this screen, the surface course type (asphalt/concrete), base course type (untreated granular /lime stabilized /cement stabilized /asphalt- treated), subbase course type (untreated granular /lime stabilized /cement stabilized /asphalt-treated), and subgrade layers properties data (LL, PI, percent of passing -200# sieve, percent of minus 2 micron clay content, Poisson's ratio υ, dry unit weight γ_d) information is entered.

The subgrade layers are labeled in four layers (layer 1, 2, 3, 4) from top to bottom. Subgrade layers can be natural soil, inert soil, or soil stabilized with lime or cement. The default lime or cement percent by weight is 6%.

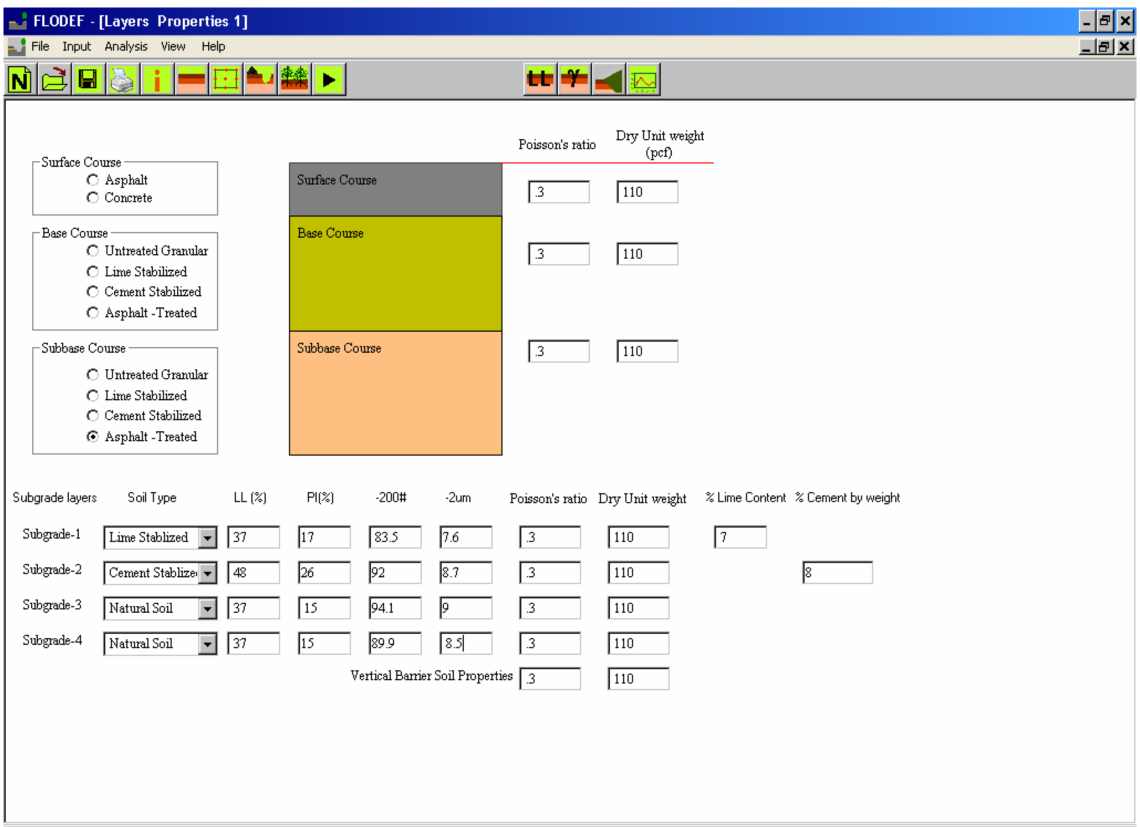
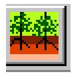


Figure 32. Layer Properties Screen.

3.5 Vegetation

The vegetation information (tree root zone depth/ grass, if any) can be entered in this screen by clicking the  icon or "Input" option, "Vegetation" sub option.

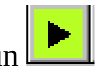
If the field site has an existing tree, the user needs to click the "Tree" button and adjust the actual tree influence extent by slowly sliding the left line with the left mouse button and the right line with the right mouse button along the pavement cross section surface. It should be emphasized that the right line should not go beyond the right range of the pavement cross section when sliding and adjusting the vegetation location extent. The surface grass extent Grass button can be input in the same way described above.

In this screen, the root transpiration rate and root zone depth are also required for the tree and grass information.

Figure 33. Vegetation Information Screen.

The default transpiration rate of 0.12 in. (3mm/day) is built into the program. It is an accurate value for most cases. Unless a very special situation occurs in which the user may want to contact the District Landscape Architect, Vegetation Management Specialist, or the Maintenance Division for the actual transpiration rate, the user should adopt the default value for the analysis.

4. RUN

After inputting all the required data information, click the run  icon on the toolbar or "Analysis" option in the menu at the top of the screen to execute the program and perform an analysis.

The usual run time for a 5 year analysis on a PC (CPU around 1G hz) is about 20 minutes; 10 years, 40 minutes; 15 years, 60 minutes; and 20 years, 80 minutes. The running screen appears below in Figure 34.

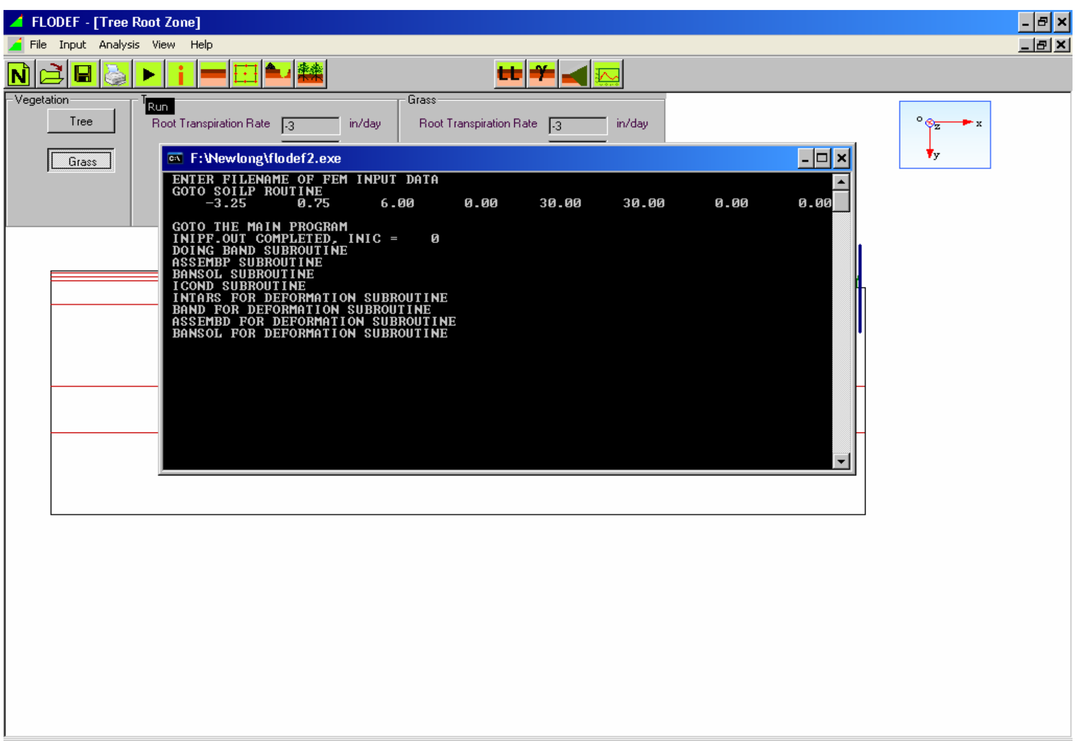


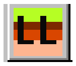
Figure 34. Running Screen.

5. OUTPUT

The program provides output options of vertical profile plot (suction/vertical displacements/horizontal displacements), contour plot (suction/vertical displacements/horizontal displacements), surface deformation plot, and time history plot (suction/vertical displacements/horizontal displacements) to review the analysis results.

5.1 Vertical Profile Plots

The user can view the vertical profiles (**Suction/Vertical Displacements/ Horizontal Displacements)** of 30 equally divided segments along the pavement cross section.

After clicking the  icon or "View" option, "Vertical Profiles" sub option on the menu bar, the following screen (Figure 35) will appear.

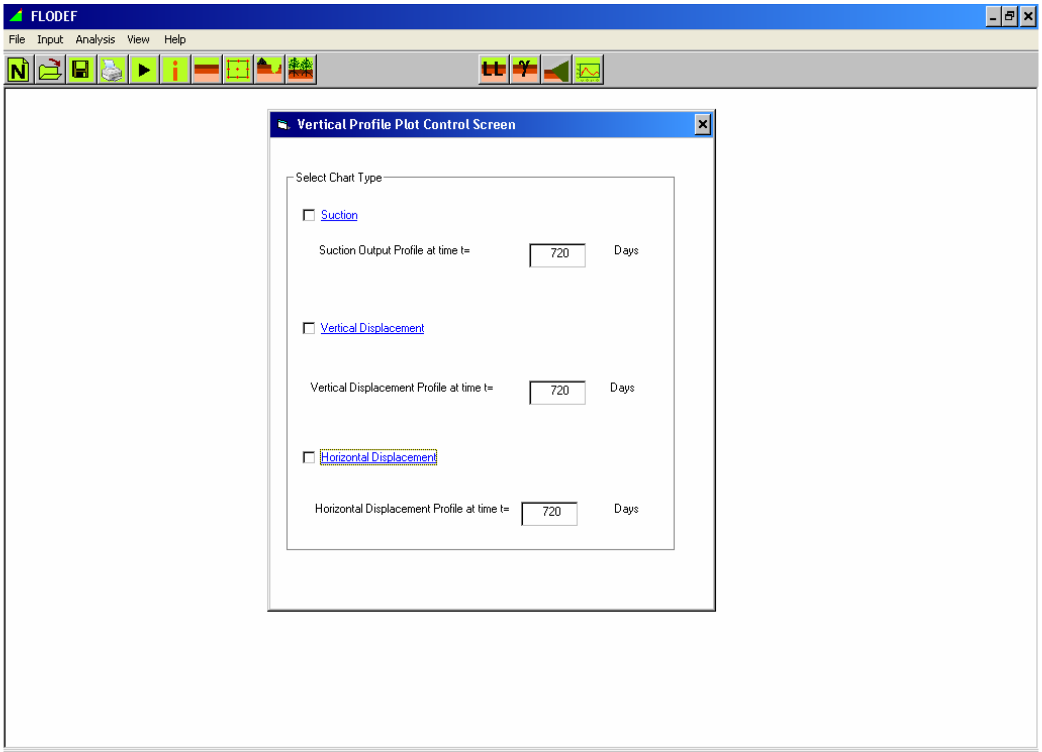
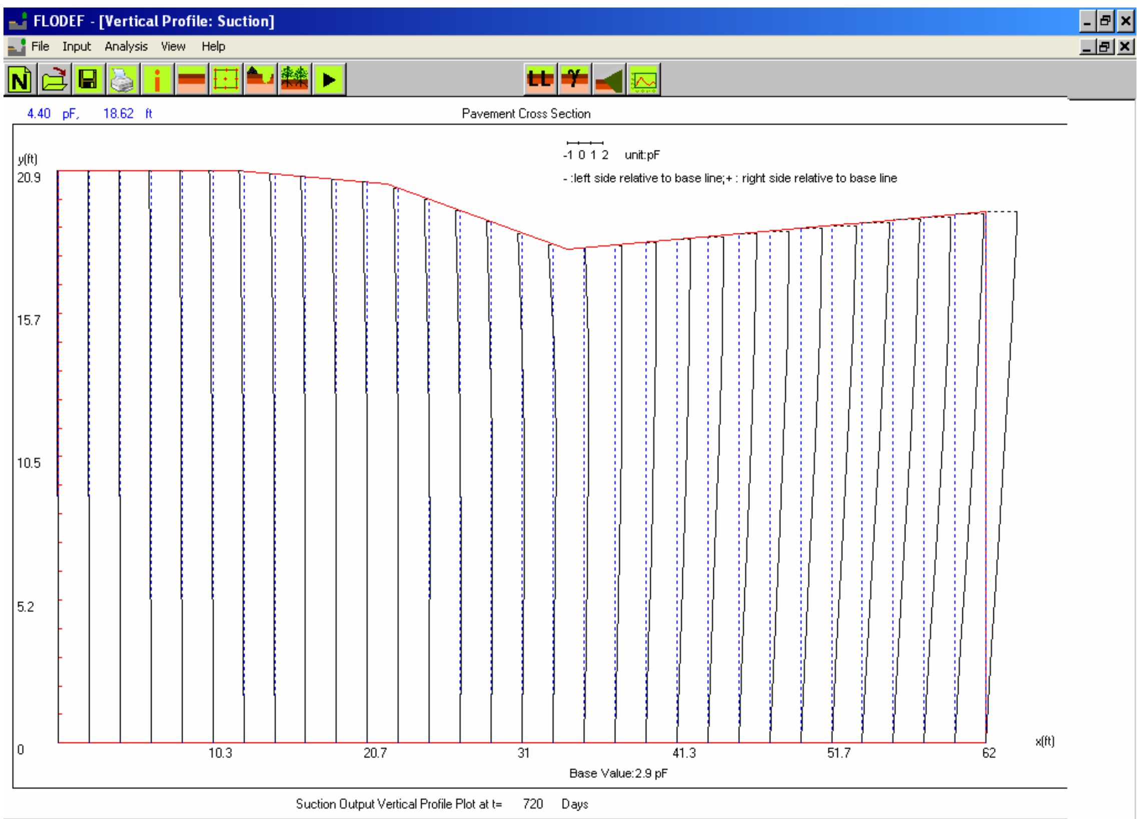


Figure 35. Vertical Profile Screens (1).

The user can view the associated vertical profile plots by inputting the desired output time in the textboxes and clicking the underlined label (suction/vertical displacement/horizontal displacement). If the cursor is moved along the vertical profile curve (black color), the associated suction (Figure 36)/vertical displacement (Figure 37)/horizontal displacement (Figure 38) value and elevation y coordinate for this location will appear in the left upper screen (text in blue color). The blue dotted lines in Figure 36/Figure 37/Figure 38 stand for the 30 equally divided segments in the pavement cross section, while the black solid lines are the suction curves (Figure 36)/ vertical displacement curves (Figure 37)/horizontal displacement curves (Figure 38) for these segments.



. **Figure 36. Vertical Profile Screens (2)**.

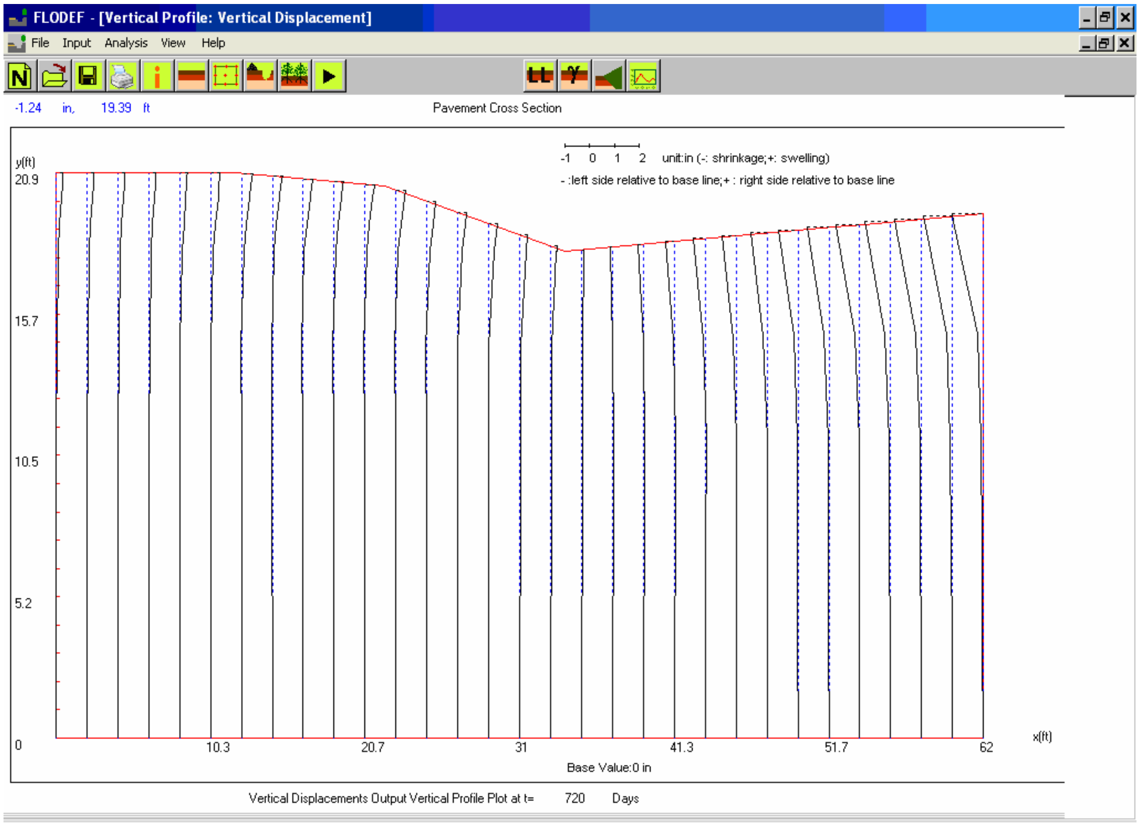


Figure 37. Vertical Profile Screens (3).

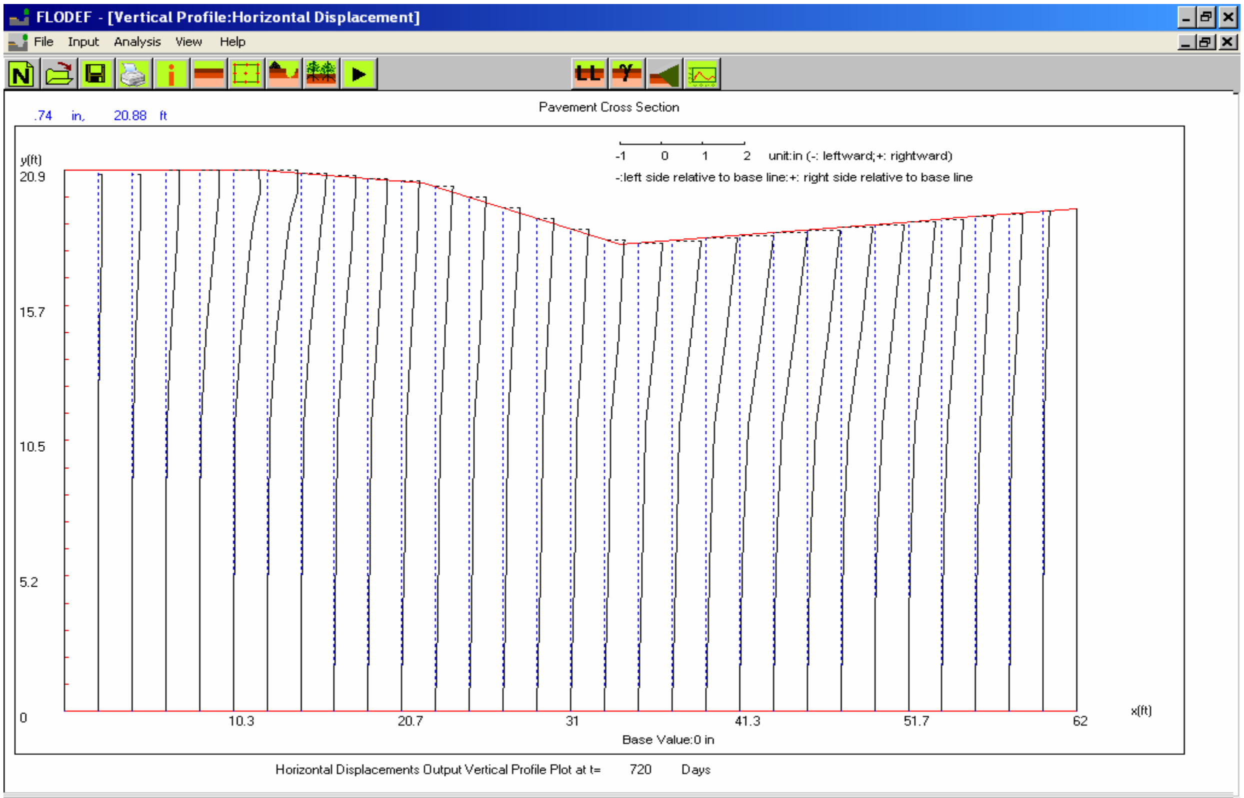
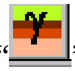


Figure 38. Vertical Profile Screens (4).

5.2 Contour Plots

After clicking the "" icon or "View" option, "Contours" sub option on the menu bar, the following screen (Figure 39) will be shown.

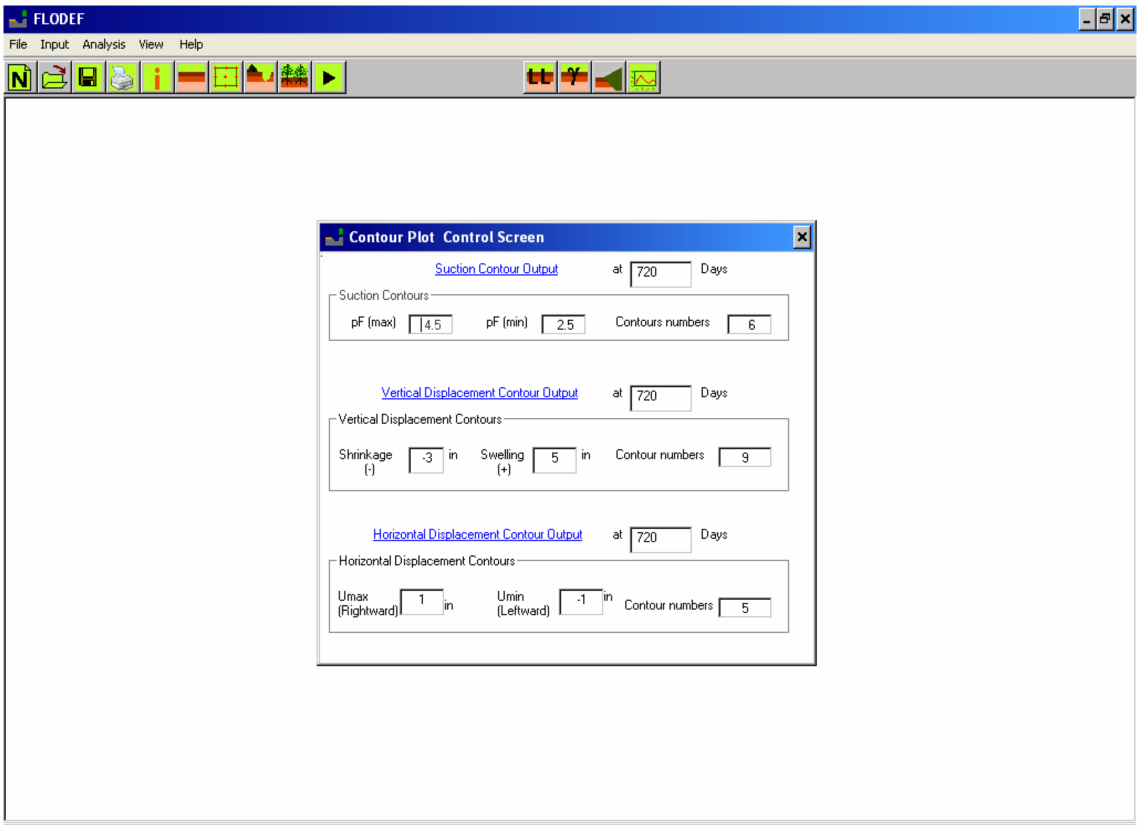


Figure 39. Contour Plot Screens (1).

By clicking the underlined blue "Suction Contour Output"/"Vertical Displacement Contour Output"/"Horizontal Displacement Contour Output" labels, the user can view the suction contours (Figure 40)/ vertical displacement contours (Figure 41)/horizontal displacement contours (Figure 42) after the desired output time, maximum/minimum display values and number of desired contours are input to the associated textboxes. The maximum value of the number of specified contours is 12 in this program.

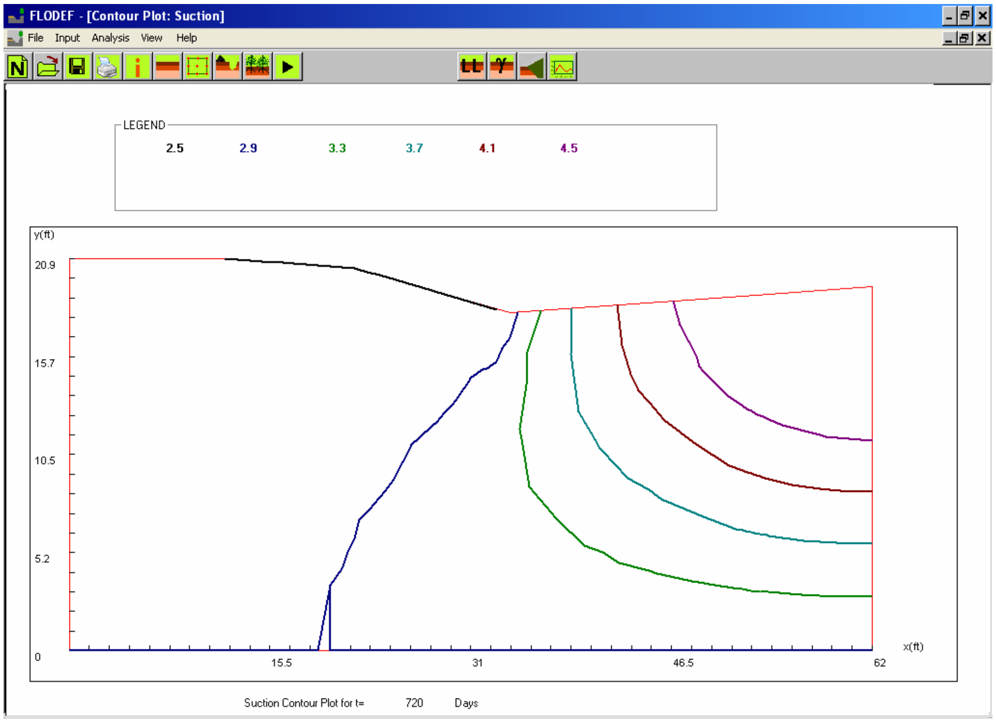


Figure 40. Contour Plot Screens (2).

Figure 41. Contour Plot Screens (3).

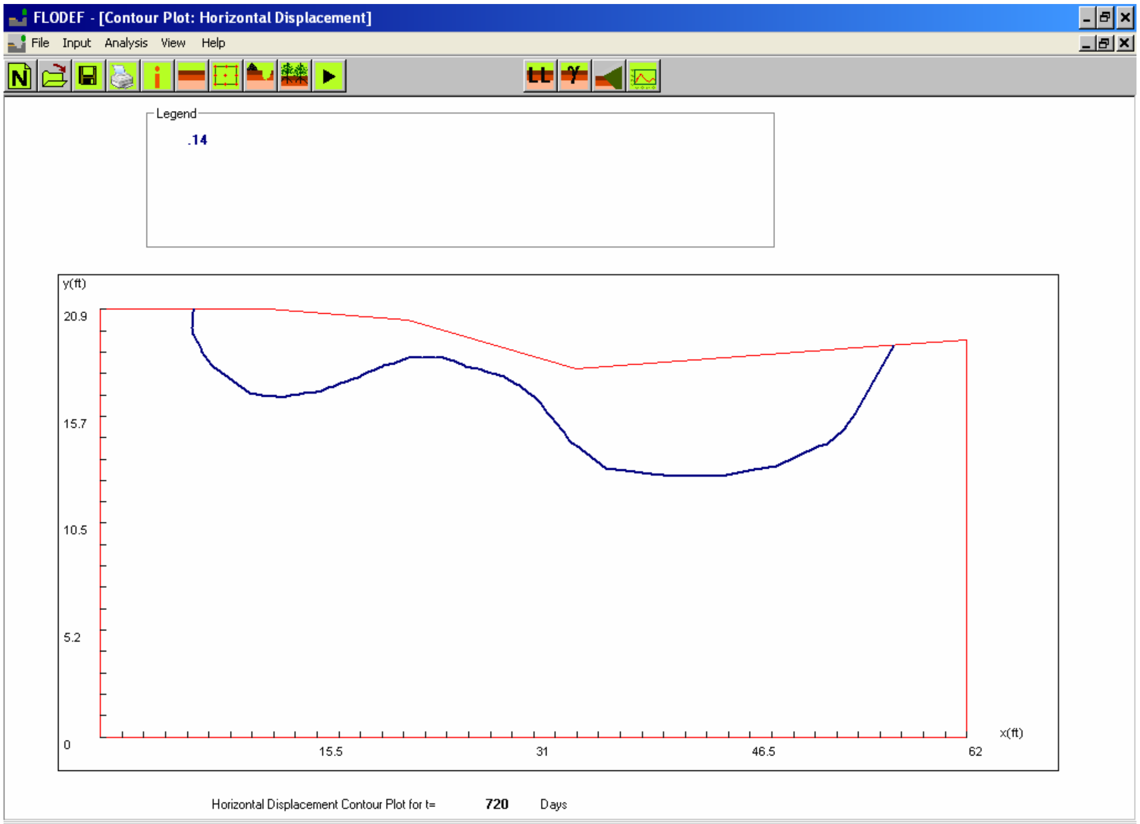
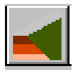


Figure 42. Contour Plot Screens (4).

It should be pointed out that for some combinations of maximum/minimum display values and number of specified contours, the program can not show any contour curve for these desired contour values.

The user can distinguish the contour lines by the associated colors. In the legend, each text is shown with a different color. For example, in Figure 40, the text "4.1" in the legend has a red font color, so the red suction contour curve stands for suction value "4.1". The unit for vertical displacement and horizontal displacement is inches. For vertical displacement, positive values "(+)" denote swelling and for horizontal displacement, "positive (+)" values denote rightward horizontal movement.

5.3 Surface Deformation Plot

After clicking the  icon or “View” option , “Surface Deformation Plots” sub option on the menu bar, the following screen (Figure 43) will appear below for specifying the desired output time, t.

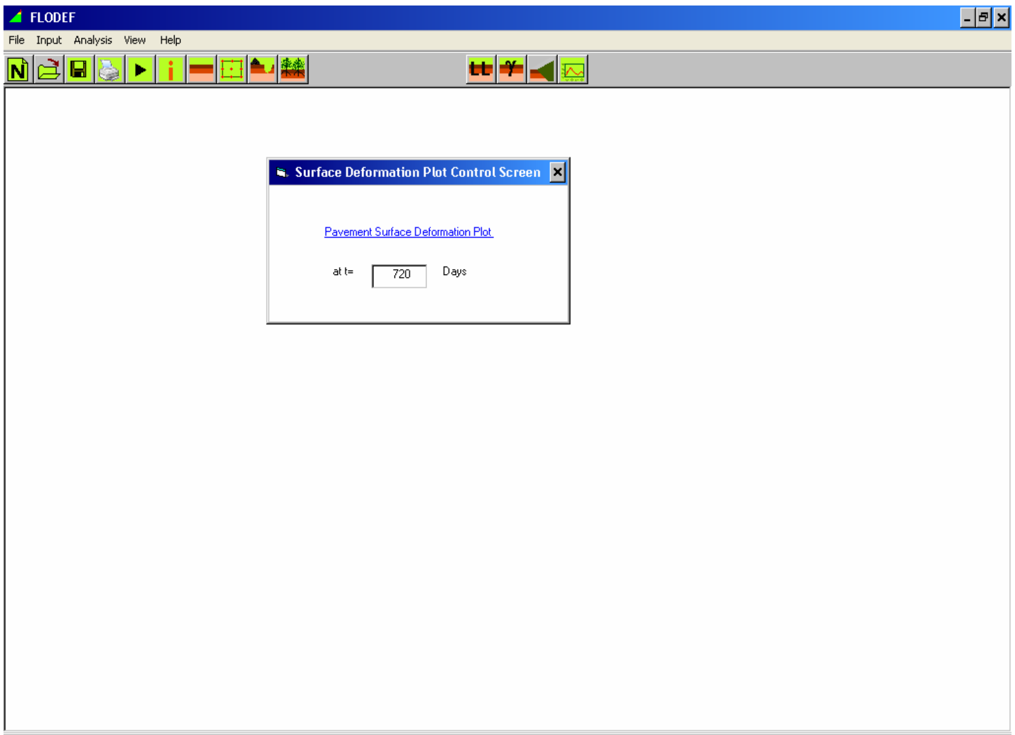


Figure 43. Surface Deformation Plot Screen (1).

By clicking the blue underlined “Pavement Surface Deformation Plot” label, the user can see the screen shown in Figure 44.

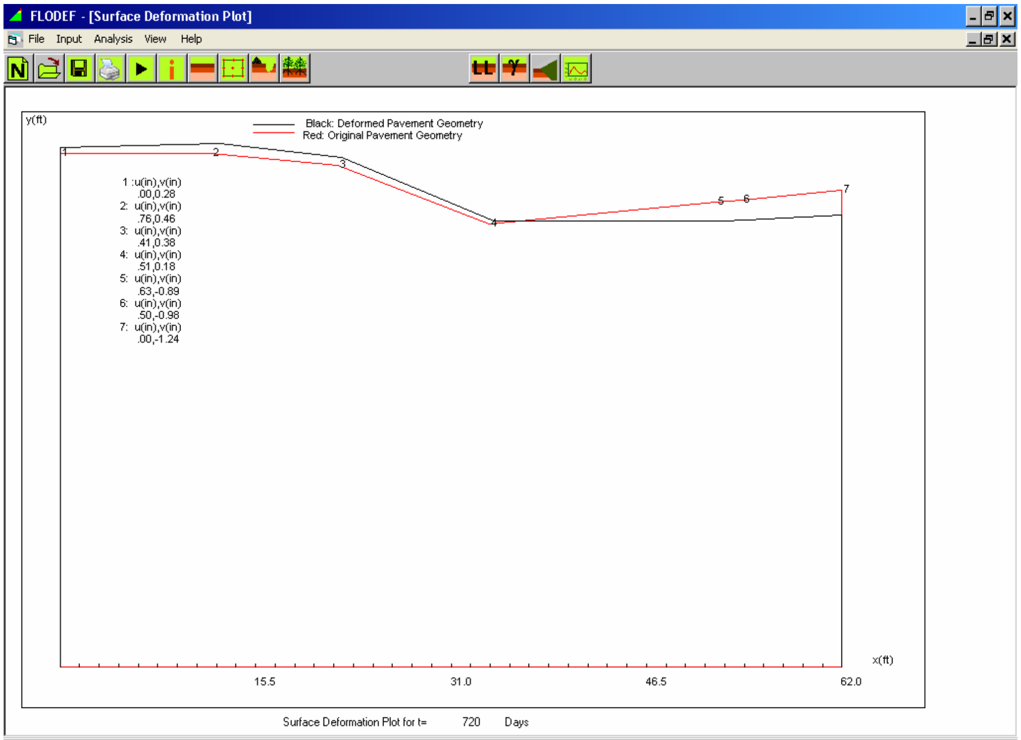
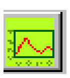
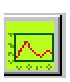


Figure 44. Surface Deformation Plot Screen (2).

5.4 Time History Plots

Figure 45 provides the options for the program to view different time history plots [suction (Figure 46)/ vertical displacement (Figure 47)/ horizontal displacement (Figure 48)] for any desired location in the pavement cross section. The viewer can either click the  icon or click on "View → Time History Plots → Suction/Vertical Displacement/Horizontal Displacement" sub option on the menu bar to review the time history plots (Figures 45-48) for 5, 10, 15, and 20 year analysis periods.

The "History Output Charts Control Screen" (Figure 45) will appear only if the user clicks the  icon.

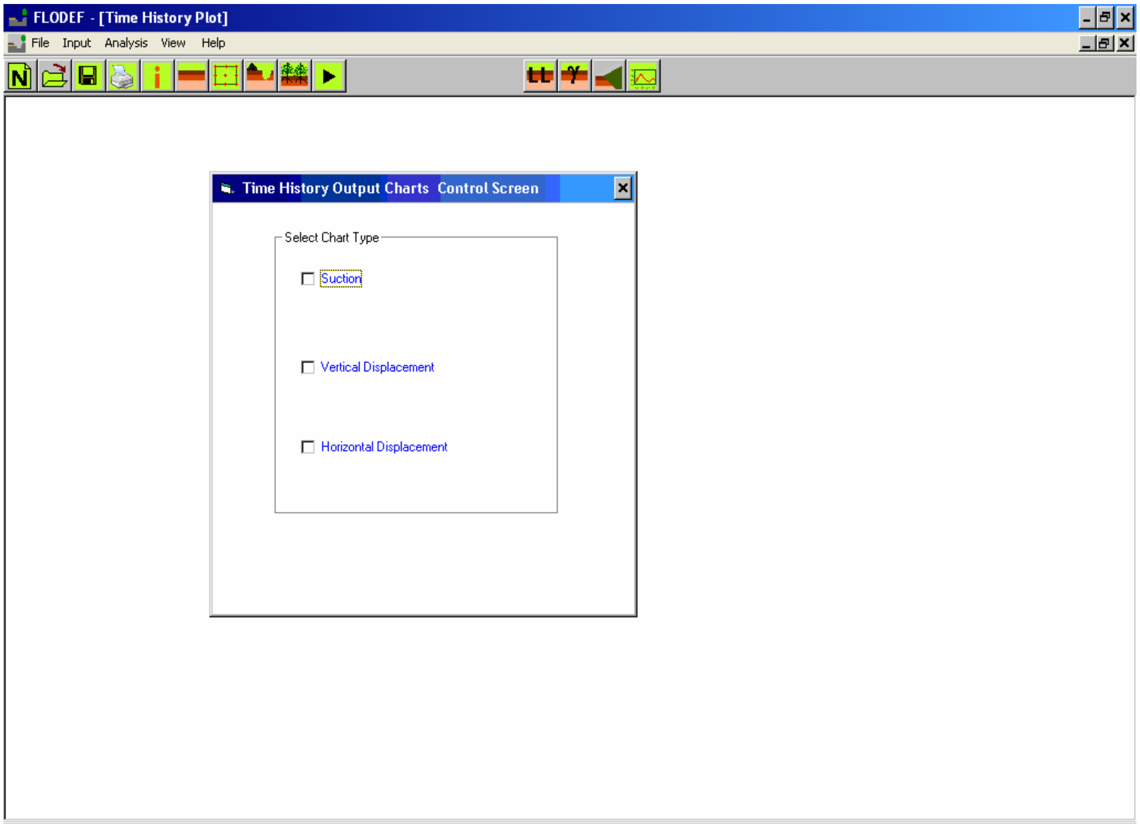


Figure 45. Time History Plot Screens (1).

By clicking the blue labels for "Suction", "Vertical Displacement", "Horizontal Displacement", the user can view Figures 46, 47, 48.

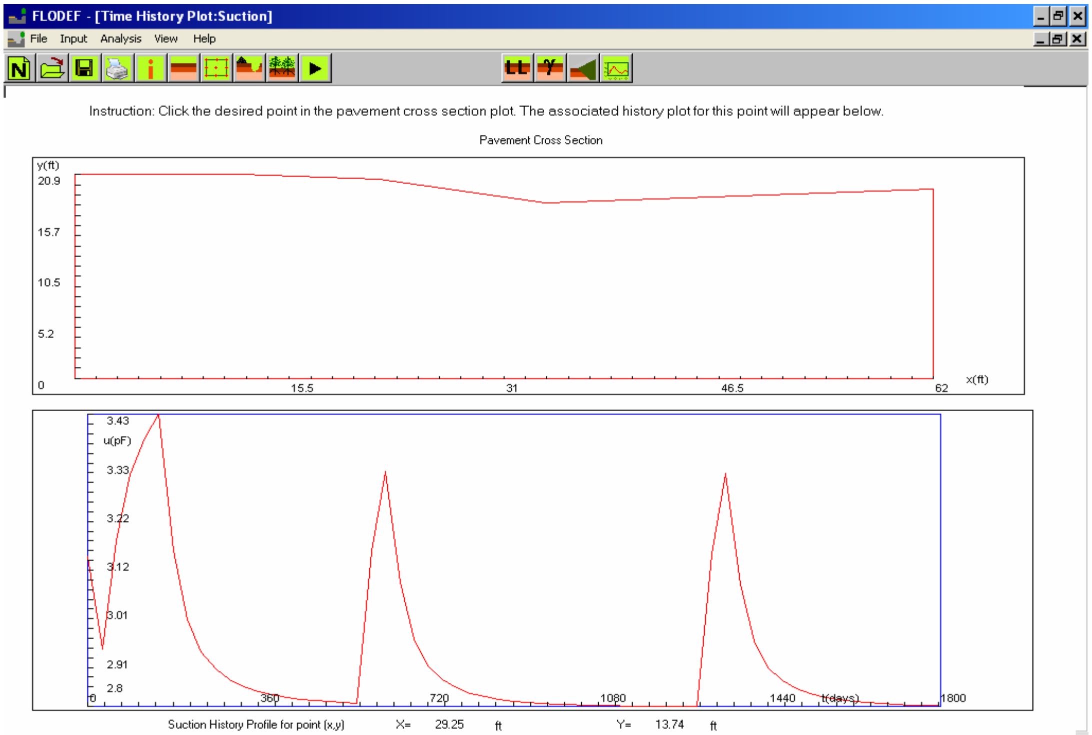


Figure 46. Time History Plot Screens (2).

Figure 47. Time History Plot Screens (3).

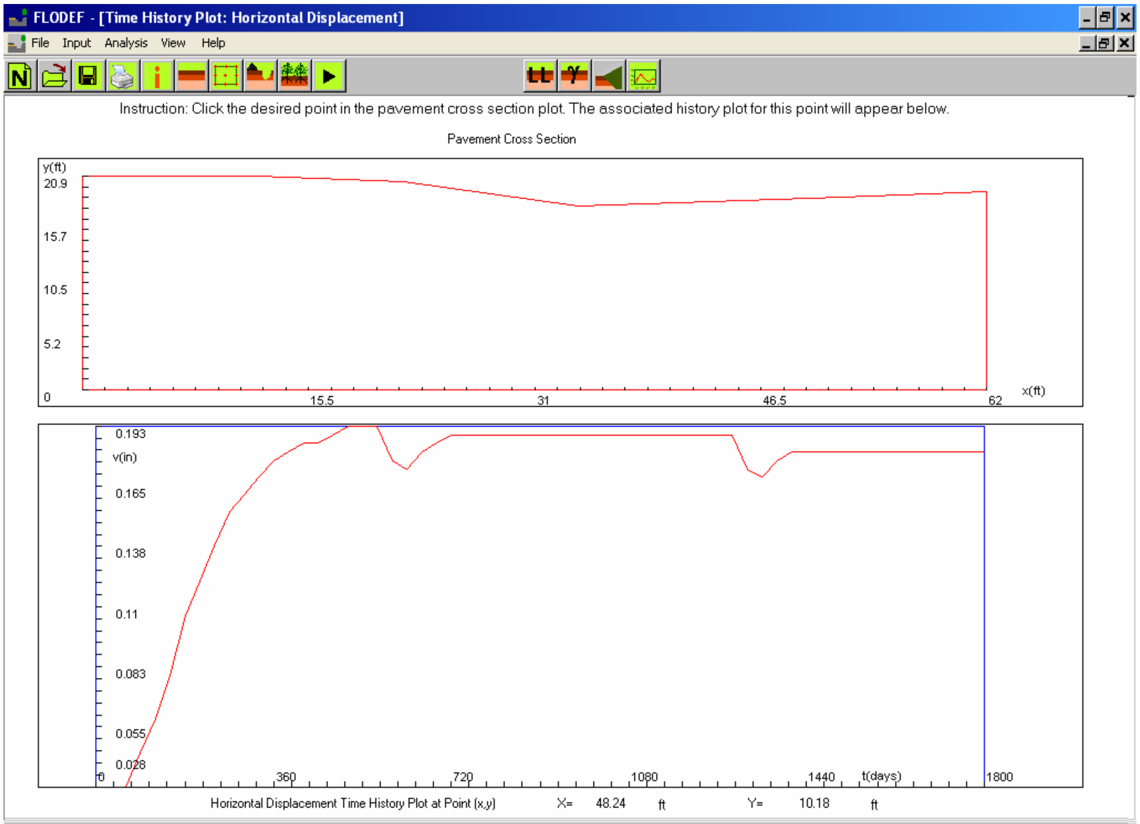
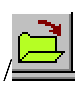
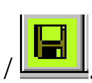


Figure 48. Time History Plot Screens (4).

6. SUPPLEMENT

The user can create a new file, open an existing file, save a file, or save a file as a different name by clicking the "File" option, "New"/ "Open"/ "Save"/ "Save As" sub options on the menu bar or clicking the associated icons  /  / .

The program also provides "Print" functions for the user to get hard copies of all the input forms and output plots. In printer preferences, the "layout" setting should be "Landscape" on the orientation tab.

APPENDIX TO MANUAL

An example of the Atlanta US 271 site case study is given below to demonstrate the input and output steps for the FLODEF program in more detail.

CASE DESCRIPTION

In the Atlanta US 271 site, there are trees and grasses existing from the ditch line out to the right-of-way line. For the two-dimensional finite element analysis in FLODEF, the tree root zone depth is assumed to be 14 ft according to the borehole data. The root transpiration rate and grass transpiration rate are estimated to be 0.12in/day. The site cross section is shown in Figure 49.

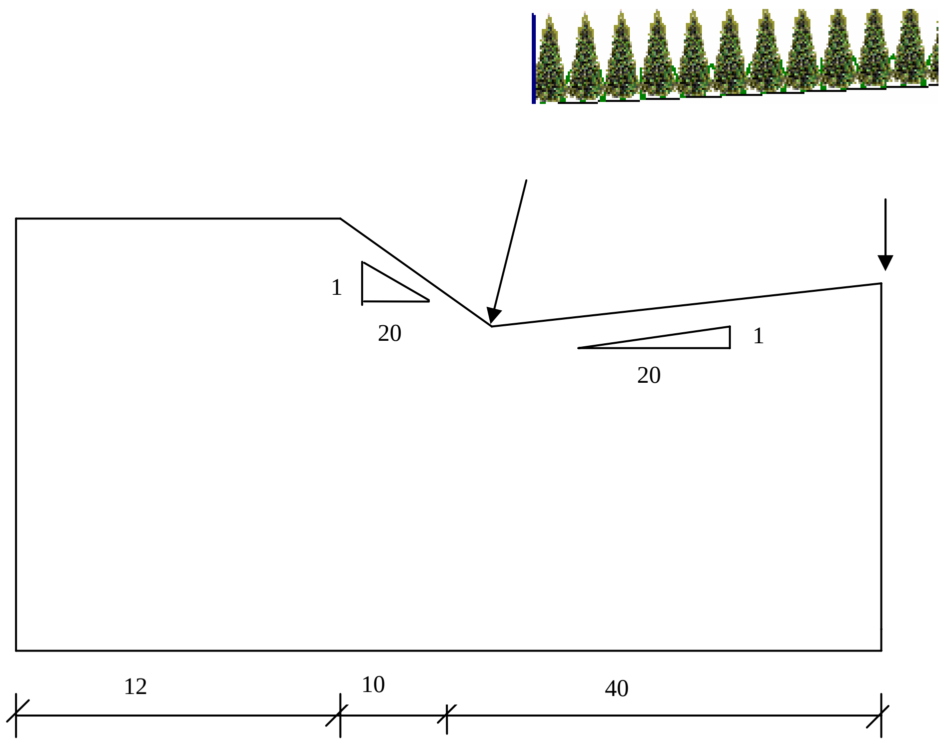


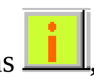
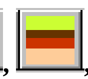
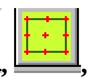
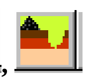
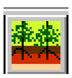
Figure 49. Atlanta Site Cross Section Sketch.

Four subgrade layers are employed for the mesh generation and finite element method analysis purposes with the thicknesses for the layers from top to bottom being: 2ft, 7ft, 4ft, and 2ft. The pavement structure has an asphalt surface (flexible pavement), untreated granular base and subbase courses. The soil properties of the subgrade layers are illustrated in Table 3.

Table 3. Soil Properties for Subgrade Layers in the Atlanta US 271 Site Example.

Location (From top to bottom)	Soil Type	LL (%)	PI (%)	-200#	-2µm
Subgrade layer 1	Natural	37	17	83.5	7.6
Subgrade layer 2	Natural	48	26	92	8.7
Subgrade layer 3	Natural	37	15	94.1	9
Subgrade layer 4	Natural	37	15	89.9	8.5

ILLUSTRATION: INPUT SCREENS

Based on the information of the pavement cross section geometries, soil layer properties, and vegetation condition, the user will click the icons , , , , and  to enter "site information", "pavement section geometry", " mesh view", "layer properties" and "vegetation" input data. Figure 50 through Figure 54 show the associated user inputs for this example.

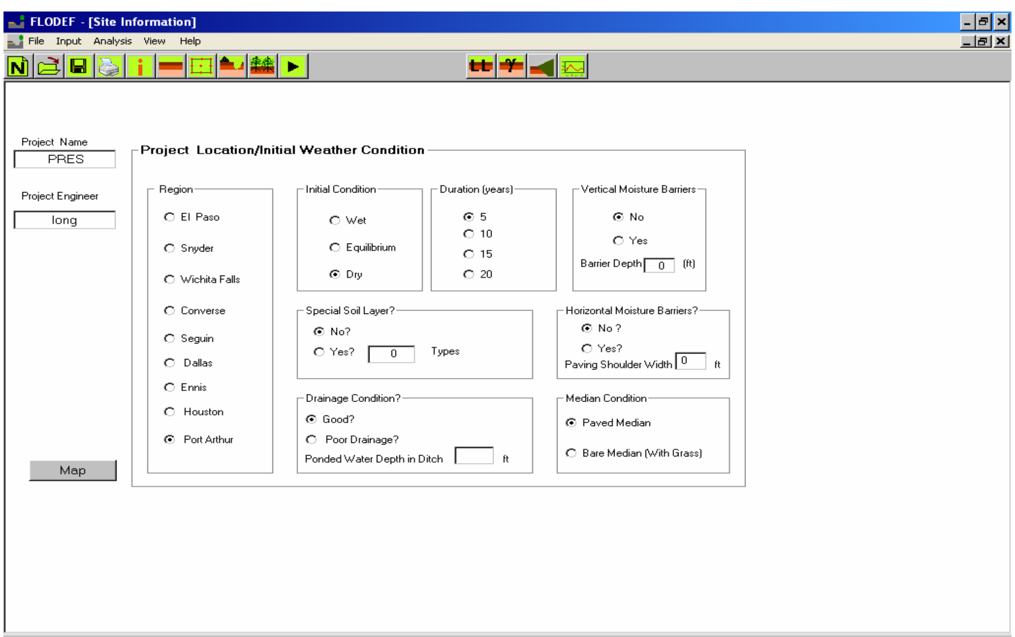


Figure 50. Input Screen 1: Site Information.

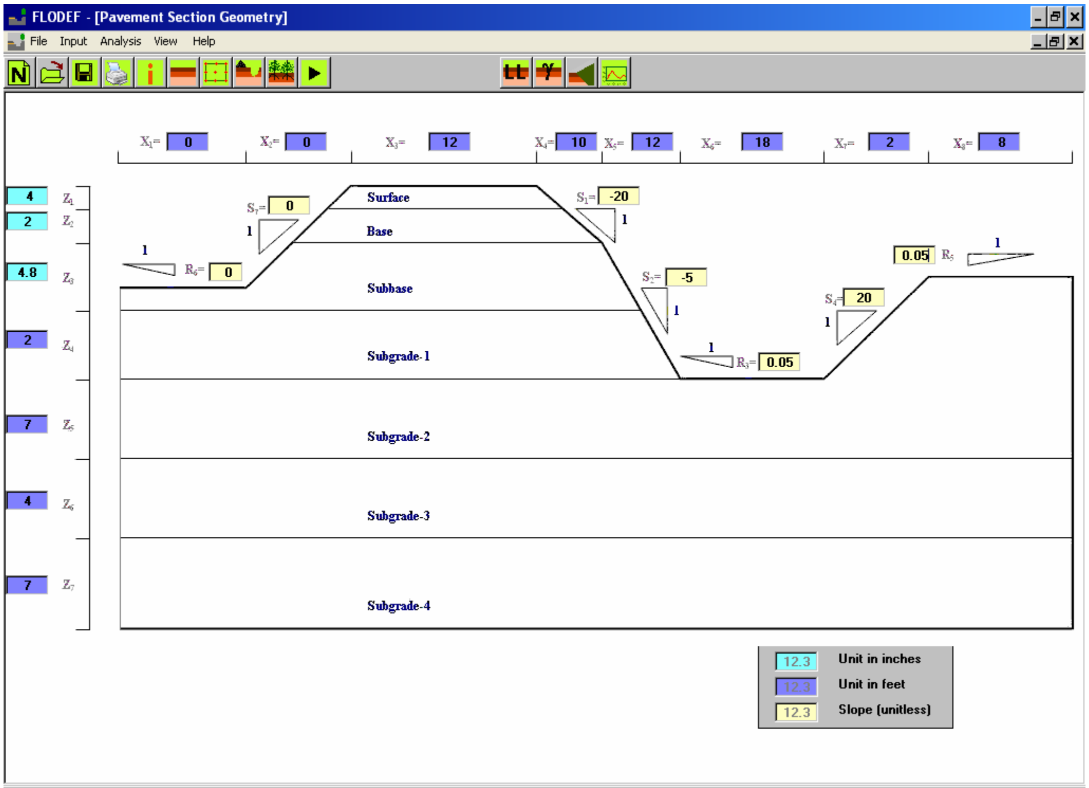


Figure 51. Input Screen 2: Pavement Section Geometry.

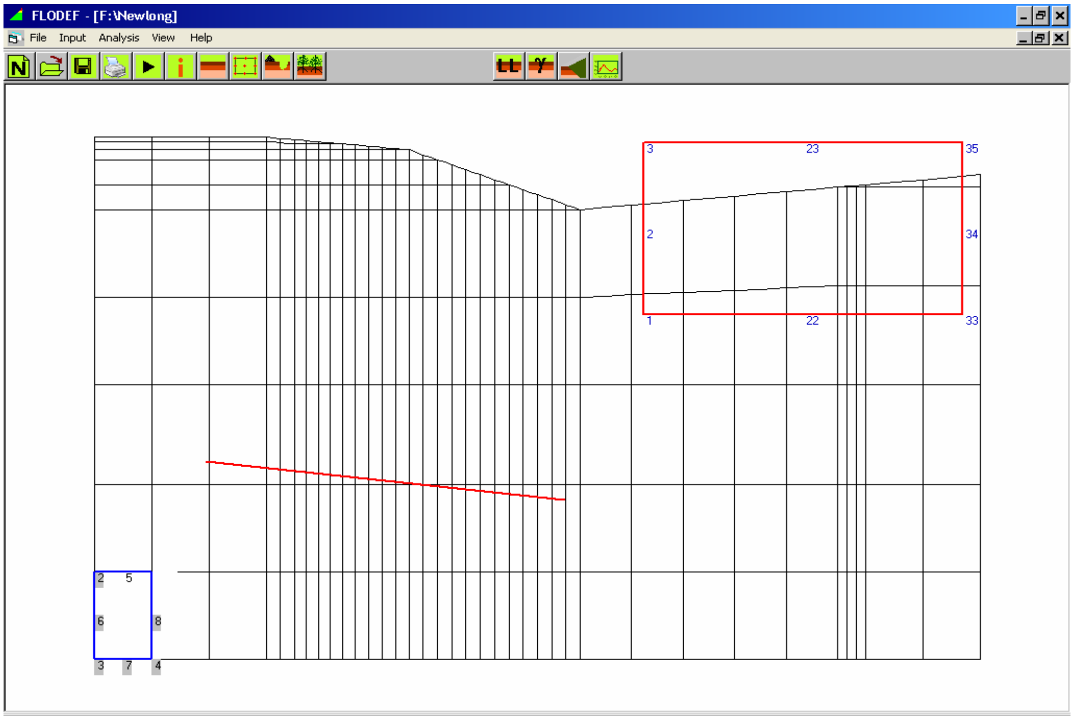


Figure 52. Input Screen 3: Automatic Mesh View.

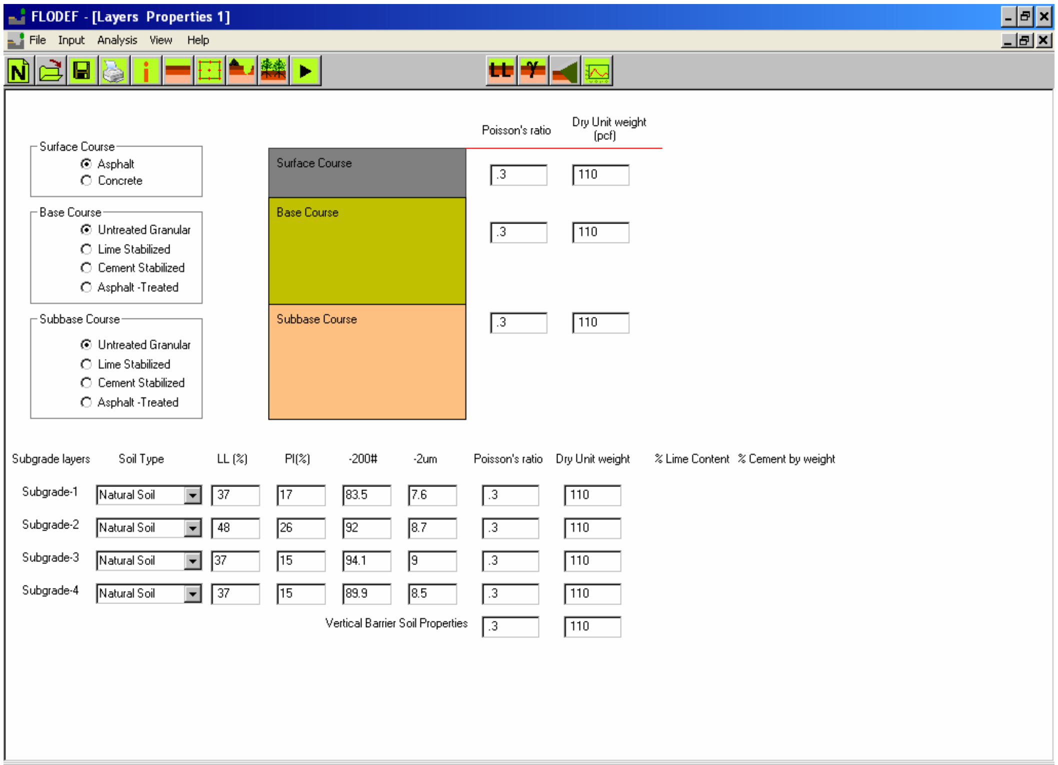


Figure 53. Input Screen 4: Layer Properties.

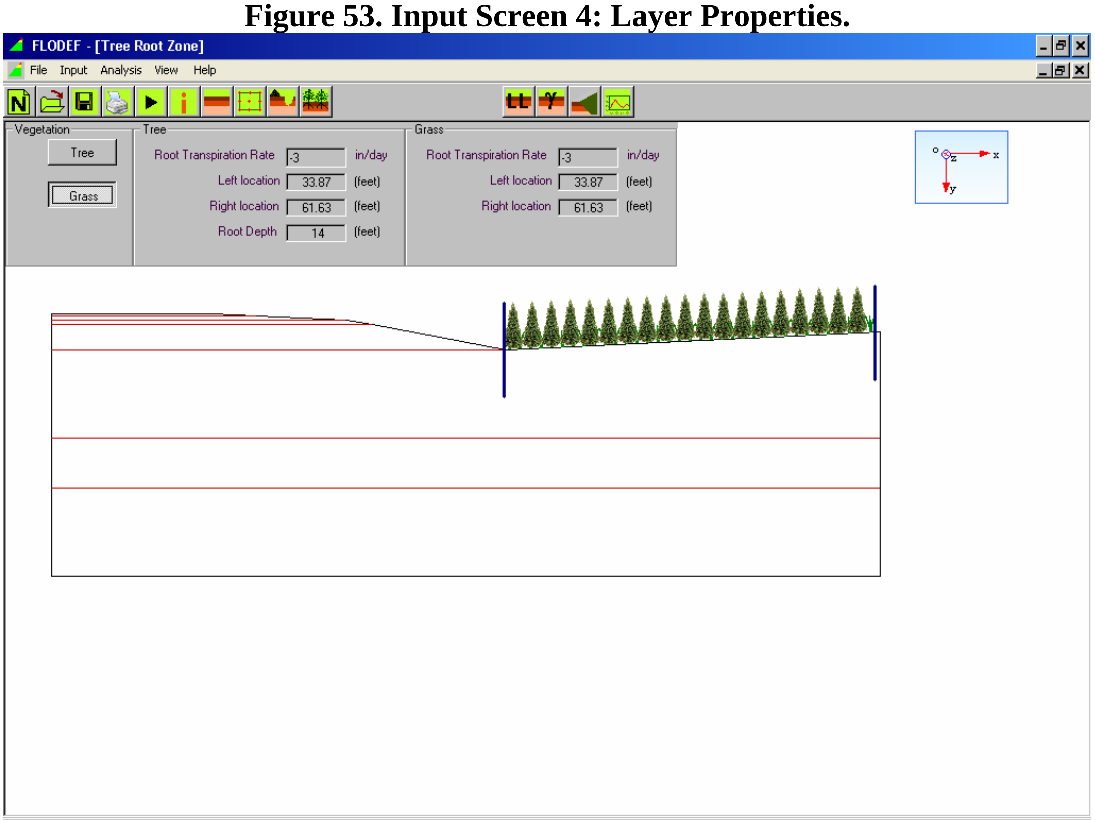
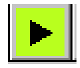


Figure 54. Input Screens: Vegetation.

After the user clicks the Run  icon with the fulfillment of the input screen parts, the program generates a file “input.dat” used for the internally built Fortran program. The format of this file is shown below:

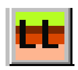
File name: Input.Dat

```
***********************************************************************
S1-info
Location:    PRES
Engineer:
 Special Soil Layer Configuration?(1:yes;0:no)
 0          0
Region, Ini Condition, Duration, Vertical barrier, Horizontal barrier, Paved Shoulder Width,Barrier depth,Median
Condition
 9          3          4          0          0          0          0     0
 Tree (no:0;yes:1), Grass(no:0;yes:1)
 1          1
 Drainage Condition?(0:good;1:poor)
 0          0
S2-section
Z1,Z2,Z3,Z4,Z5,Z6,Z7
 2 4 4.8 2 7 4 7
x1, x2, X3,X4,X5,X6,X7,X8
 12 10 12 18 2 8 0 0
S1,S2,S3,S4,S5,S6,S7
-20 -5 0.05 20 0.05 0 0
S3-property-pavement
Layer   Poisson's-Ratio   Dry-unit-weight
 1          1          0.3         110
 2          1          0.3         110
 3          1          0.3         110
S4-property-subgrade
No.  ID   LL(%)  PI(%)  -200#    -2um  Poisson's-Ratio   Dry-unit-weight  %Lime-or-Cement
 1          1          37          17          83.5        7.6         0.3         110         0
 2          1          48          26          92          8.7         0.3         110         0
 3          1          37          15          94.1        9           0.3         110         0
 4          1          37          15          89.9        8.5         0.3         110         0
S5-tree
 -4
 33.6279726261762          61.790504704876          14
S6-grass
 -3
 33.8666381522669          61.6313943541488
-----------------------------------------------------------------------
```

ILLUSTRATION: OUTPUT PLOT SCREENS

After FLODEF has executed, the program generates output files for the suction and displacement (vertical/horizontal) calculations. If the analysis period is 5 years, the output files will be PF1.DAT~PF6.DAT, DY1.DAT~DF6.DAT. For the case of a 20 years analysis period, the output files then will be PF1.DAT~PF24.DAT, DY1.DAT~DY24.DAT. The user can review all the output files in the directory where the program is installed.

For this example, the associated output plot screens for Vertical Profile Plots/ Contour Plots/Surface Deformation Plot/Time History Plots are demonstrated in Figure 55 through Figure 68 for an arbitrary selected output time of 720 days. The user can change the output time according to their review needs.

After the user clicks the  icon, the vertical profile plots for suction/vertical displacement/horizontal displacement options can be displayed for review purposes.

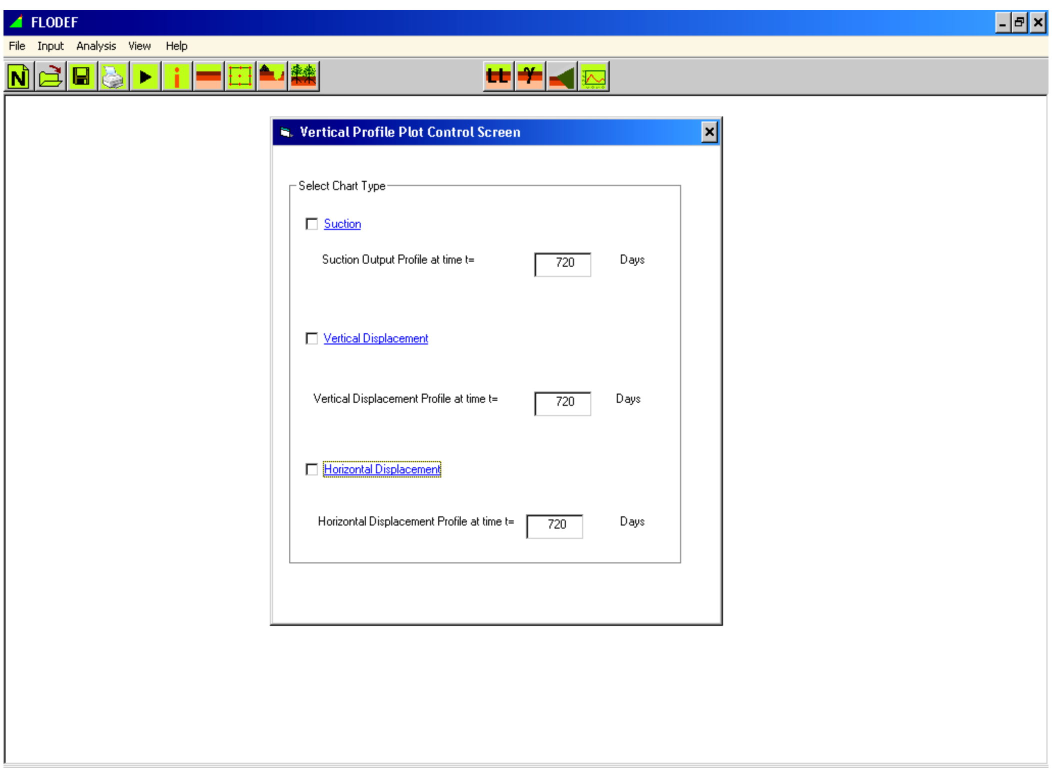


Figure 55. Output Plots Screens: Vertical Profile Plots Selection.

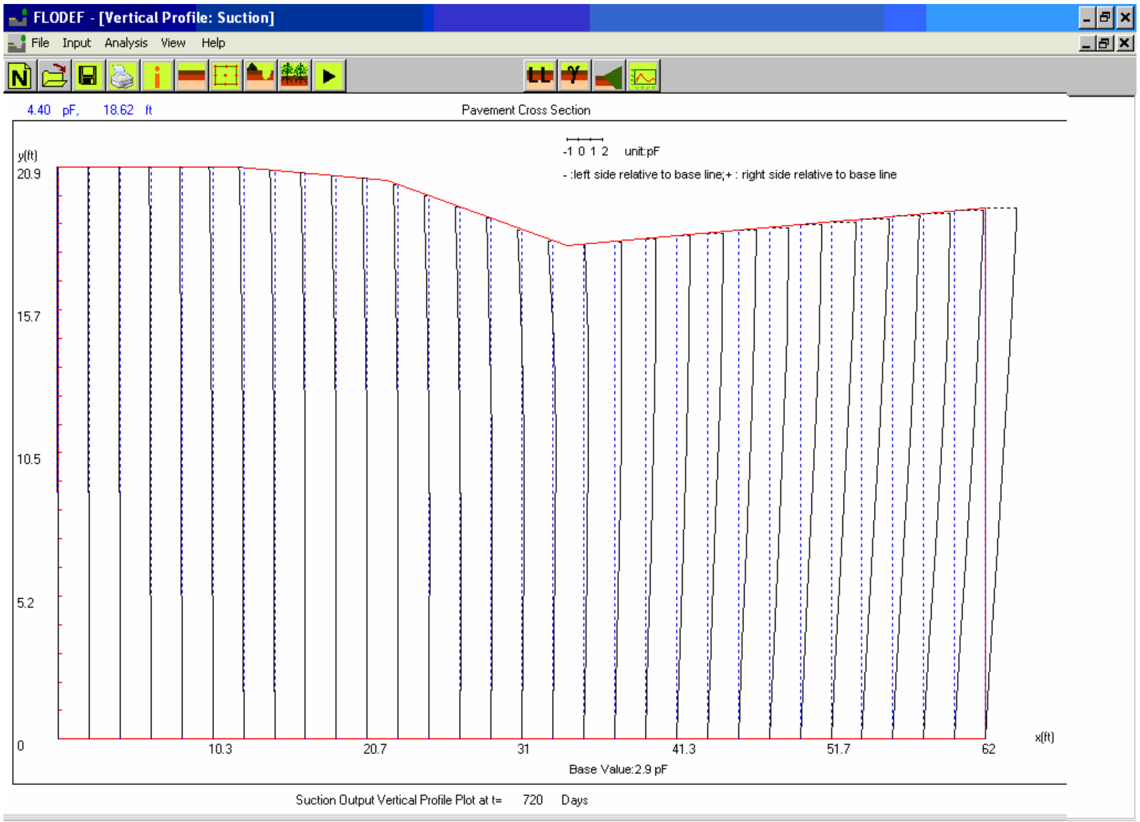


Figure 56. Output Plots Screens: Vertical Profile Plots-Suction.

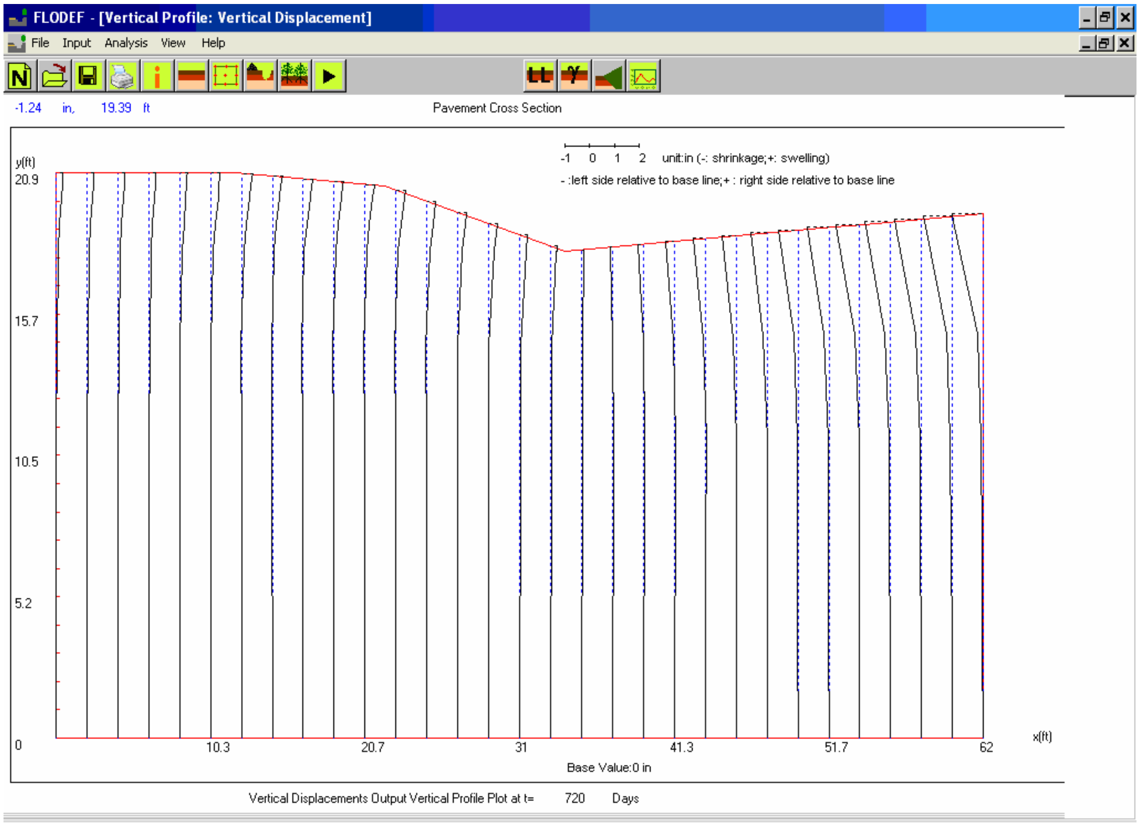


Figure 57. Output Plots Screens: Vertical Profile Plots-Vertical Displacement.

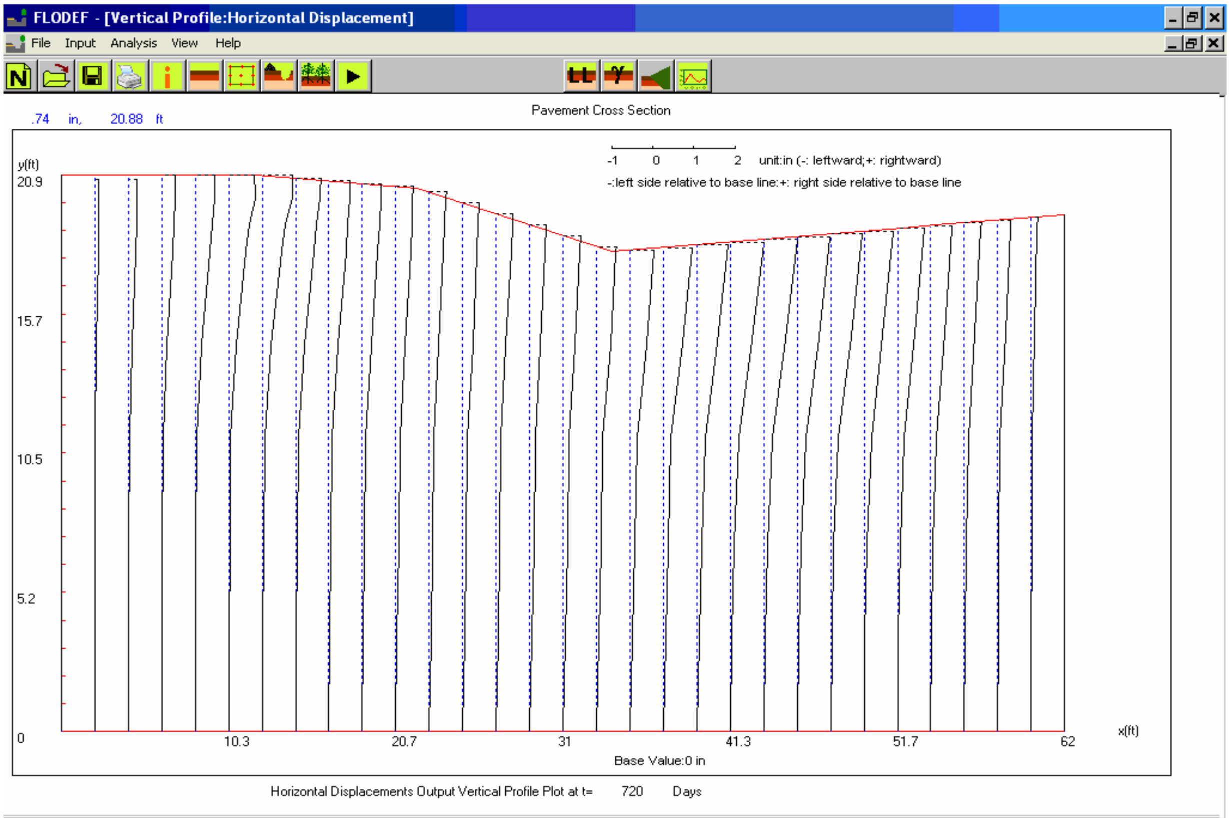
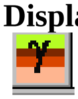


Figure 58. Output Plots Screens: Vertical Profile Plots-Horizontal Displacement.

The contour plots screens can be accessed after the user clicks the  icon, as shown in Figure 59 through Figure 62. The unit for vertical and horizontal displacement is inches.

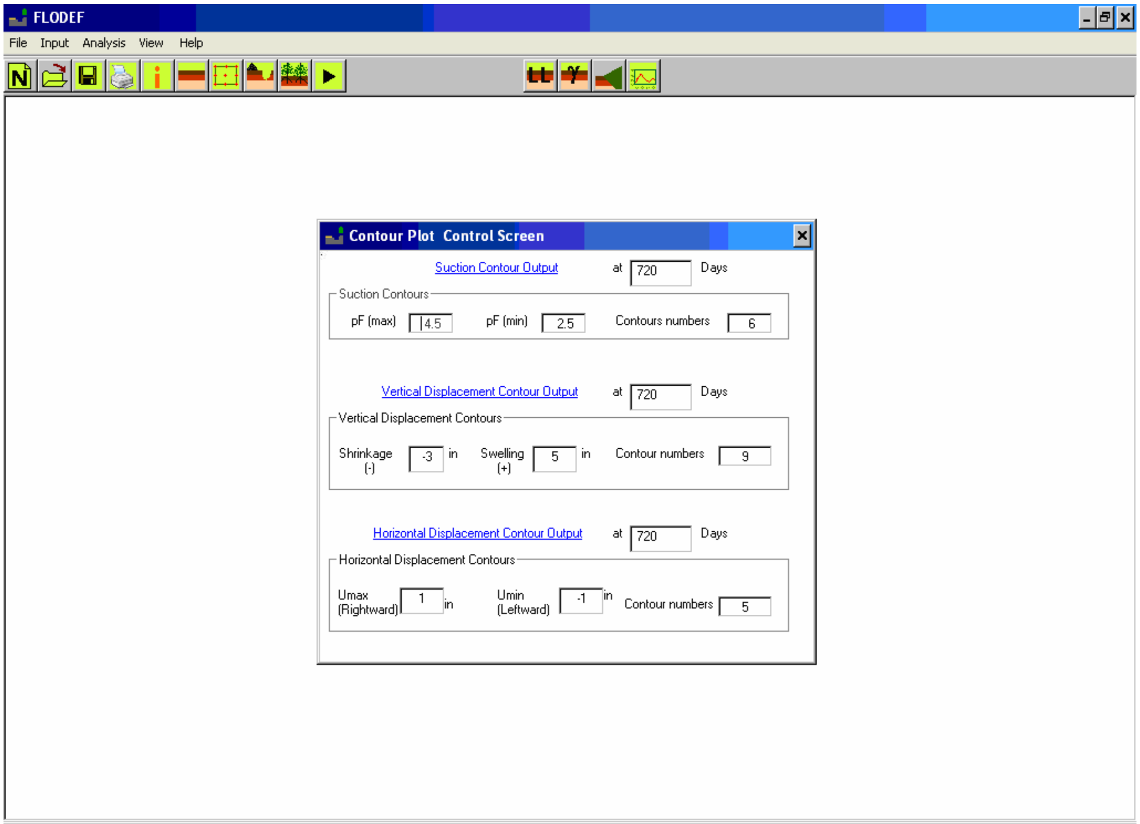


Figure 59. Output Plots Screens: Contour Plot Selection.

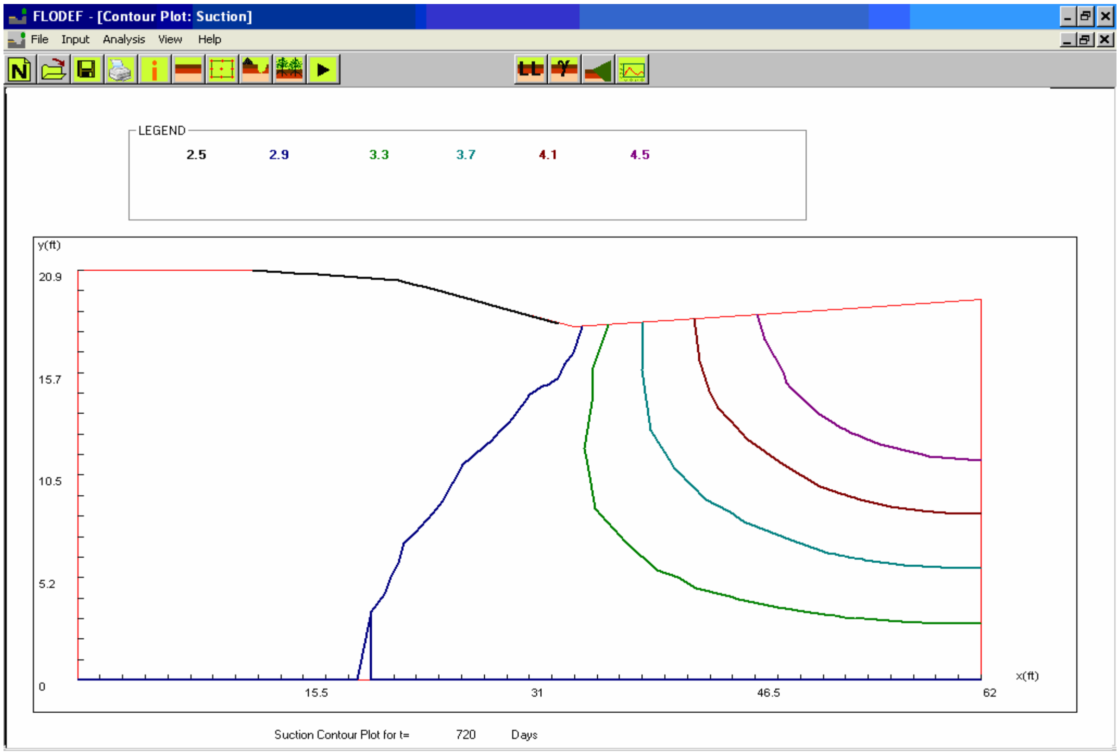


Figure 60. Output Plots Screens: Contour Plots Screens-Suction.

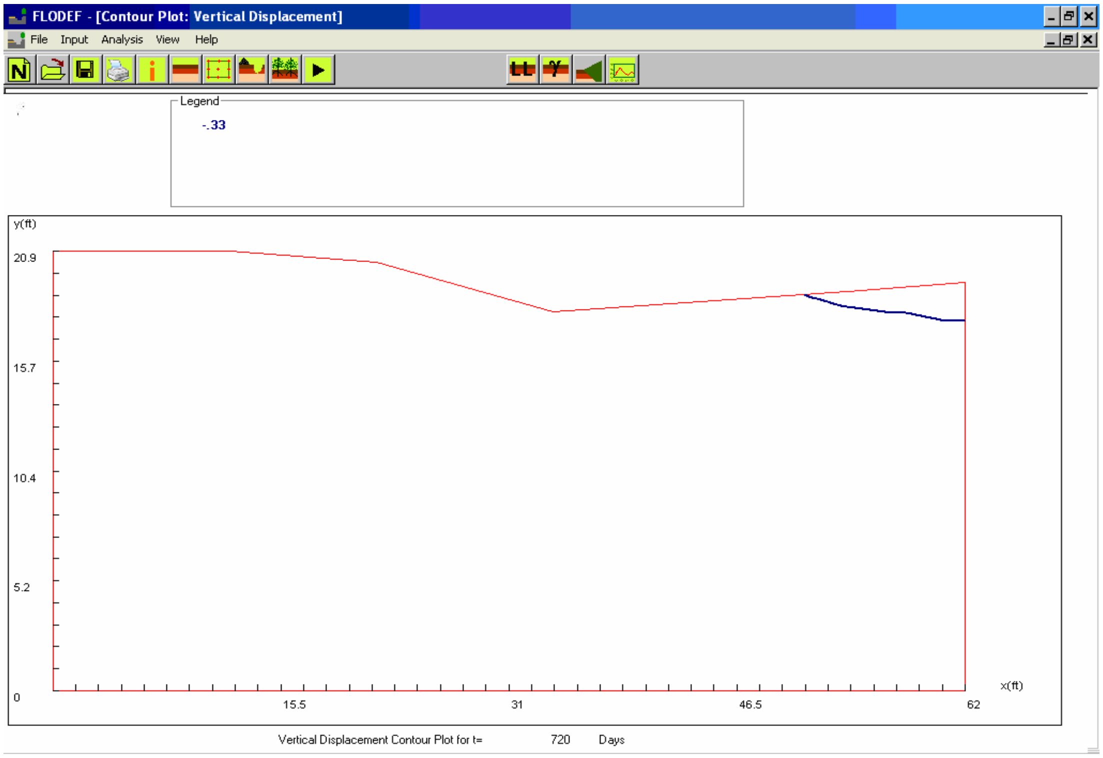


Figure 61. Output Plots Screens: Contour Plots Screens-Vertical Displacement.

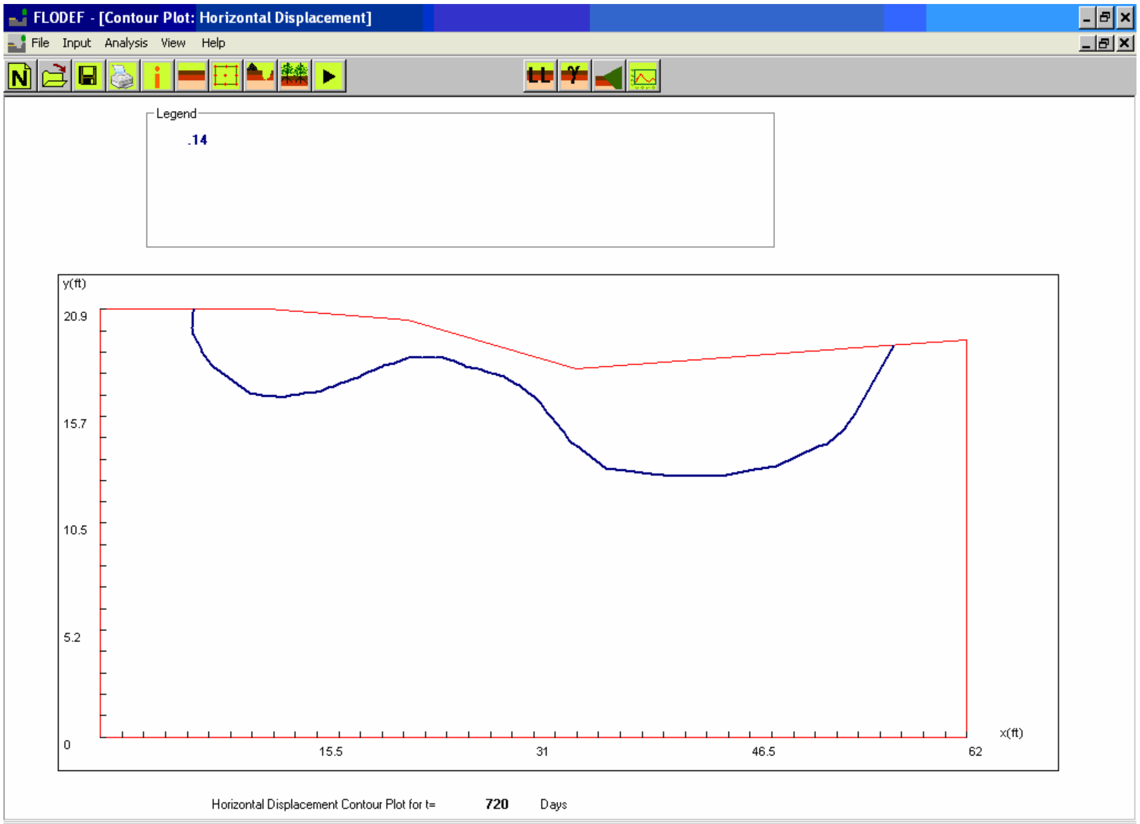
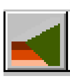


Figure 62. Output Plots Screens: Contour Plots Screens-Horizontal Displacement.

The surface deformation plot (Figure 63 and Figure 64) is displayed with the click of  icon.

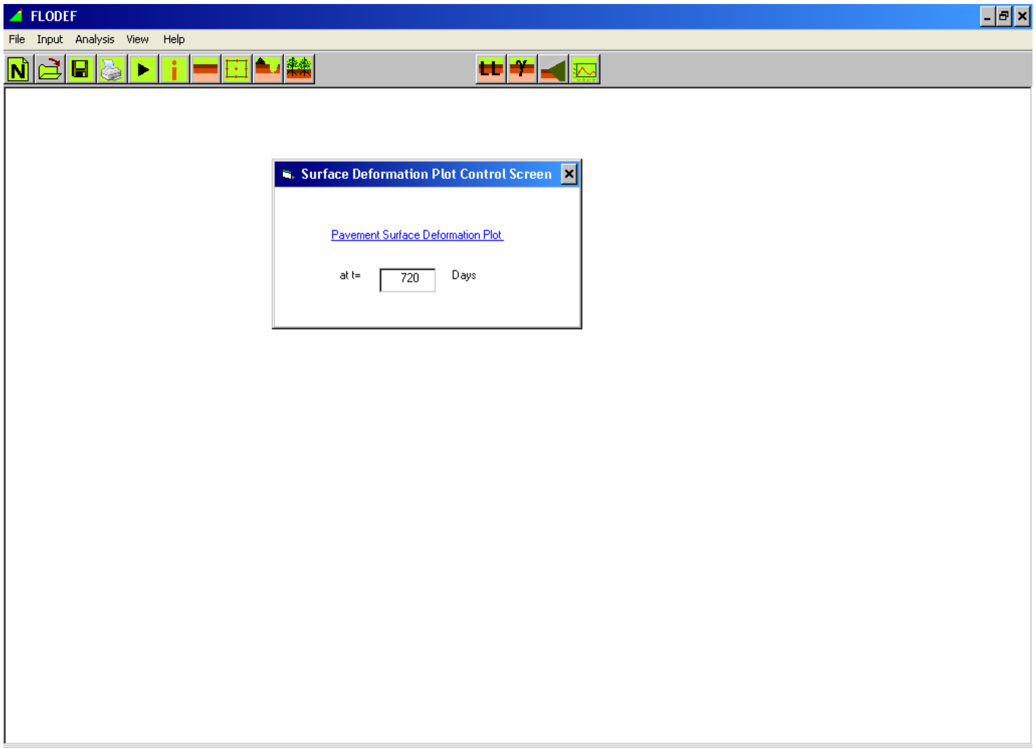


Figure 63. Output Plots Screens: Surface Deformation Plot Screen (1).

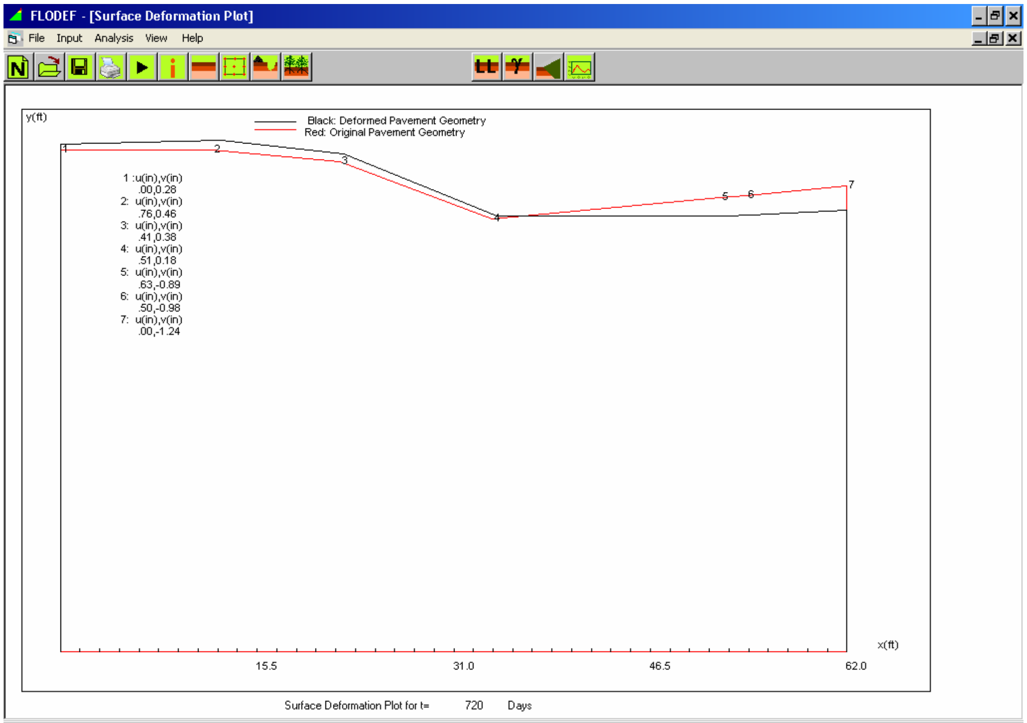
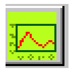


Figure 64. Output Plots Screens: Surface Deformation Plot Screen (2).

By clicking the  icon, the user can view the time history plots for suction/vertical displacement/horizontal displacement, which are shown in Figure 65 through Figure 68.

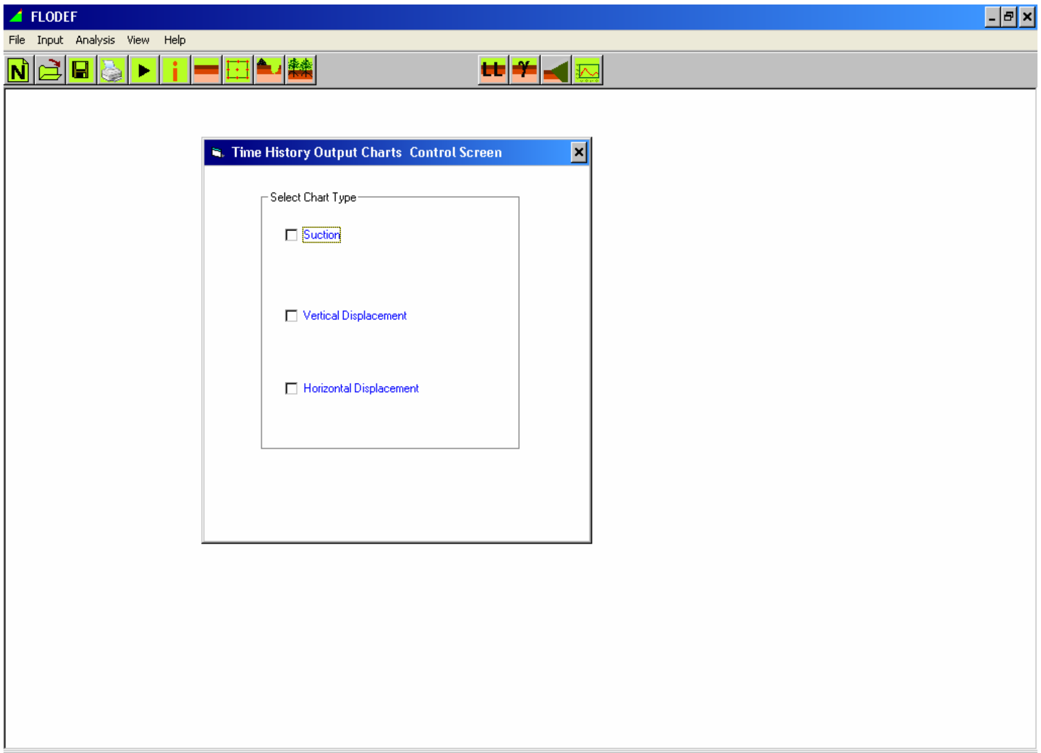


Figure 65. Output Plots Screens: Time History Plot Selection.

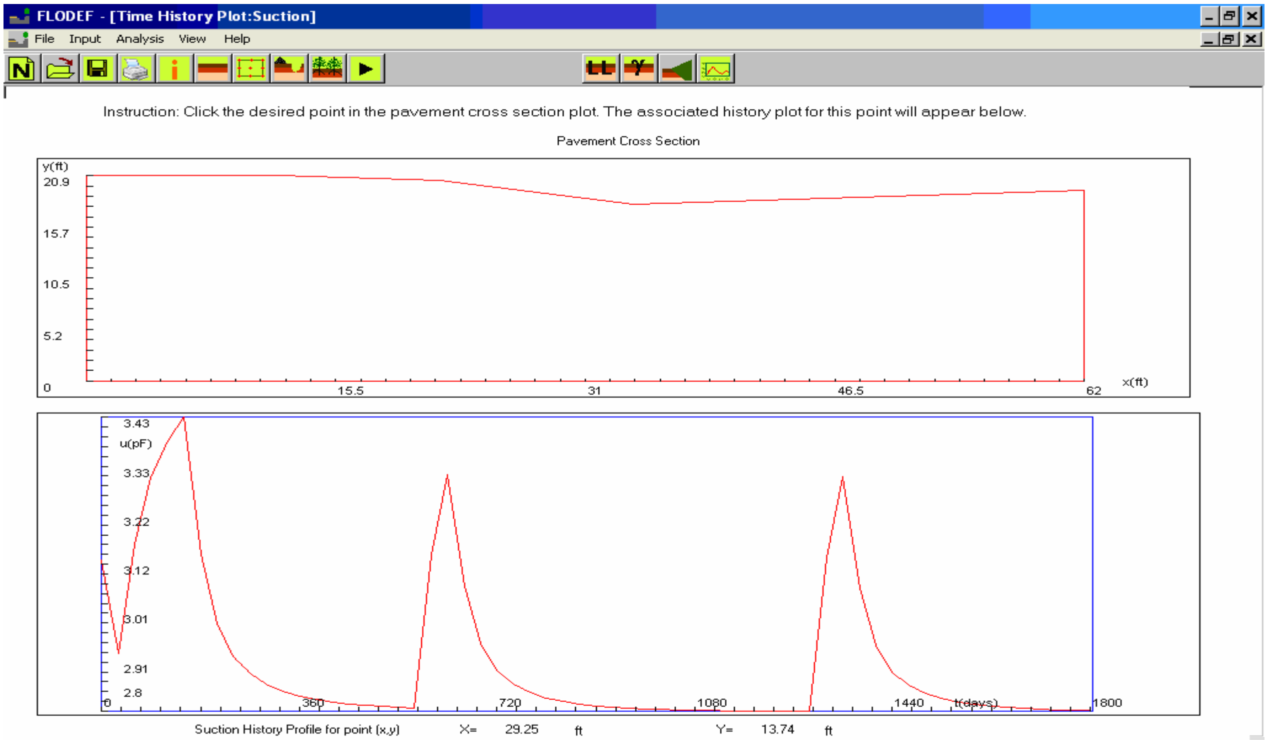


Figure 66. Output Plots Screens: Time History Plot-Suction.

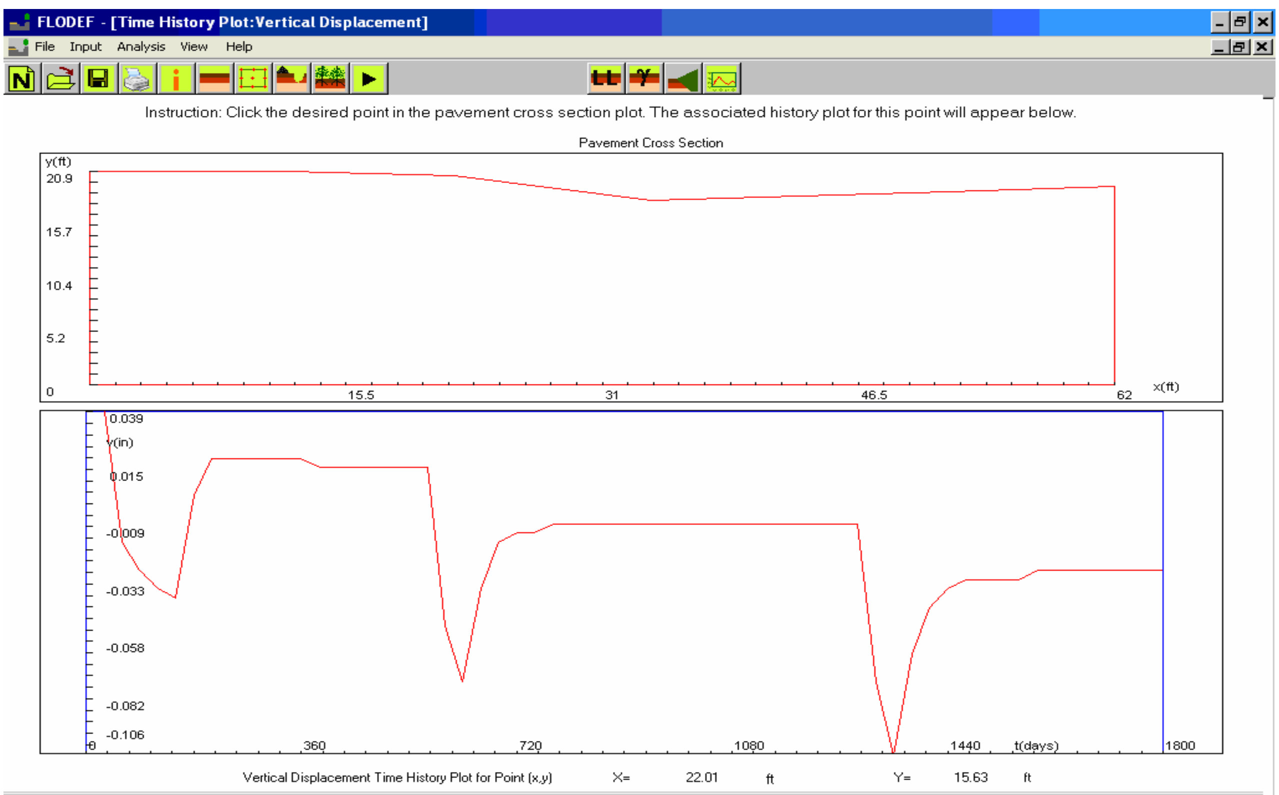


Figure 67. Output Plots Screens: Time History Plot-Vertical Displacement.

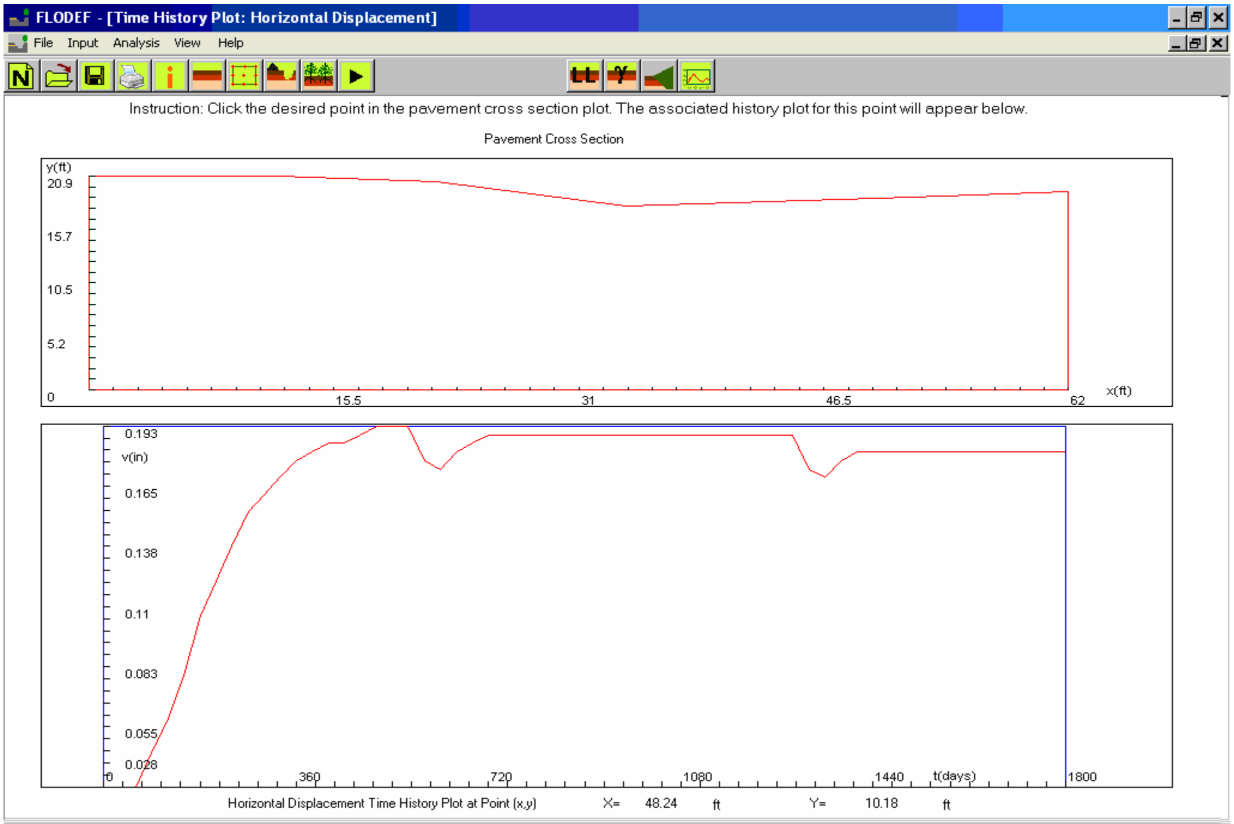


Figure 68. Output Plots Screens: Time History Plot-Horizontal Displacement.