WINPRES
USER MANUAL

Version 1.0

by

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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.

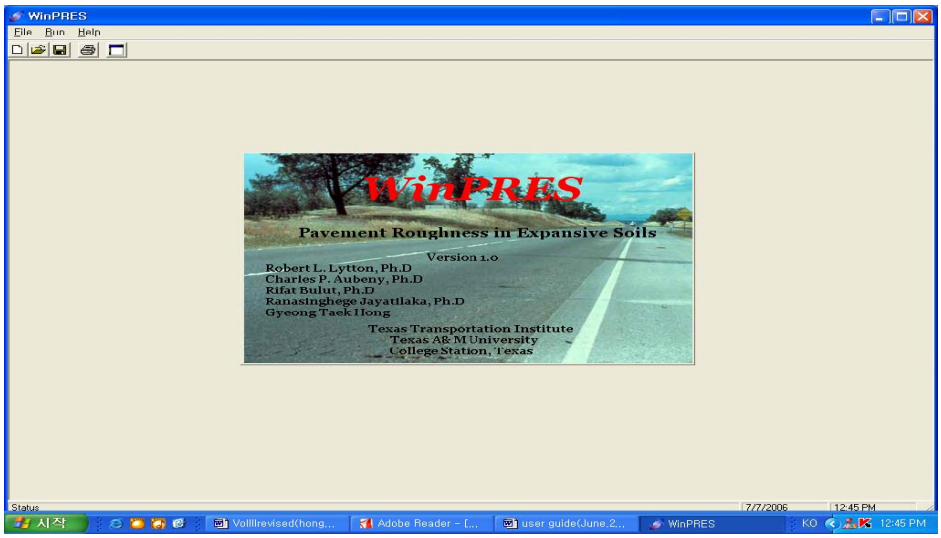

Figure 1. Main Dialog Box.

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).

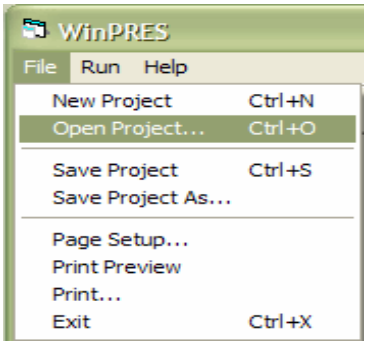

Figure 2. File Menu.

2.2 The Run Menu

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

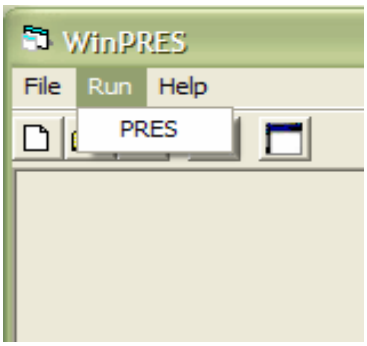

Figure 3. Run Menu.

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 information is presented in this box.

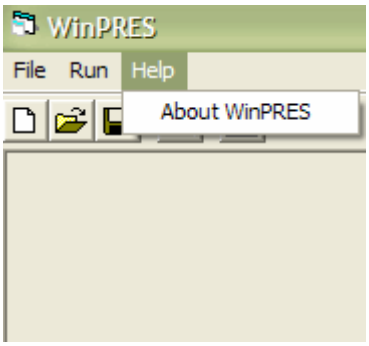

Figure 4. Help Menu.

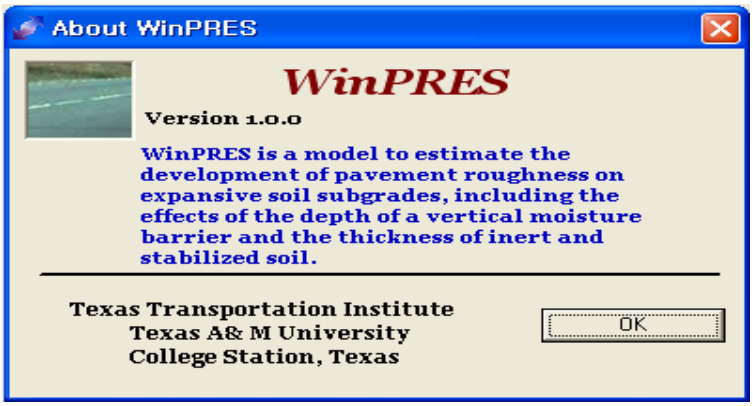

Figure 5. About WinPRES.

3. INPUT DIALOG BOX

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

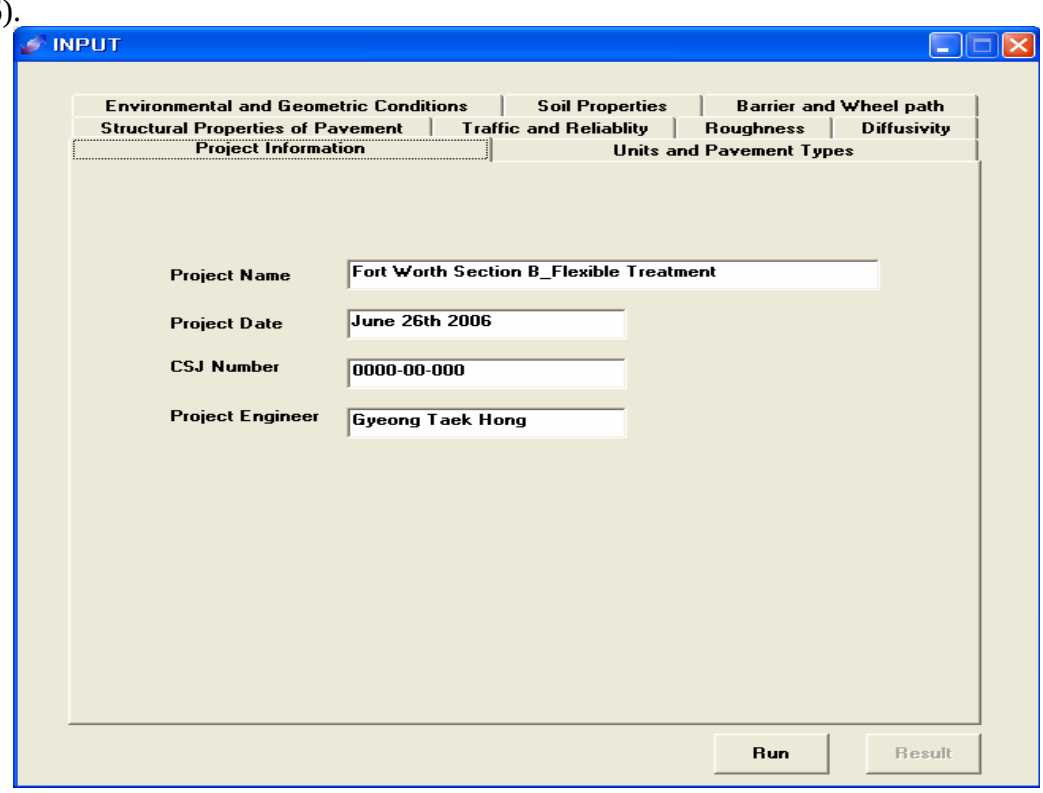

Figure 6. INPUT Dialog Box.

3.2 Units and Pavement Types

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

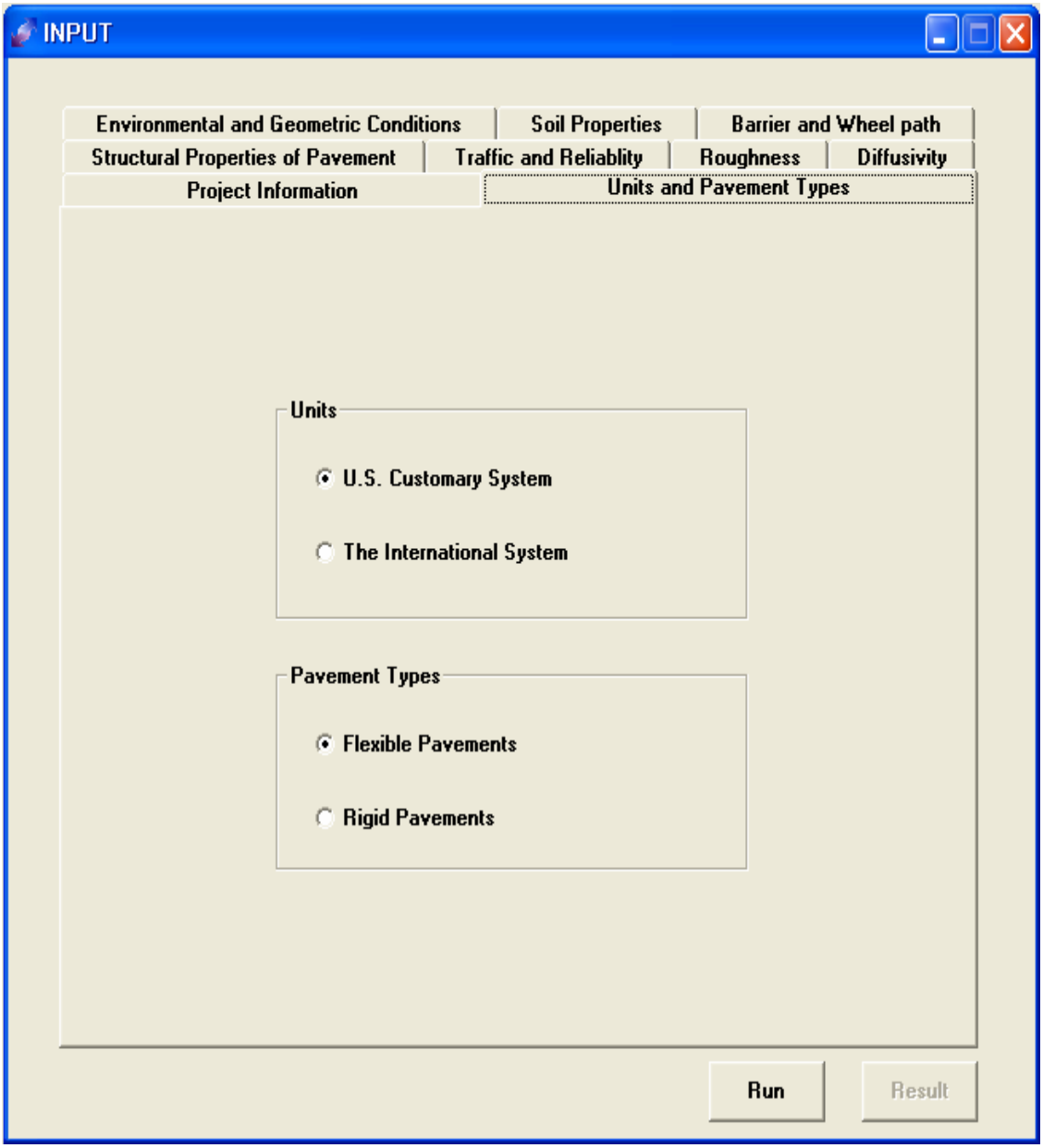

Figure 7. Units and Pavement Types.

3.3 Environmental and Geometric Conditions

This screen is used to enter the environmental and geometric conditions for a project (Fig. 8).

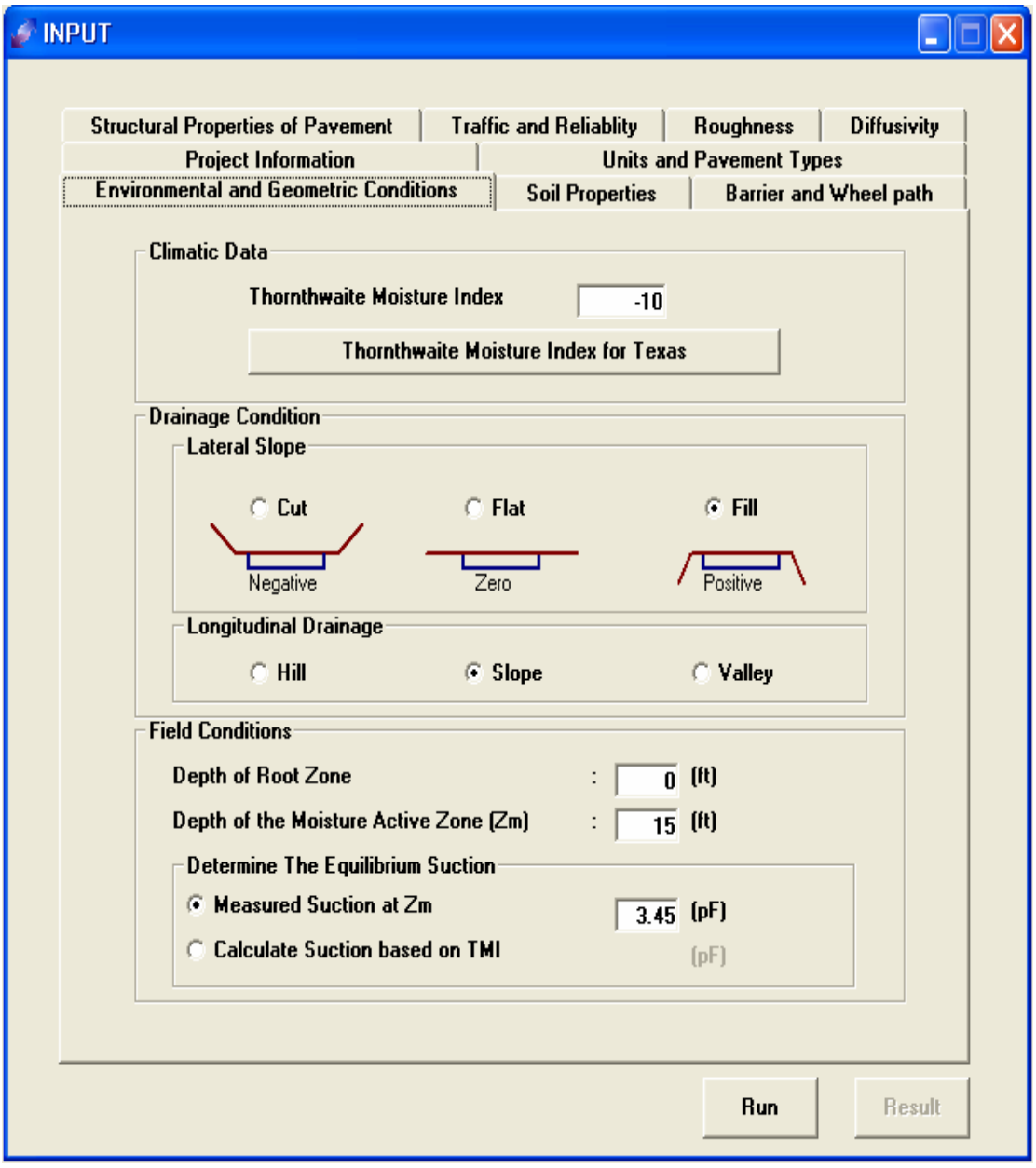

Figure 8. Environmental and Geometric Conditions.

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 test sites. The TMI can be calculated by a water balance procedure that involves: (1) determination of monthly potential evapotranspiration; (2) allocation of available water to storage, deficit, and runoff on a monthly basis; and (3) summation of monthly runoff moisture depth, deficit moisture depth, and evapotranspiration to obtain annual values. Then the TMI is given by:

$$TMI = \frac{100R - 60DEF}{E_p} \quad (1)$$

where

R = runoff moisture depth

DEF = deficit moisture depth

E_p = evapotranspiration.

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

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

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 Fig. 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.

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.

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

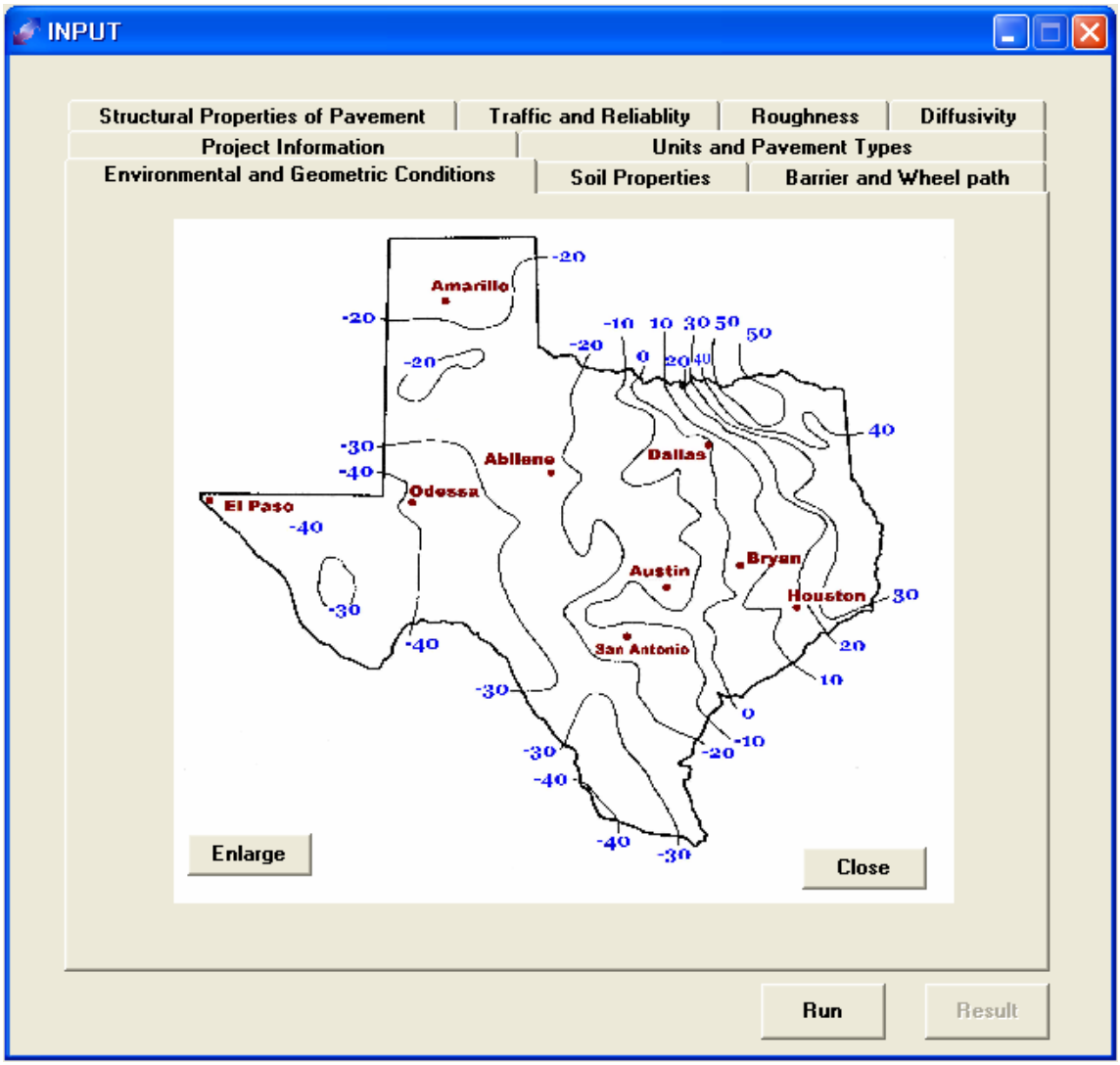

Figure 9. Thornthwaite Moisture Index Map of Texas.

Depth of root zone is needed at the site that has some trees near the edge of pavement. Maximum suction at the site should be wilting point 4.5 pF up to depth of 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. Depth of moisture active zone (Zm), the deepest depth for possible moisture flow, is assumed as a point where equilibrium suction begins.

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 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.

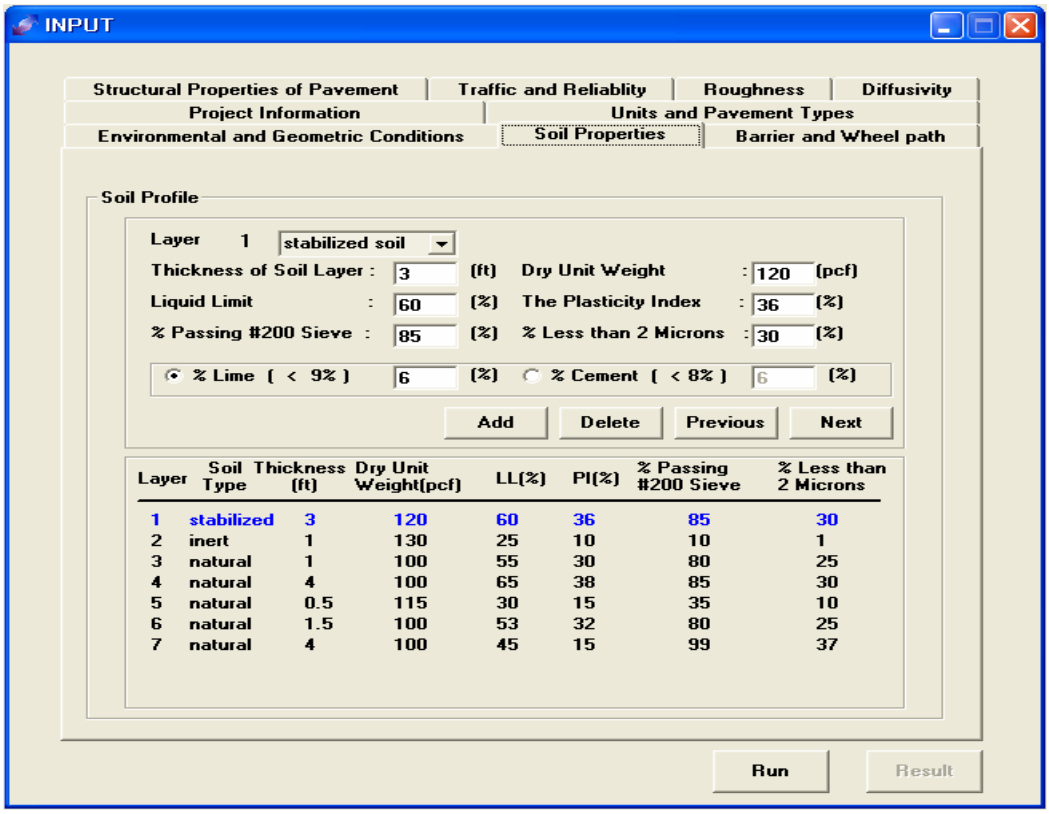

Figure 10. Soil Properties.

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 Previous Next and add or delete a layer by using these buttons Add Delete.

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 pavement 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.

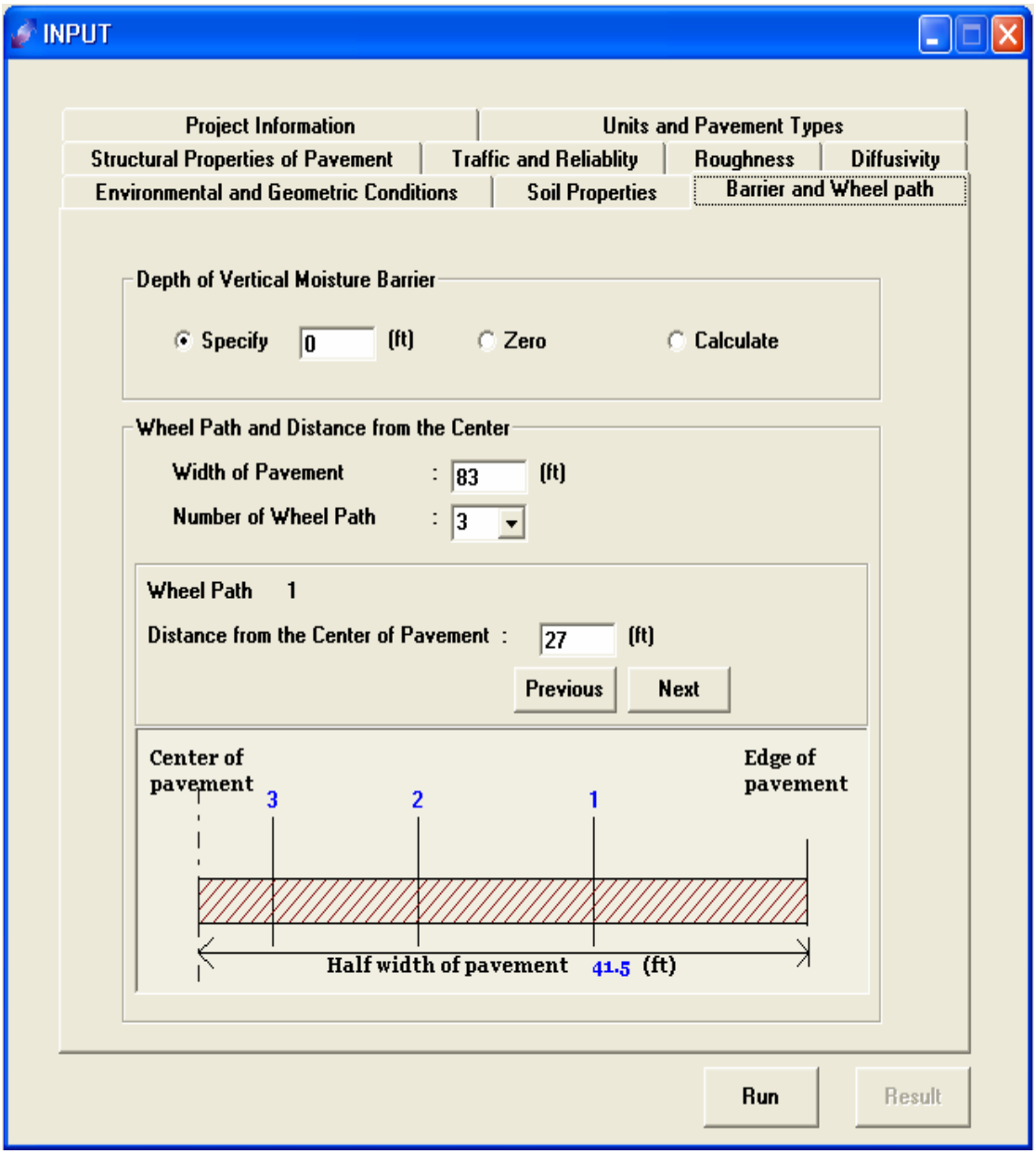

Figure 11. Barrier and Wheel Path.

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

The screens shown in Figs. 12-17 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).

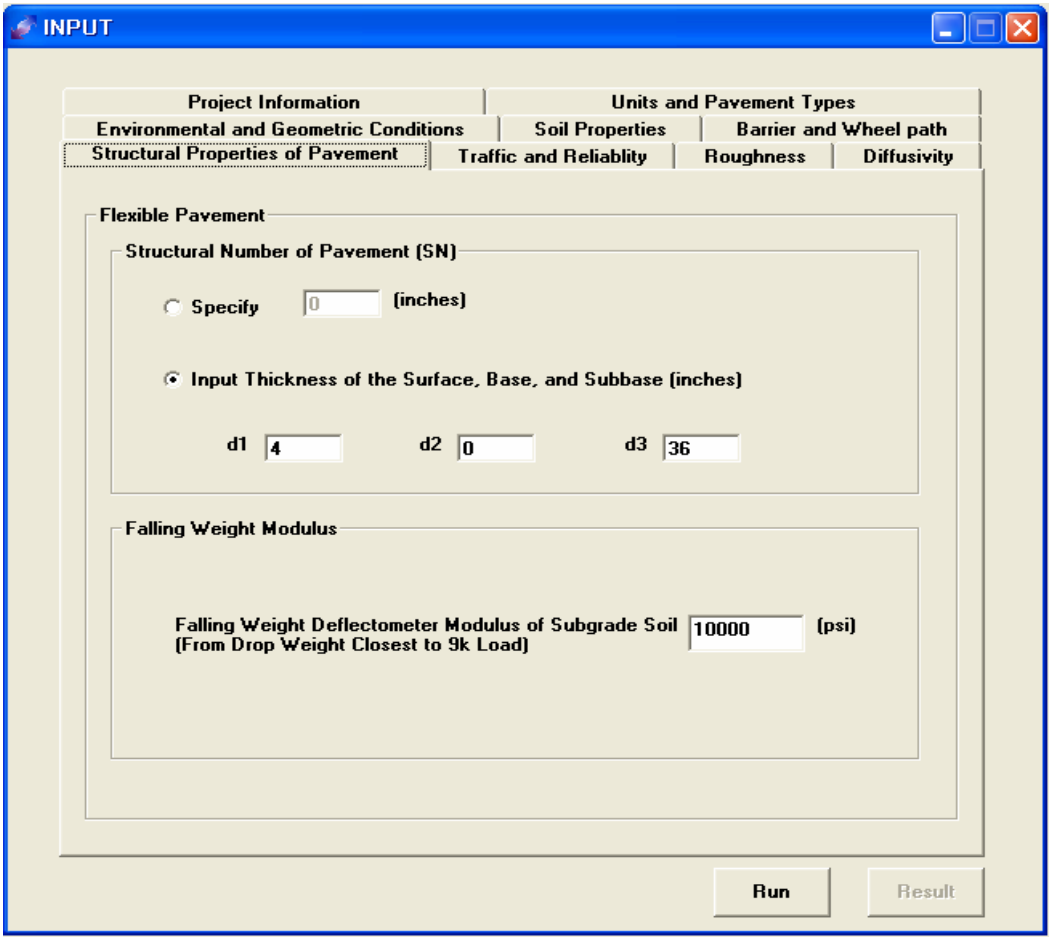

Figure 12. Structural Properties of Flexible Pavements.

Structural number of flexible pavement is computed by:

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

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) (Fig 12).

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, and load transfer coefficient (Fig. 13).

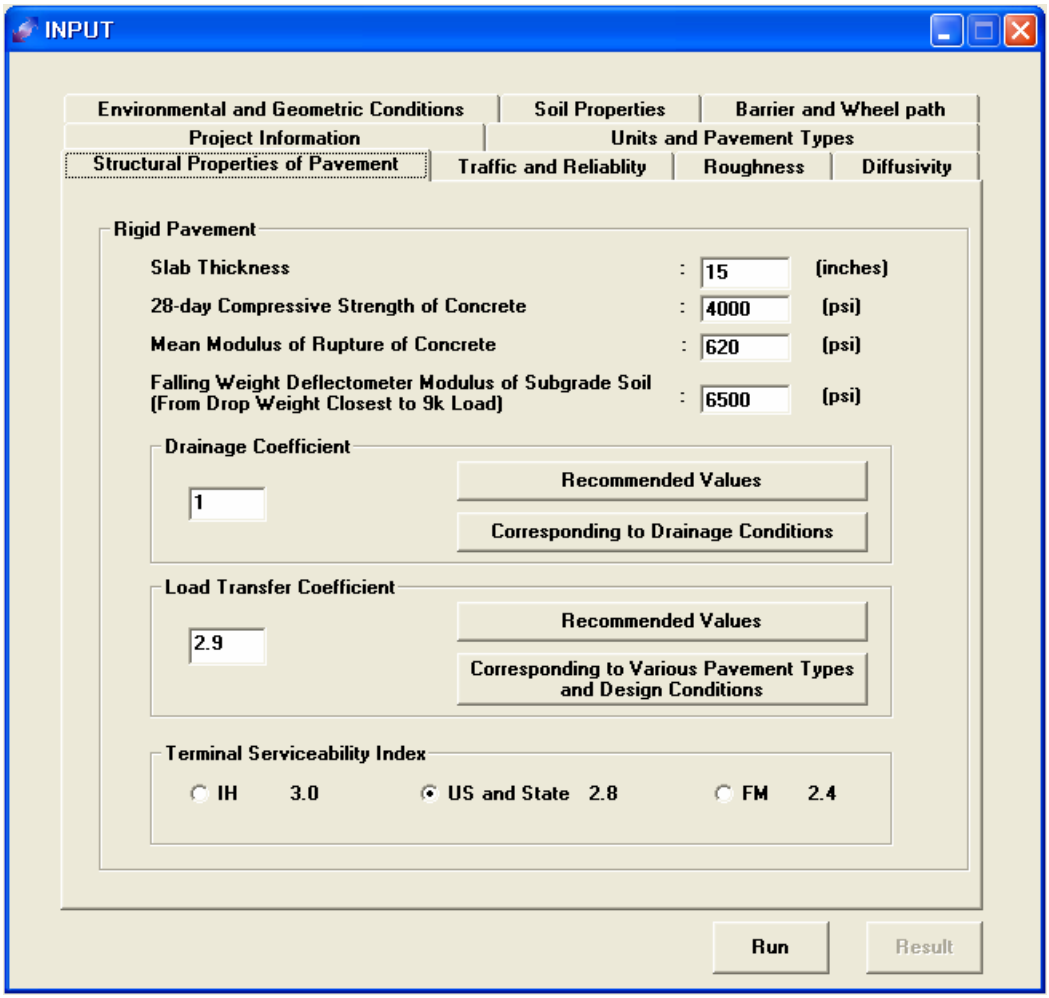

Figure 13. Structural Properties of Rigid Pavements.

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 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 (Huang 1993). If the slab is placed directly on the subgrade without a subbase, the American Association of State Highway and Transportation Officials (AASHTO) suggested the use of the following theoretical relationship based on an analysis of the plate bearing test:

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

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

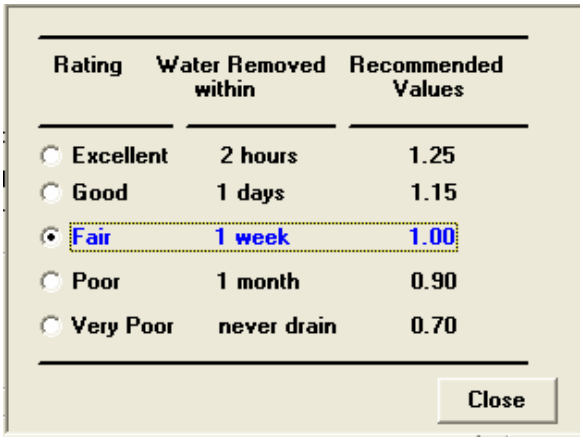

Figure 14. Recommended Values for Drainage Coefficient in Rigid Pavements.

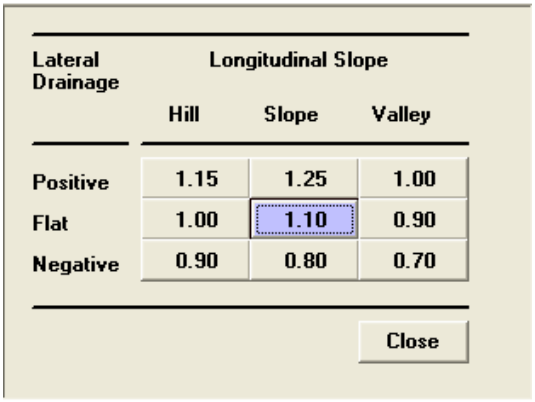

Figure 15. Drainage Coefficient Corresponding to Drainage Conditions.

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 Corresponding to Various Pavement Types and Design Conditions .

The load transfer coefficient, J , is a factor used in rigid pavement design to account for the ability of a concrete pavement structure to transfer a load across joints and cracks.

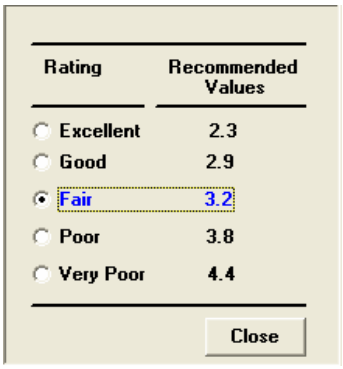

Figure 16. Recommended Values for Load Transfer Coefficient in Rigid Pavement.

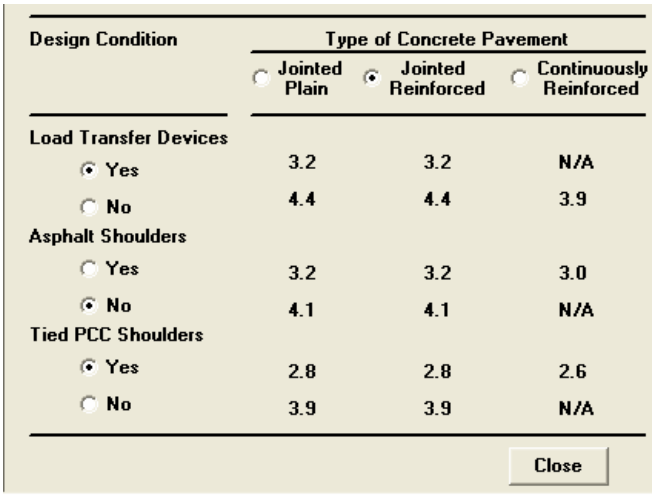

Figure 17. Load Transfer Coefficient Corresponding to Various Pavement Types and Design Conditions in Rigid Pavements.

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) (current level) and average daily traffic in one direction T_k =C (r_c) (final level), 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.

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

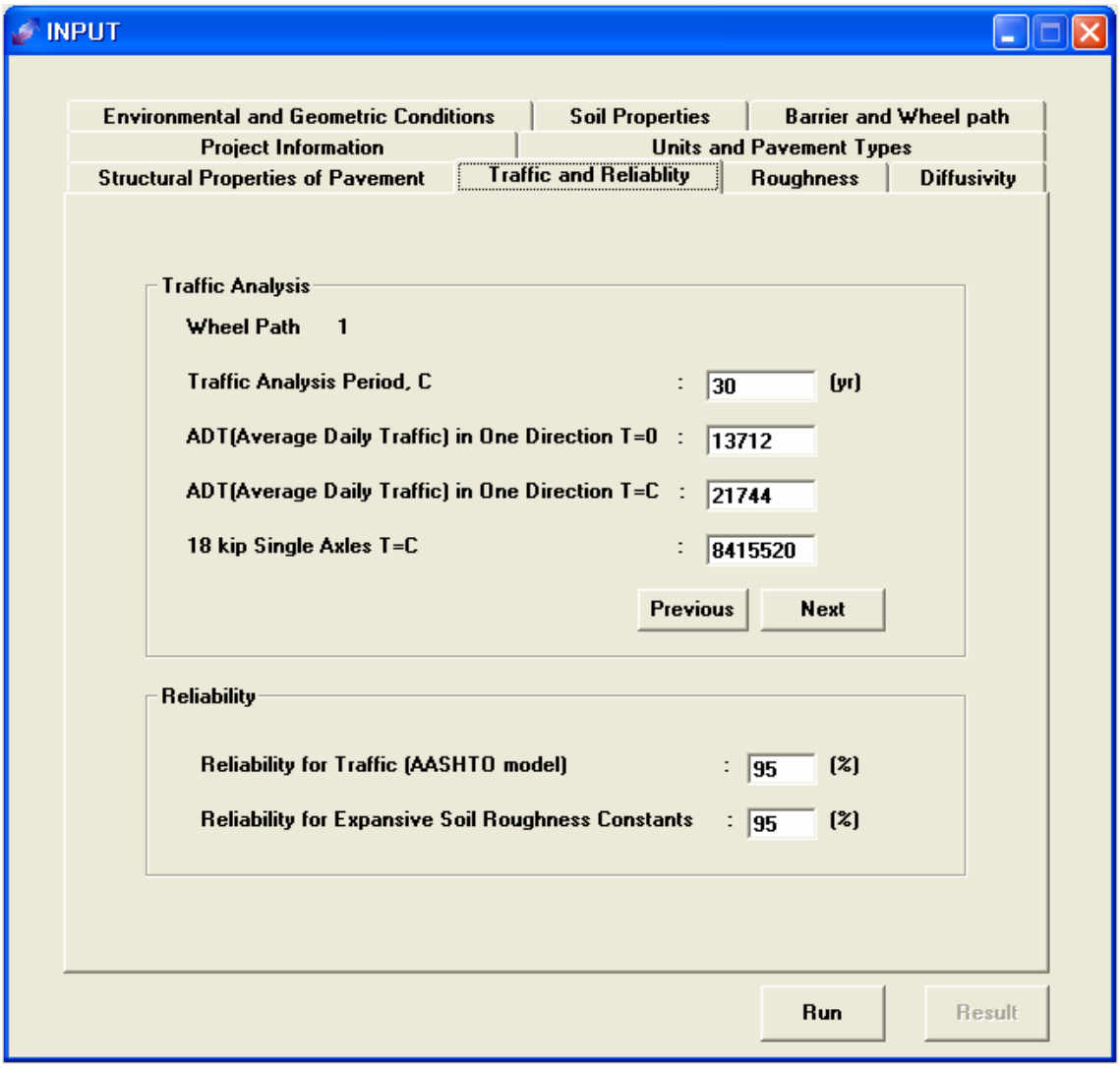

Figure 18. Traffic Analysis and Reliability.

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 level of reliability to be used for design should increase as the volume of traffic, and public expectation of availability increase." Table 2 presents the 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 %

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

3.8 Roughness

The initial serviceability index or international roughness index and years roughness calculation required for each wheel path are required in 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 1.2 m to 30 m and is linearly proportional to roughness. The relationship developed between IRI and SI is as follows:

$$IRI = 8.4193 \exp(-0.4664SI) \quad (6)$$

Equivalent pavement roughness measures estimated with respect to serviceability based on Equation (6) are given in Table 3.

Table 3. Equivalent Pavement Roughness Measures

International Roughness Index		Serviceability Index
(m/km)	(in/mile)	
0.95	60	4.68
1.03	65	4.51
1.10	70	4.35
1.18	75	4.21
1.26	80	4.07
1.34	85	3.94
1.42	90	3.82
1.50	95	3.70
1.58	100	3.59
1.66	105	3.48
1.74	110	3.39
1.82	115	3.29
1.89	120	3.20
1.97	125	3.11
2.05	130	3.03
2.13	135	2.95
2.21	140	2.87
2.29	145	2.79
2.37	150	2.72
2.45	155	2.65

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 or international roughness index and years roughness calculation required for each wheel path (Fig. 19).

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).

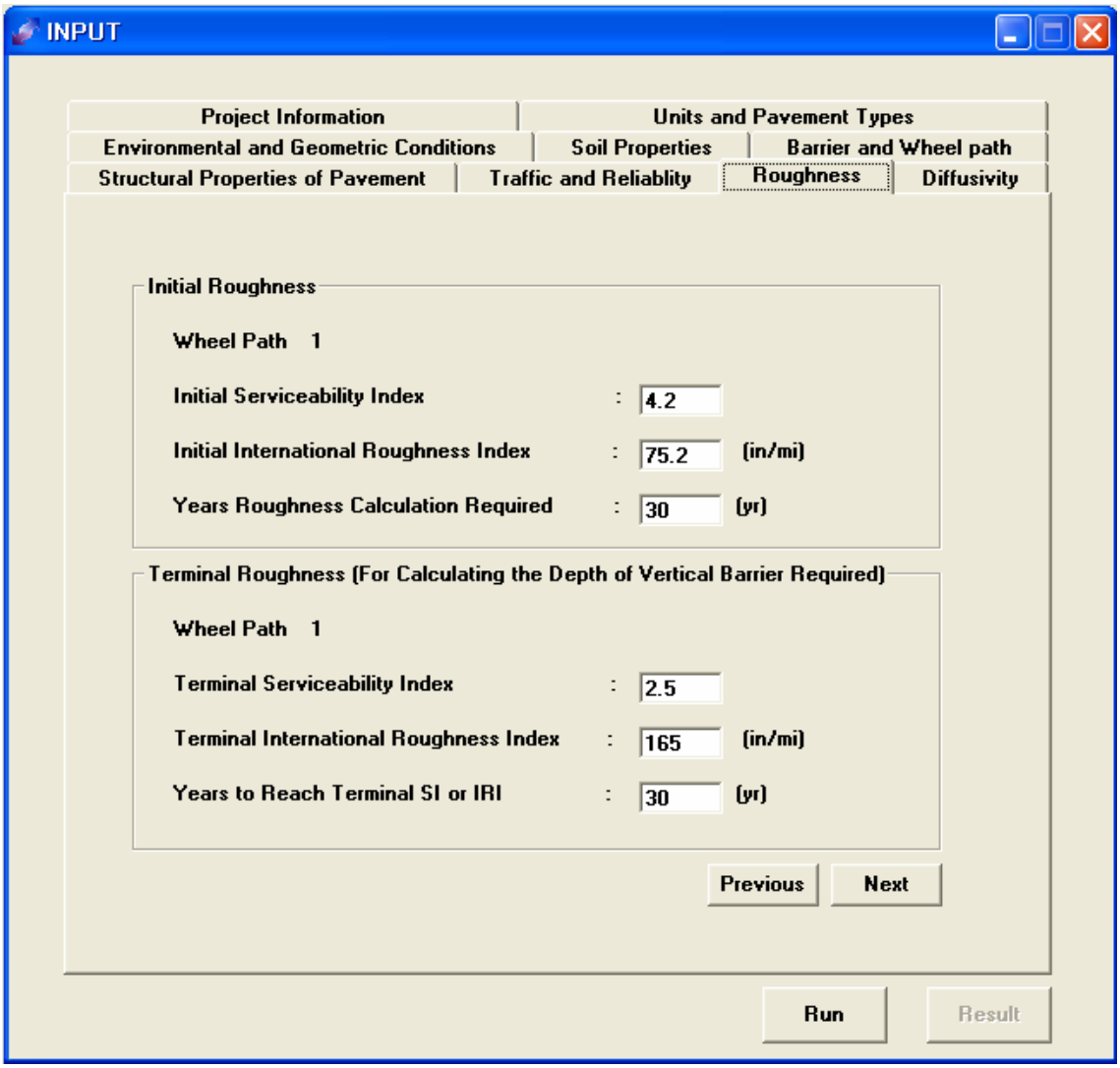

Figure 19. Initial and Terminal Roughness.

3.9 Diffusivity

The moisture diffusion coefficient, α, is the most critical parameter controlling the depth of the moisture active zone and the suction envelope of the extreme case for wet and dry condition in the field. Laboratory measurements of α on intact clay samples will normally be far less than that representative of field conditions. The moisture diffusion coefficient, α, can be determined by selecting the option ◉ Calculate based on the empirical equation or ◉ Lab Value with Soil Mass Multiplier (Fig. 20).

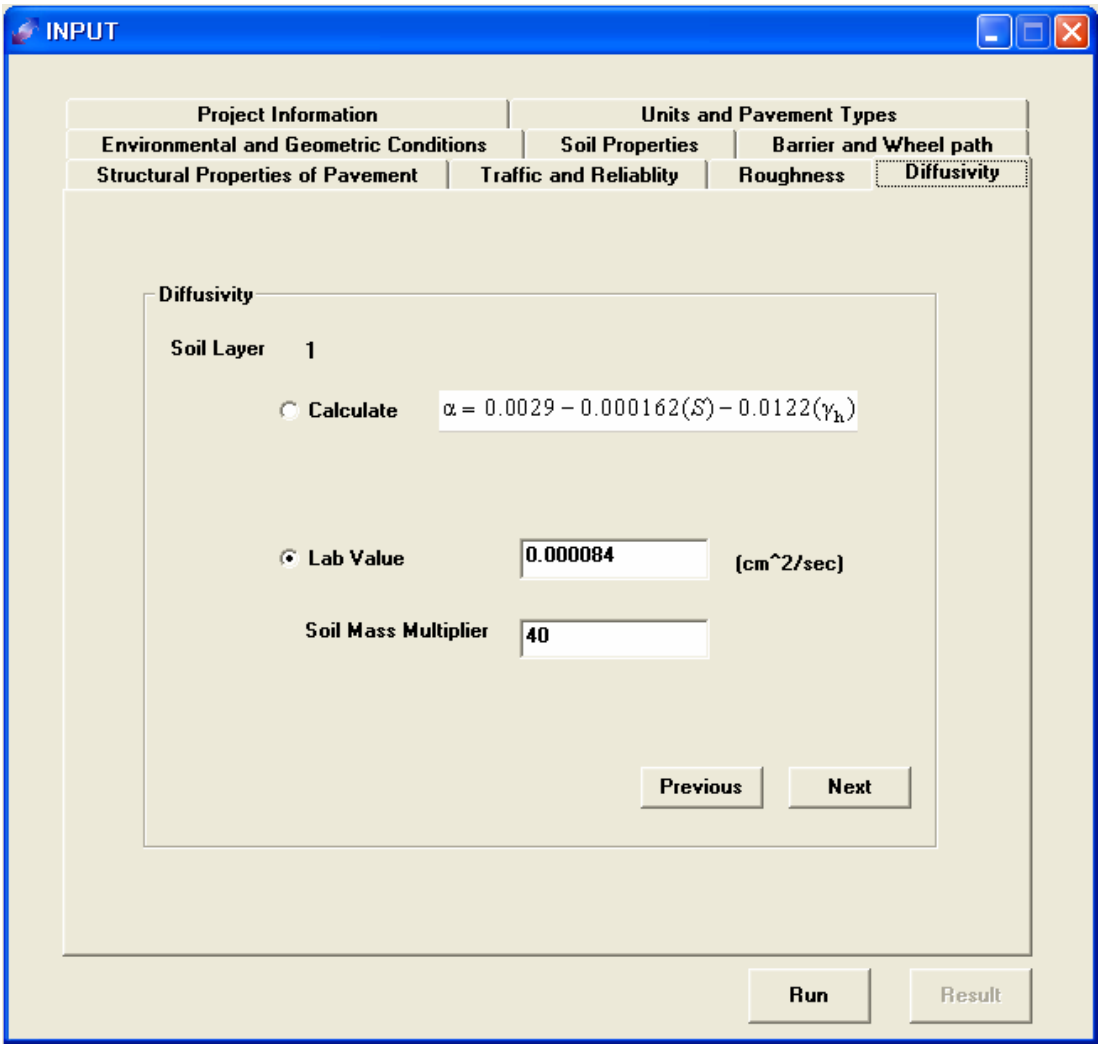

Figure 20. Diffusivity.

3.9.1 Estimation of Empirical Diffusivity α

The program can automatically estimate the diffusion coefficient α according to the empirical relationship:

$$\alpha = 0.0029 - 0.000162\ S - 0.0122\ \gamma_h \quad (7)$$

where γ_h is the suction compression index (also estimated by program), and S is the slope of the suction-water content curve:

$$S = -20.3 - 0.155\ (LL) - 0.117\ (PI) + 0.068\ (\%-\#200) \quad (8)$$

where:

LL = the liquid limit in percent

PI = the plasticity index in percent

$\%-\#200$ = the percent of soil passing the #200 sieve.

The above estimation of α is a default option; however, a site-specific determination is definitely desirable when sufficient data are available. Two approaches for a site-specific determination are discussed below.

3.9.2 Laboratory Measurement with Crack Correction

The unsaturated soil diffusivity test performed in the laboratory represents conditions of an intact soil mass. While intact conditions can occur under certain conditions such as the absence of root penetration or desiccation cracking, more commonly some degree of cracking can be expected within the soil mass. Such cracking will substantially increase the apparent diffusivity, α_{field}, of the soil mass to well above that indicated from a laboratory test. In addition, the existence of fractures will generate heterogeneity in the soil mass such that α_{field} depends on sampling location; hence, α_{field} must be expressed in probabilistic terms. Figure 21 shows the relationship of the ratio $\alpha_{field}/\alpha_{lab}$ expressed in terms of probability of non-exceedance for crack depths ranging from 1 to 16 ft. This figure shows that for crack depths up to 16 ft, α_{field} can exceed α_{lab} by a multiplier of greater than 100.

Figure 22 shows the general nature of desiccation crack patterns in a soil mass. Crack patterns near the ground surface are usually closely spaced. However, the spacing of deep cracks is much wider than the shallower cracks, with crack spacing being approximately equal to crack depth. Estimating crack depth through direct observation is generally difficult. However, there are several indirect indicators of crack depth that are reasonably reliable. The first is the occurrence of any root fiber. Tree roots cannot penetrate an intact clay mass; i.e., root penetration occurs along cracks in clay soils. In addition, the roots induce desiccation within a vicinity of about 2 ft; therefore, cracking will extend to about 2 ft deeper than the deepest root fiber.

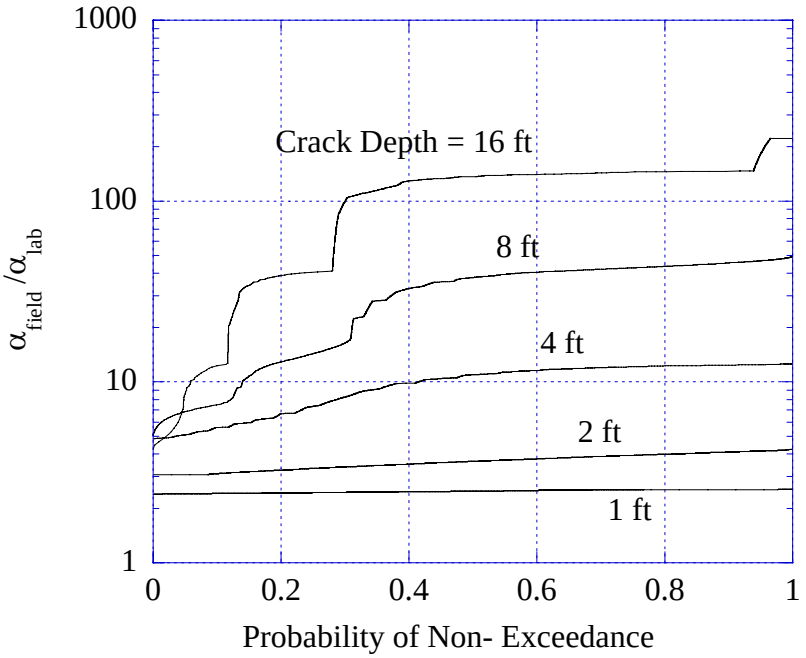

Figure 21. Adjustment of Laboratory Measurements of Diffusivity for Effects of Cracking.

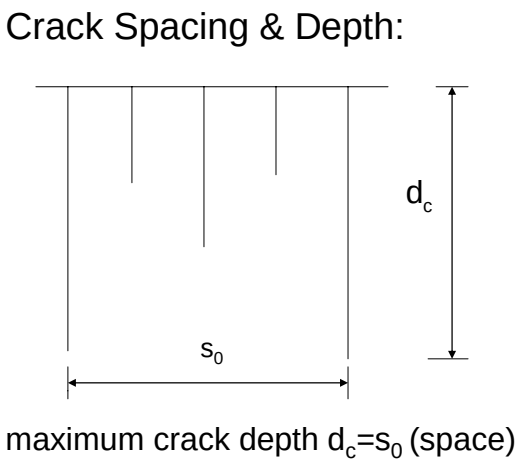

Figure 22. Desiccation Crack Pattern in a Soil Mass.

Example 1

A diffusivity measured in a laboratory diffusion test indicates $\alpha_{lab} = 8.0 \times 10^{-5}$ cm^2/sec. Root fibers in the borehole from which the soil sample was taken were observed to a depth of 6 ft. Estimate the field diffusivity α_{field} corresponding to a 50% level of non-exceedance.

Since roots were observed to a depth of 6 ft, a maximum crack depth of 8 ft should be assumed. From Fig. 21, for a 50% level of non-exceedance and a crack depth of 8 ft, $\alpha_{field}/\alpha_{field}$=40. Hence:

$$\alpha_{field} = 40 \times 8.0\text{x}10^{-5}\ \text{cm}^2/\text{sec} = 3.2\text{x}10^{-3}\ \text{cm}^2/\text{sec} \quad (9)$$

A second indicator of tree root depth is a suction profile at or near the wilting point of vegetation, about 4.5 pF. Figure 23 shows the characteristic suction profile of a deep root zone. Corrections for crack depths estimated through this method are computed in an identical manner as that shown in the above example.

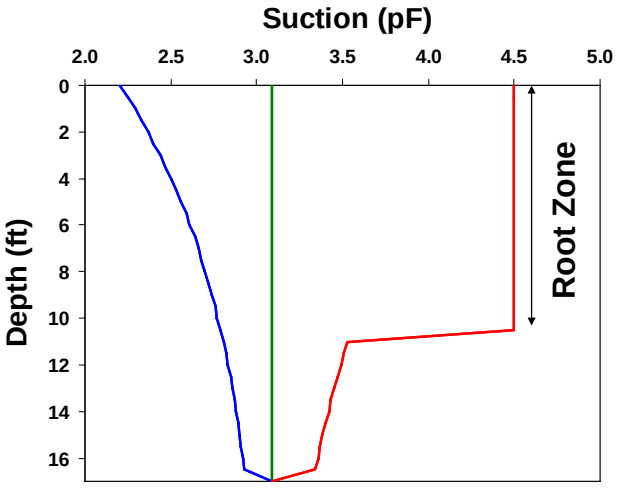

Figure 23. Characteristic Suction Profile for a Deep Root Zone.

3.9.3 Diffusivity from the Depth of Moisture Active Zone

Estimates of the depth of the moisture active zone y_{ma} can also provide a basis for estimating field diffusivity α_{field} using the relationship:

$$\alpha_{field} = 0.6\, n\, (y_{ma})^2 \quad (10)$$

where n is the frequency of seasonal suction variation, usually 1cycle/yr.

Example 2

An examination of a suction profile indicates that an equilibrium suction is reached at a depth of 12 ft. Estimate the field diffusivity α_{field}. In this case, the depth of the moisture active zone y_{ma} = 12 ft. Based on the Equation (10), assuming a seasonal frequency n = 1 yr leads to:

$$\alpha_{field} = 0.6\ (1\ \text{cycle/yr})\ (12\ \text{ft})^2 = 86.4\ \text{ft}^2/\text{yr}$$

Conversion to units of cm^2/sec leads to $\alpha_{field} = 2.6 \times 10^{-3}\ cm^2/sec$.

4. PROGRAM EXECUTION

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

Several error message boxes (Fig. 24) will appear if a mistake has been made with the input data.

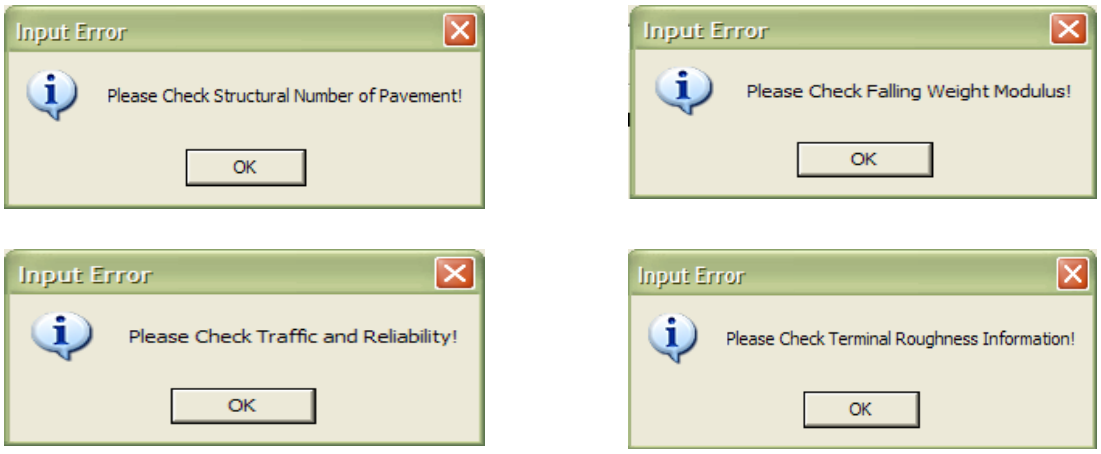

Figure 24. Several Error Message Boxes.

When all input data are correct, a dark execute window will appear as in Fig. 25 when the program is running. It will take a few minutes to complete it. To show results, click the button Result .

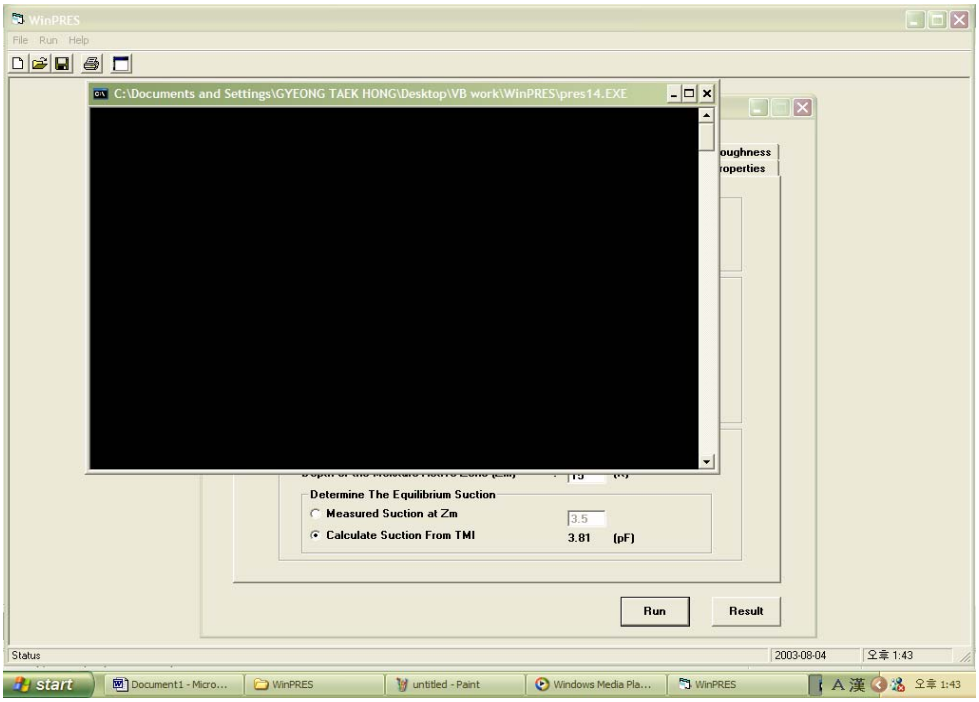

Figure 25. Execute Window.

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. 26).

After running the program, a message box may appear that informs the designer that the expansive clay roughness will increase too rapidly (Fig. 27). In this case, the roughness with time will not be calculated. To determine this information for a less extreme condition in controlling rate of increase of roughness due to expansive clays, use a vertical moisture barrier, a lower reliability for expansive clay roughness or removal and replacement of subgrade with either inert or stabilized soil. In order to decrease rate of increase of roughness due to traffic, increase structural number (SN) or modulus of subgrade soil or decrease reliability for traffic.

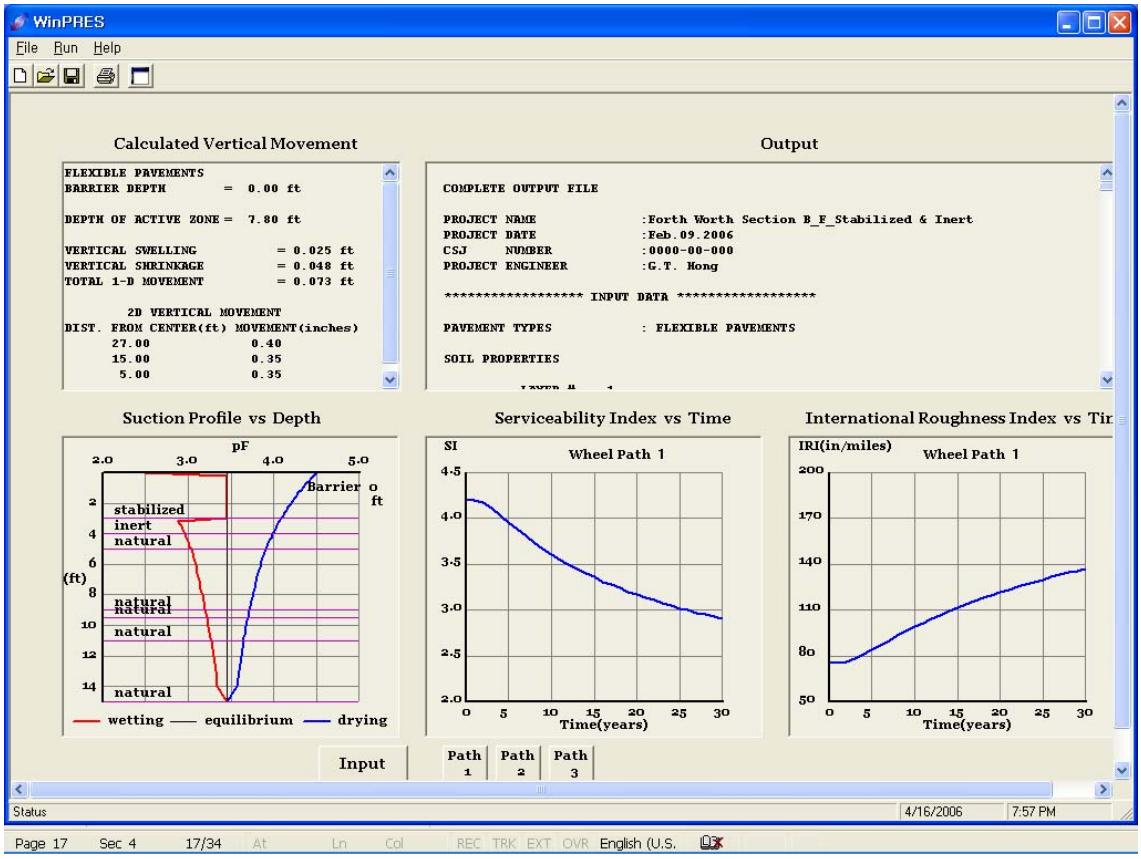

Figure 26. Output Dialog Window.

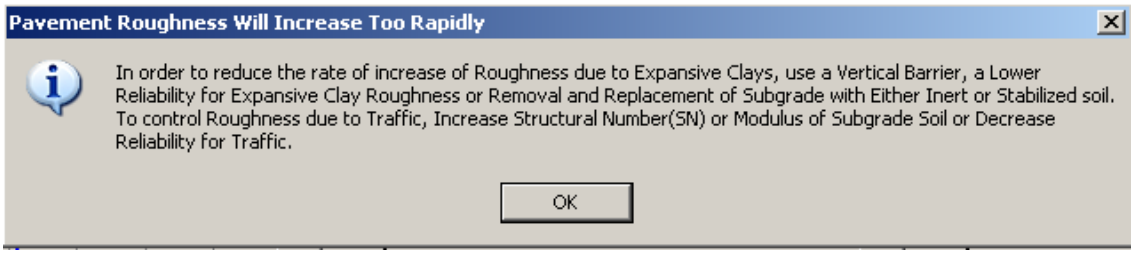

Figure 27. Information Message Box for the Roughness.

After executing the program, the five output files such as suction.txt, SI.txt, IRI.txt, summary.txt, and outputfull.txt will appear in the folder that has an executable file winpres.exe. The suction.txt file includes the suction profile with depth. The SI.txt and IRI.txt files have serviceability index and international roughness index versus time, respectively. The summary.txt file includes the vertical movement at the edge of pavement and in the wheel path of interest. The outputfull.txt 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. 28).

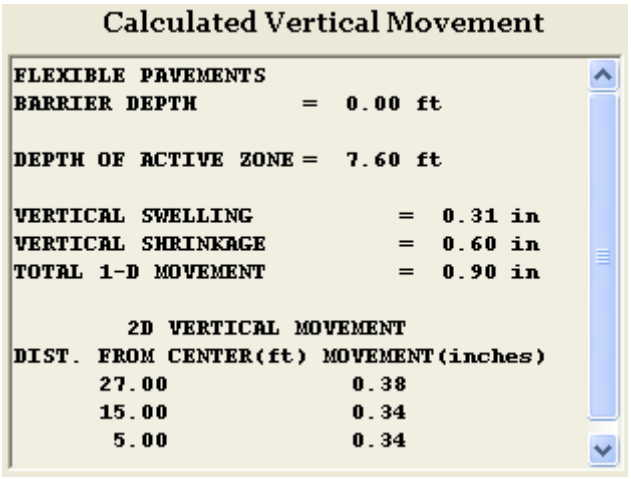

Figure 28. Calculated Vertical Movement.

5.2 Output

The user can view the full results of the data by moving the right scrollbar up or down (Fig. 29).

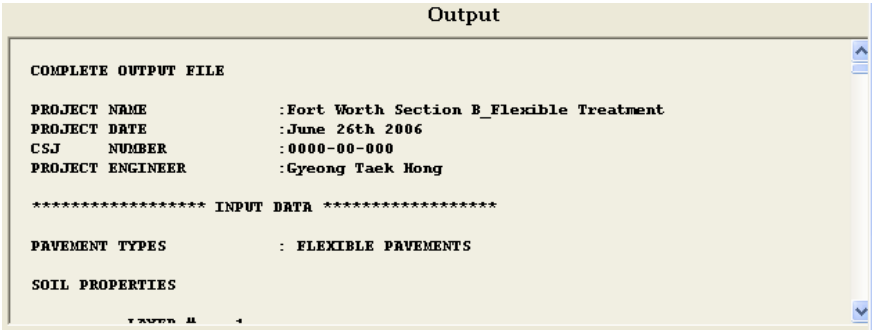

Figure 29. Complete Output.

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. 30).

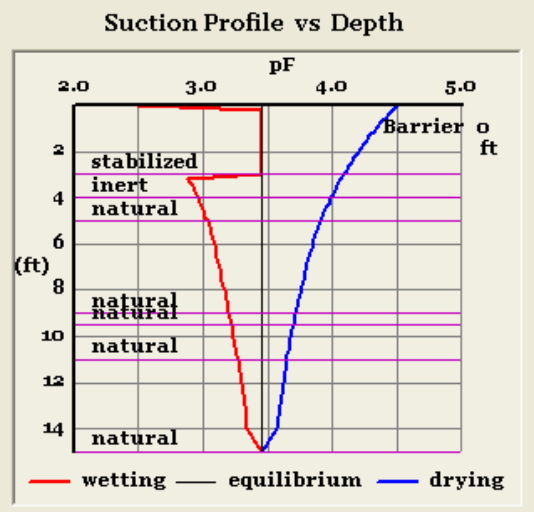

Figure 30. Suction Profile versus Depth.

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 Path 1 Path 2 Path 3 (Fig. 31).

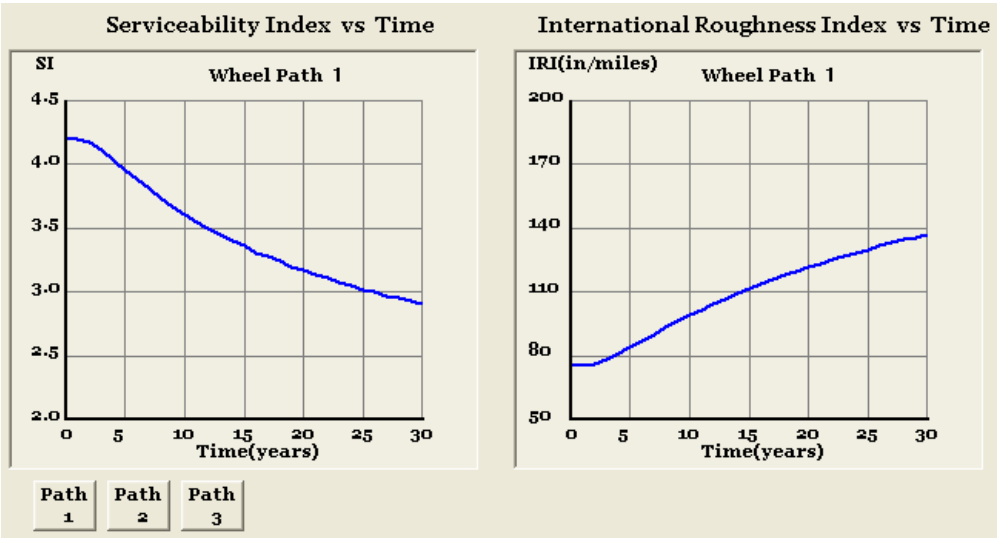

Figure 31. Roughness with Time.

To demonstrate various applications of the computer program WinPRES and to serve as exercises as well as output interpretation, four examples based on case studies are given in the EXAMPLES.

EXAMPLES

Input File Name: Fort Worth SectionA Flexible No Treat

```
 COMPLETE OUTPUT FILE

 PROJECT NAME               :Fort Worth Section A Flexible No Treat
 PROJECT DATE               :June 26th 2006
 CSJ     NUMBER             :0000-00-000
 PROJECT ENGINEER           :Gyeong Taek Hong

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

 PAVEMENT TYPES             : FLEXIBLE PAVEMENTS

 SOIL PROPERTIES

          LAYER #    1
 SOIL TYPE                          =  NATURAL SOIL
 THICKNESS (ft)                     =     3.00
 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 #    2
 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 #    3
 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 #    4
 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 #    5
 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 #    6
 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           3.00                16
      2           4.20                20
      3           1.30                 7
      4           0.50                 3
      5           3.50                18
      6           2.50                 6

  ENVIRONMENTAL AND GEOMETRIC CONDITION

  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)                            =   0.26
  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                     =  13712.0
  ADT IN ONE DIRECTION WHEN T=C                     =  21744.0
  18 kip SINGLE AXLES  WHEN T=C                     =  8415520.0

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


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

  SUCTION COMPRESSION INDEX (SCI)
  LAYER NO.   ZONE         SCI      alpha(cm^2/s)
       1        4        0.0313       0.00346400
       2        4        0.0288       0.00356000
       3        2        0.0257       0.00412000
       4        1        0.0180       0.00412000
       5        3        0.0529       0.00236000
       6        3        0.0576       0.00080000

SUCTION PROFILE(h), VOL. WATER CONTENT(m), AND VERTICAL  MOVEMENT
DEPTH(ft)  h(EQ.)  h(WET)  h(DRY)   m(WET)  m(DRY) SWELL(IN) SHRINK(IN) TOTAL(IN)
   0.00     2.58    2.50    4.50    0.5943  0.2286   0.0636    1.0690    1.1326
   0.19     2.58    2.50    4.44    0.5939  0.2392   0.0596    1.0254    1.0850
   0.38     2.58    2.50    4.39    0.5934  0.2495   0.0557    0.9832    1.0389
   0.56     2.58    2.51    4.33    0.5930  0.2595   0.0519    0.9422    0.9941
   0.75     2.58    2.51    4.28    0.5926  0.2691   0.0482    0.9024    0.9507
   0.94     2.58    2.51    4.23    0.5922  0.2785   0.0447    0.8639    0.9086
   1.13     2.58    2.51    4.18    0.5919  0.2876   0.0412    0.8265    0.8677
   1.31     2.58    2.52    4.13    0.5915  0.2964   0.0379    0.7903    0.8282
   1.50     2.58    2.52    4.08    0.5911  0.3050   0.0346    0.7551    0.7898
   1.69     2.58    2.52    4.04    0.5908  0.3133   0.0315    0.7210    0.7525
   1.88     2.58    2.52    3.99    0.5904  0.3213   0.0285    0.6880    0.7164
   2.06     2.58    2.52    3.95    0.5901  0.3291   0.0255    0.6559    0.6814
   2.25     2.58    2.52    3.91    0.5898  0.3367   0.0227    0.6248    0.6475
   2.44     2.58    2.53    3.87    0.5895  0.3440   0.0199    0.5946    0.6145
```

2.63	2.58	2.53	3.83	0.5892	0.3511	0.0172	0.5654	0.5826
2.81	2.58	2.53	3.79	0.5889	0.3580	0.0146	0.5370	0.5517
3.00	2.58	2.53	3.76	0.5886	0.3647	0.0121	0.5095	0.5216
3.21	2.58	2.53	3.72	0.6109	0.3855	0.0096	0.4820	0.4916
3.42	2.58	2.53	3.68	0.6106	0.3927	0.0072	0.4553	0.4625
3.63	2.58	2.54	3.64	0.6103	0.3996	0.0048	0.4296	0.4344
3.84	2.58	2.54	3.61	0.6101	0.4064	0.0026	0.4047	0.4073
4.05	2.58	2.54	3.57	0.6098	0.4129	0.0006	0.3806	0.3812
4.26	2.58	2.54	3.54	0.6095	0.4192	0.0000	0.3567	0.3567
4.47	2.58	2.54	3.51	0.6093	0.4253	0.0000	0.3328	0.3328
4.68	2.58	2.54	3.48	0.6090	0.4312	0.0000	0.3091	0.3091
4.89	2.58	2.54	3.45	0.6088	0.4368	0.0000	0.2857	0.2857
5.10	2.58	2.55	3.42	0.6086	0.4423	0.0000	0.2631	0.2631
5.31	2.58	2.55	3.39	0.6083	0.4477	0.0000	0.2413	0.2413
5.52	2.58	2.55	3.36	0.6081	0.4528	0.0000	0.2204	0.2204
5.73	2.58	2.55	3.34	0.6079	0.4578	0.0000	0.2003	0.2003
5.94	2.58	2.55	3.31	0.6077	0.4626	0.0000	0.1812	0.1812
6.15	2.58	2.55	3.29	0.6075	0.4672	0.0000	0.1629	0.1629
6.36	2.58	2.55	3.26	0.6073	0.4717	0.0000	0.1456	0.1456
6.57	2.58	2.55	3.24	0.6072	0.4760	0.0000	0.1293	0.1293
6.78	2.58	2.55	3.22	0.6070	0.4802	0.0000	0.1139	0.1139
6.99	2.58	2.55	3.20	0.6068	0.4843	0.0000	0.0994	0.0994
7.20	2.58	2.56	3.18	0.6067	0.4882	0.0000	0.0860	0.0860
7.39	2.58	2.56	3.16	0.3915	0.3171	0.0000	0.0756	0.0756
7.57	2.58	2.56	3.14	0.3914	0.3191	0.0000	0.0658	0.0658
7.76	2.58	2.56	3.13	0.3913	0.3210	0.0000	0.0567	0.0567
7.94	2.58	2.56	3.11	0.3912	0.3228	0.0000	0.0482	0.0482
8.13	2.58	2.56	3.10	0.3912	0.3246	0.0000	0.0404	0.0404
8.31	2.58	2.56	3.09	0.3911	0.3264	0.0000	0.0333	0.0333
8.50	2.58	2.56	3.07	0.3910	0.3281	0.0000	0.0268	0.0268
8.67	2.58	2.56	3.06	0.4039	0.3414	0.0000	0.0229	0.0229
8.83	2.58	2.56	3.05	0.4038	0.3429	0.0000	0.0193	0.0193
9.00	2.58	2.56	3.04	0.4038	0.3443	0.0000	0.0161	0.0161
9.19	2.58	2.56	3.02	0.6069	0.5204	0.0000	0.0097	0.0097
9.39	2.58	2.56	3.00	0.6067	0.5235	0.0000	0.0048	0.0048
9.58	2.58	2.56	2.99	0.6066	0.5265	0.0000	0.0016	0.0016
9.78	2.58	2.56	2.97	0.6065	0.5294	0.0000	0.0000	0.0000
9.97	2.58	2.56	2.96	0.6064	0.5322	0.0000	0.0000	0.0000
10.17	2.58	2.56	2.94	0.6063	0.5349	0.0000	0.0000	0.0000
10.36	2.58	2.57	2.93	0.6061	0.5375	0.0000	0.0000	0.0000
10.56	2.58	2.57	2.91	0.6060	0.5400	0.0000	0.0000	0.0000
10.75	2.58	2.57	2.90	0.6059	0.5424	0.0000	0.0000	0.0000
10.94	2.58	2.57	2.89	0.6058	0.5447	0.0000	0.0000	0.0000
11.14	2.58	2.57	2.88	0.6058	0.5469	0.0000	0.0000	0.0000
11.33	2.58	2.57	2.87	0.6057	0.5491	0.0000	0.0000	0.0000
11.53	2.58	2.57	2.86	0.6056	0.5511	0.0000	0.0000	0.0000
11.72	2.58	2.57	2.85	0.6055	0.5531	0.0000	0.0000	0.0000
11.92	2.58	2.57	2.84	0.6054	0.5550	0.0000	0.0000	0.0000
12.11	2.58	2.57	2.83	0.6053	0.5568	0.0000	0.0000	0.0000
12.31	2.58	2.57	2.82	0.6053	0.5586	0.0000	0.0000	0.0000
12.50	2.58	2.57	2.81	0.6052	0.5603	0.0000	0.0000	0.0000
12.92	2.58	2.57	2.78	0.6095	0.5705	0.0000	0.0000	0.0000
13.33	2.58	2.57	2.75	0.6093	0.5755	0.0000	0.0000	0.0000
13.75	2.58	2.57	2.73	0.6091	0.5798	0.0000	0.0000	0.0000
14.17	2.58	2.57	2.71	0.6090	0.5835	0.0000	0.0000	0.0000
14.58	2.58	2.58	2.69	0.6089	0.5867	0.0000	0.0000	0.0000
15.00	2.58	2.58	2.58	0.6080	0.6080	0.0000	0.0000	0.0000

TOTAL POTENTIAL VERTICAL SWELLING = 0.005 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE = 0.089 ft
TOTAL 1-D VERTICAL MOVEMENT = 0.094 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST = 4.05 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST = 9.78 ft

DEPTH OF VERTICAL BARRIER = 0.00ft

DEPTH OF AVAILABLE MOISTURE dam (ft) = 2.00
PARAMETERS FOR VERTICAL MOVEMENT
XI-1 = 0.4650
XI-2 = 0.7373
XI-3 = 4.4968

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 13.38 * EXP((0.7373 * d/D) ** 4.4968) mm

VERTICAL MOVEMENT

DISTANCE FROM CENTER ,d, (ft)	VERTICAL MOVEMENT,VM,(inches)
27.00	0.55

Pavement Roughness will increase too rapidly.

<Controlling Roughness due to Expansive Clay>

Use a Vertical Barrier, a Lower Reliability for Expansive

Clay Roughness or Removal and Replacement of Subgrade

with Either Inert or Stabilized soil .

<Controlling Roughness due to Traffic>

Increase Structural Number(SN) or Modulus of Subgrade Soil

Input File Name: Fort Worth SectionB Flexible No Treat

```
 COMPLETE OUTPUT FILE

 PROJECT NAME               :Fort Worth Section B_Flexible No Treatment
 PROJECT DATE               :June 26th 2006
 CSJ     NUMBER             :0000-00-000
 PROJECT ENGINEER           :Gyeong Taek Hong

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

 PAVEMENT TYPES             : FLEXIBLE PAVEMENTS

 SOIL PROPERTIES

          LAYER #    1
 SOIL TYPE                          =  NATURAL SOIL
 THICKNESS (ft)                     =     3.50
 LIQUID LIMIT (%)                   =    60.00
 PLASTICITY INDEX (%)               =    36.00
 PERCENT PASSING # 200 (%)          =    85.00
 LESS THAN 2 MICRONS (%)            =    30.00
 DRY UNIT WEIGHT (lb/ft3)           =   100.00

          LAYER #    2
 SOIL TYPE                          =  NATURAL SOIL
 THICKNESS (ft)                     =     1.50
 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 #    3
 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 #    4
 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 #    5
 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 #    6
 SOIL TYPE                          =  NATURAL SOIL
 THICKNESS (ft)                     =     4.00
 LIQUID LIMIT (%)                   =    45.00
 PLASTICITY INDEX (%)               =    15.00
 PERCENT PASSING # 200 (%)          =    99.00
 LESS THAN 2 MICRONS (%)            =    37.00
 DRY UNIT WEIGHT (lb/ft3)           =   100.00


 ELEMENT DATA

 LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
```

1	3.50	18
2	1.50	8
3	4.00	20
4	0.50	3
5	1.50	8
6	4.00	6

ENVIRONMENTAL AND GEOMETRIC CONDITION

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) = 0.26
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 = 13712.0
ADT IN ONE DIRECTION WHEN T=C = 21744.0
18 kip SINGLE AXLES WHEN T=C = 8415520.0

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

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

SUCTION COMPRESSION INDEX (SCI)

LAYER NO.	ZONE	SCI	alpha(cm^2/s)
1	3	0.0706	0.00336000
2	3	0.0469	0.00336000
3	3	0.0565	0.00330400
4	2	0.0257	0.00344000
5	2	0.0547	0.00386400
6	4	0.0262	0.00304400

SUCTION PROFILE(h), VOL. WATER CONTENT(m), AND VERTICAL MOVEMENT

DEPTH(ft)	h(EQ.)	h(WET)	h(DRY)	m(WET)	m(DRY)	SWELL(IN)	SHRINK(IN)	TOTAL(IN)
0.00	3.45	2.50	4.50	0.5594	0.2169	2.4568	1.2744	3.7311
0.19	3.45	2.53	4.47	0.5543	0.2226	2.2916	1.2207	3.5123
0.39	3.45	2.56	4.43	0.5493	0.2282	2.1333	1.1685	3.3018
0.58	3.45	2.59	4.40	0.5444	0.2335	1.9816	1.1164	3.0980
0.78	3.45	2.62	4.37	0.5397	0.2387	1.8361	1.0644	2.9005
0.97	3.45	2.64	4.34	0.5352	0.2437	1.6966	1.0126	2.7092
1.17	3.45	2.67	4.32	0.5308	0.2486	1.5627	0.9612	2.5239
1.36	3.45	2.69	4.29	0.5265	0.2533	1.4343	0.9101	2.3444
1.56	3.45	2.72	4.26	0.5224	0.2579	1.3111	0.8595	2.1706
1.75	3.45	2.74	4.24	0.5184	0.2623	1.1928	0.8094	2.0022
1.94	3.45	2.76	4.21	0.5145	0.2665	1.0792	0.7599	1.8391
2.14	3.45	2.78	4.19	0.5108	0.2707	0.9702	0.7110	1.6812
2.33	3.45	2.81	4.16	0.5072	0.2747	0.8654	0.6627	1.5282
2.53	3.45	2.83	4.14	0.5037	0.2786	0.7648	0.6152	1.3800
2.72	3.45	2.85	4.12	0.5003	0.2823	0.6681	0.5683	1.2365

2.92	3.45	2.86	4.10	0.4970	0.2860	0.5752	0.5222	1.0975
3.11	3.45	2.88	4.08	0.4938	0.2895	0.4859	0.4769	0.9629
3.31	3.45	2.90	4.06	0.4907	0.2929	0.4001	0.4324	0.8325
3.50	3.45	2.92	4.04	0.4877	0.2962	0.3206	0.3886	0.7092
3.69	3.45	2.94	4.02	0.4615	0.2838	0.2749	0.3605	0.6354
3.88	3.45	2.95	4.00	0.4589	0.2866	0.2335	0.3329	0.5664
4.06	3.45	2.97	3.98	0.4564	0.2894	0.1963	0.3058	0.5021
4.25	3.45	2.98	3.97	0.4540	0.2921	0.1629	0.2792	0.4421
4.44	3.45	3.00	3.95	0.4516	0.2947	0.1332	0.2532	0.3864
4.63	3.45	3.01	3.94	0.4493	0.2972	0.1071	0.2277	0.3348
4.81	3.45	3.02	3.92	0.4471	0.2997	0.0843	0.2033	0.2877
5.00	3.45	3.04	3.91	0.4450	0.3020	0.0648	0.1806	0.2454
5.20	3.45	3.05	3.89	0.4940	0.3407	0.0445	0.1546	0.1991
5.40	3.45	3.06	3.88	0.4916	0.3434	0.0282	0.1308	0.1590
5.60	3.45	3.08	3.86	0.4893	0.3459	0.0158	0.1091	0.1248
5.80	3.45	3.09	3.85	0.4871	0.3484	0.0070	0.0894	0.0964
6.00	3.45	3.10	3.84	0.4849	0.3508	0.0018	0.0718	0.0736
6.20	3.45	3.11	3.82	0.4828	0.3531	0.0000	0.0562	0.0562
6.40	3.45	3.12	3.81	0.4808	0.3554	0.0000	0.0426	0.0426
6.60	3.45	3.13	3.80	0.4788	0.3575	0.0000	0.0309	0.0309
6.80	3.45	3.14	3.79	0.4769	0.3596	0.0000	0.0212	0.0212
7.00	3.45	3.15	3.78	0.4751	0.3617	0.0000	0.0133	0.0133
7.20	3.45	3.16	3.77	0.4733	0.3636	0.0000	0.0073	0.0073
7.40	3.45	3.17	3.76	0.4716	0.3655	0.0000	0.0031	0.0031
7.60	3.45	3.18	3.75	0.4699	0.3674	0.0000	0.0007	0.0007
7.80	3.45	3.19	3.74	0.4683	0.3691	0.0000	0.0000	0.0000
8.00	3.45	3.20	3.73	0.4668	0.3708	0.0000	0.0000	0.0000
8.20	3.45	3.21	3.72	0.4653	0.3725	0.0000	0.0000	0.0000
8.40	3.45	3.22	3.71	0.4638	0.3741	0.0000	0.0000	0.0000
8.60	3.45	3.22	3.70	0.4624	0.3757	0.0000	0.0000	0.0000
8.80	3.45	3.23	3.69	0.4610	0.3772	0.0000	0.0000	0.0000
9.00	3.45	3.24	3.68	0.4597	0.3786	0.0000	0.0000	0.0000
9.17	3.45	3.24	3.68	0.3069	0.2535	0.0000	0.0000	0.0000
9.33	3.45	3.25	3.67	0.3062	0.2542	0.0000	0.0000	0.0000
9.50	3.45	3.25	3.67	0.3055	0.2550	0.0000	0.0000	0.0000
9.69	3.45	3.26	3.66	0.3866	0.3246	0.0000	0.0000	0.0000
9.88	3.45	3.27	3.65	0.3858	0.3255	0.0000	0.0000	0.0000
10.06	3.45	3.27	3.65	0.3850	0.3264	0.0000	0.0000	0.0000
10.25	3.45	3.28	3.64	0.3842	0.3273	0.0000	0.0000	0.0000
10.44	3.45	3.28	3.64	0.3834	0.3282	0.0000	0.0000	0.0000
10.63	3.45	3.29	3.63	0.3826	0.3290	0.0000	0.0000	0.0000
10.81	3.45	3.29	3.63	0.3819	0.3298	0.0000	0.0000	0.0000
11.00	3.45	3.30	3.62	0.3812	0.3306	0.0000	0.0000	0.0000
11.67	3.45	3.31	3.60	0.4769	0.4208	0.0000	0.0000	0.0000
12.33	3.45	3.33	3.59	0.4740	0.4240	0.0000	0.0000	0.0000
13.00	3.45	3.34	3.57	0.4714	0.4269	0.0000	0.0000	0.0000
13.67	3.45	3.35	3.56	0.4691	0.4295	0.0000	0.0000	0.0000
14.33	3.45	3.36	3.55	0.4670	0.4317	0.0000	0.0000	0.0000
15.00	3.45	3.45	3.45	0.4652	0.4338	0.0000	0.0000	0.0000

TOTAL POTENTIAL VERTICAL SWELLING = 0.205 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE = 0.106 ft
TOTAL 1-D VERTICAL MOVEMENT = 0.311 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST = 6.00 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST = 7.60 ft

DEPTH OF VERTICAL BARRIER = 0.00ft

DEPTH OF AVAILABLE MOISTURE dam (ft) = 1.90
PARAMETERS FOR VERTICAL MOVEMENT
XI-1 = 0.3809
XI-2 = 0.9424
XI-3 = 2.8429

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 36.10 * EXP((0.9424 * d/D) ** 2.8429) mm

VERTICAL MOVEMENT
DISTANCE FROM CENTER ,d, (ft) VERTICAL MOVEMENT,VM,(inches)
27.00 1.82

Pavement Roughness will increase too rapidly.

<Controlling Roughness due to Expansive Clay>

Use a Vertical Barrier, a Lower Reliability for Expansive Clay Roughness or Removal and Replacement of Subgrade with Either Inert or Stabilized soil .

<Controlling Roughness due to Traffic>

Increase Structural Number(SN) or Modulus of Subgrade Soil or Decrease Reliability for Traffic.

Input File Name: Fort Worth SectionB Flexible Treat

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COMPLETE OUTPUT FILE

PROJECT NAME                :Fort Worth Section B_Flexible Treatment
PROJECT DATE                :June 26th 2006
CSJ     NUMBER              :0000-00-000
PROJECT ENGINEER            :Gyeong Taek Hong

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

PAVEMENT TYPES              : FLEXIBLE PAVEMENTS

SOIL PROPERTIES

          LAYER #    1
SOIL TYPE                           =  STABILIZED SOIL
THICKNESS (ft)                      =     3.00
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 (%)                 =     6.00

          LAYER #    2
SOIL TYPE                           =  INERT SOIL
THICKNESS (ft)                      =     1.00
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)                      =     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
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LIQUID LIMIT (%)                    =    45.00
PLASTICITY INDEX (%)                =    15.00
PERCENT PASSING # 200 (%)           =    99.00
LESS THAN 2 MICRONS (%)             =    37.00
DRY UNIT WEIGHT (lb/ft3)            =   100.00


ELEMENT DATA

LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
    1           3.00                  16
    2           1.00                   6
    3           1.00                   6
    4           4.00                  20
    5           0.50                   3
    6           1.50                   8
    7           4.00                   6

ENVIRONMENTAL AND GEOMETRIC CONDITION

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
  2            15.00
  3             5.00

INITIAL ROUGHNESS
WHEEL PATH NO.      SI          IRI (in/mi)
    1             4.20        75.20
    2             4.20        75.20
    3             4.20        75.20

DEPTH OF VERTICAL BARRIER (ft)                    =    0.00


STRUCTURAL PROPERTIES OF PAVEMENT

STRUCTURAL NUMBER (ft)                            =   0.48
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                     =  13712.0
ADT IN ONE DIRECTION WHEN T=C                     =  21744.0
18 kip SINGLE AXLES  WHEN T=C                     =  8415520.0

                    WHEEL PATH NO.   2
TRAFFIC ANALYSIS PERIOD (Years)                   =     30.0
ADT IN ONE DIRECTION WHEN T=0                     =  13712.0
ADT IN ONE DIRECTION WHEN T=C                     =  21744.0
18 kip SINGLE AXLES  WHEN T=C                     =  8415520.0

                    WHEEL PATH NO.   3
TRAFFIC ANALYSIS PERIOD (Years)                   =     30.0
ADT IN ONE DIRECTION WHEN T=0                     =  13712.0
ADT IN ONE DIRECTION WHEN T=C                     =  21744.0
18 kip SINGLE AXLES  WHEN T=C                     =  8415520.0

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


********** RESULTS **********
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SUCTION COMPRESSION INDEX (SCI)

LAYER NO.	ZONE	SCI	alpha(cm^2/s)
1	3	0.0212	0.00336000
2	2	0.0120	0.00336000
3	3	0.0469	0.00336000
4	3	0.0565	0.00330400
5	2	0.0257	0.00344000
6	2	0.0547	0.00386400
7	4	0.0262	0.00304400

SUCTION PROFILE(h), VOL. WATER CONTENT(m), AND VERTICAL MOVEMENT

DEPTH(ft)	h(EQ.)	h(WET)	h(DRY)	m(WET)	m(DRY)	SWELL(IN)	SHRINK(IN)	TOTAL(IN)
0.00	3.45	2.50	4.50	0.1259	0.0540	0.3064	0.5979	0.9043
0.19	3.45	3.45	4.47	0.0917	0.0551	0.2610	0.5816	0.8426
0.38	3.45	3.45	4.44	0.0917	0.0562	0.2610	0.5657	0.8267
0.56	3.45	3.45	4.41	0.0917	0.0573	0.2610	0.5499	0.8108
0.75	3.45	3.45	4.38	0.0917	0.0584	0.2610	0.5341	0.7950
0.94	3.45	3.45	4.35	0.0917	0.0594	0.2610	0.5183	0.7793
1.13	3.45	3.45	4.32	0.0917	0.0604	0.2610	0.5027	0.7636
1.31	3.45	3.45	4.29	0.0917	0.0613	0.2610	0.4871	0.7481
1.50	3.45	3.45	4.27	0.0917	0.0623	0.2610	0.4717	0.7327
1.69	3.45	3.45	4.24	0.0917	0.0632	0.2610	0.4564	0.7174
1.88	3.45	3.45	4.22	0.0917	0.0641	0.2610	0.4413	0.7023
2.06	3.45	3.45	4.20	0.0917	0.0649	0.2610	0.4264	0.6874
2.25	3.45	3.45	4.17	0.0917	0.0657	0.2610	0.4117	0.6726
2.44	3.45	3.45	4.15	0.0917	0.0665	0.2610	0.3971	0.6581
2.63	3.45	3.45	4.13	0.0917	0.0673	0.2610	0.3828	0.6437
2.81	3.45	3.45	4.11	0.0917	0.0680	0.2610	0.3686	0.6296
3.00	3.45	3.45	4.09	0.0917	0.0688	0.2610	0.3547	0.6157
3.17	3.45	2.89	4.07	0.1188	0.0734	0.2610	0.3478	0.6087
3.33	3.45	2.90	4.05	0.1179	0.0741	0.2493	0.3409	0.5902
3.50	3.45	2.92	4.04	0.1173	0.0747	0.2380	0.3342	0.5722
3.67	3.45	2.93	4.02	0.1167	0.0753	0.2273	0.3276	0.5548
3.83	3.45	2.95	4.01	0.1162	0.0759	0.2172	0.3211	0.5383
4.00	3.45	2.96	3.99	0.1157	0.0765	0.2078	0.3146	0.5225
4.17	3.45	2.97	3.98	0.4550	0.2909	0.1769	0.2909	0.4678
4.33	3.45	2.99	3.96	0.4529	0.2933	0.1490	0.2675	0.4165
4.50	3.45	3.00	3.95	0.4508	0.2955	0.1240	0.2446	0.3686
4.67	3.45	3.01	3.93	0.4488	0.2978	0.1016	0.2221	0.3237
4.83	3.45	3.02	3.92	0.4469	0.2999	0.0820	0.2007	0.2827
5.00	3.45	3.04	3.91	0.4450	0.3020	0.0648	0.1806	0.2454
5.20	3.45	3.05	3.89	0.4940	0.3407	0.0445	0.1546	0.1991
5.40	3.45	3.06	3.88	0.4916	0.3434	0.0282	0.1308	0.1590
5.60	3.45	3.08	3.86	0.4893	0.3459	0.0158	0.1091	0.1248
5.80	3.45	3.09	3.85	0.4871	0.3484	0.0070	0.0894	0.0964
6.00	3.45	3.10	3.84	0.4849	0.3508	0.0018	0.0718	0.0736
6.20	3.45	3.11	3.82	0.4828	0.3531	0.0000	0.0562	0.0562
6.40	3.45	3.12	3.81	0.4808	0.3554	0.0000	0.0426	0.0426
6.60	3.45	3.13	3.80	0.4788	0.3575	0.0000	0.0309	0.0309
6.80	3.45	3.14	3.79	0.4769	0.3596	0.0000	0.0212	0.0212
7.00	3.45	3.15	3.78	0.4751	0.3617	0.0000	0.0133	0.0133
7.20	3.45	3.16	3.77	0.4733	0.3636	0.0000	0.0073	0.0073
7.40	3.45	3.17	3.76	0.4716	0.3655	0.0000	0.0031	0.0031
7.60	3.45	3.18	3.75	0.4699	0.3674	0.0000	0.0007	0.0007
7.80	3.45	3.19	3.74	0.4683	0.3691	0.0000	0.0000	0.0000
8.00	3.45	3.20	3.73	0.4668	0.3708	0.0000	0.0000	0.0000
8.20	3.45	3.21	3.72	0.4653	0.3725	0.0000	0.0000	0.0000
8.40	3.45	3.22	3.71	0.4638	0.3741	0.0000	0.0000	0.0000
8.60	3.45	3.22	3.70	0.4624	0.3757	0.0000	0.0000	0.0000
8.80	3.45	3.23	3.69	0.4610	0.3772	0.0000	0.0000	0.0000
9.00	3.45	3.24	3.68	0.4597	0.3786	0.0000	0.0000	0.0000
9.17	3.45	3.24	3.68	0.3069	0.2535	0.0000	0.0000	0.0000
9.33	3.45	3.25	3.67	0.3062	0.2542	0.0000	0.0000	0.0000
9.50	3.45	3.25	3.67	0.3055	0.2550	0.0000	0.0000	0.0000
9.69	3.45	3.26	3.66	0.3866	0.3246	0.0000	0.0000	0.0000
9.88	3.45	3.27	3.65	0.3858	0.3255	0.0000	0.0000	0.0000
10.06	3.45	3.27	3.65	0.3850	0.3264	0.0000	0.0000	0.0000
10.25	3.45	3.28	3.64	0.3842	0.3273	0.0000	0.0000	0.0000
10.44	3.45	3.28	3.64	0.3834	0.3282	0.0000	0.0000	0.0000
10.63	3.45	3.29	3.63	0.3826	0.3290	0.0000	0.0000	0.0000
10.81	3.45	3.29	3.63	0.3819	0.3298	0.0000	0.0000	0.0000
11.00	3.45	3.30	3.62	0.3812	0.3306	0.0000	0.0000	0.0000
11.67	3.45	3.31	3.60	0.4769	0.4208	0.0000	0.0000	0.0000
12.33	3.45	3.33	3.59	0.4740	0.4240	0.0000	0.0000	0.0000
13.00	3.45	3.34	3.57	0.4714	0.4269	0.0000	0.0000	0.0000
13.67	3.45	3.35	3.56	0.4691	0.4295	0.0000	0.0000	0.0000

14.33	3.45	3.36	3.55	0.4670	0.4317	0.0000	0.0000	0.0000
15.00	3.45	3.45	3.45	0.4652	0.4338	0.0000	0.0000	0.0000

TOTAL POTENTIAL VERTICAL SWELLING = 0.026 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE = 0.050 ft
TOTAL 1-D VERTICAL MOVEMENT = 0.075 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST = 6.00 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST = 7.60 ft

DEPTH OF VERTICAL BARRIER = 0.00ft

DEPTH OF AVAILABLE MOISTURE dam (ft) = 1.03
PARAMETERS FOR VERTICAL MOVEMENT
XI-1 = 0.3759
XI-2 = 0.8210
XI-3 = 3.5141

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 8.64 * EXP((0.8210 * d/D) ** 3.5141) mm

VERTICAL MOVEMENT

DISTANCE FROM CENTER ,d, (ft)	VERTICAL MOVEMENT,VM,(inches)
27.00	0.38
15.00	0.34
5.00	0.34

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

ROUGHNESS CONSTANTS
THE COEFFICIENT ,As = 476.5531
THE COEFFICIENT ,Bs = 24.8608
THE COEFFICIENT ,Rhos = 236.8177
THE COEFFICIENT ,Ai = 940.2037
THE COEFFICIENT ,Bi = 49.2369
THE COEFFICIENT ,Rhoi = 465.4063

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	75.28	0.00	0.00	0.08	0.00
2	4.17	76.19	0.03	0.00	0.91	0.08
3	4.12	78.08	0.07	0.01	2.50	0.38
4	4.05	80.58	0.12	0.03	4.42	0.96
5	3.97	83.39	0.17	0.05	6.40	1.79
6	3.90	86.31	0.22	0.08	8.30	2.82
7	3.83	89.26	0.26	0.12	10.07	3.99
8	3.76	92.17	0.29	0.15	11.69	5.28
9	3.70	95.00	0.32	0.19	13.17	6.63
10	3.64	97.75	0.34	0.23	14.50	8.04
11	3.58	100.39	0.36	0.26	15.71	9.48
12	3.53	102.94	0.38	0.30	16.81	10.94
13	3.48	105.39	0.39	0.33	17.79	12.40
14	3.43	107.74	0.40	0.37	18.69	13.85
15	3.39	110.00	0.41	0.40	19.49	15.30
16	3.34	112.16	0.42	0.44	20.23	16.74
17	3.30	114.25	0.43	0.47	20.89	18.15
18	3.27	116.25	0.43	0.50	21.50	19.55
19	3.23	118.17	0.44	0.53	22.05	20.93
20	3.20	120.03	0.44	0.56	22.55	22.28
21	3.17	121.81	0.45	0.59	23.01	23.60
22	3.14	123.53	0.45	0.62	23.42	24.91
23	3.11	125.19	0.45	0.64	23.81	26.19
24	3.08	126.80	0.45	0.67	24.15	27.44
25	3.05	128.35	0.45	0.69	24.47	28.67
26	3.03	129.84	0.45	0.72	24.76	29.88
27	3.00	131.29	0.45	0.74	25.03	31.06
28	2.98	132.69	0.45	0.77	25.28	32.22
29	2.96	134.05	0.45	0.79	25.50	33.35
30	2.94	135.37	0.45	0.81	25.70	34.46

WHEEL PATH NO. 2

DISTANCE FROM CENTER OF THE PAVEMENT (ft) = 15.00

ROUGHNESS CONSTANTS
THE COEFFICIENT ,As = 476.5531
THE COEFFICIENT ,Bs = 24.8608
THE COEFFICIENT ,Rhos = 258.8540
THE COEFFICIENT ,Ai = 940.2037
THE COEFFICIENT ,Bi = 49.2369
THE COEFFICIENT ,Rhoi = 509.0492

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	75.25	0.00	0.00	0.05	0.00
2	4.18	75.96	0.02	0.00	0.68	0.08
3	4.13	77.52	0.06	0.01	1.94	0.38
4	4.07	79.68	0.10	0.03	3.52	0.96
5	4.00	82.16	0.14	0.05	5.17	1.79
6	3.94	84.80	0.18	0.08	6.78	2.82
7	3.87	87.49	0.21	0.12	8.30	3.99
8	3.81	90.18	0.24	0.15	9.70	5.28
9	3.74	92.82	0.27	0.19	10.99	6.63
10	3.69	95.40	0.29	0.23	12.16	8.04
11	3.63	97.90	0.31	0.26	13.22	9.48
12	3.58	100.32	0.32	0.30	14.18	10.94
13	3.53	102.66	0.33	0.33	15.06	12.40
14	3.49	104.91	0.34	0.37	15.85	13.85
15	3.44	107.08	0.35	0.40	16.57	15.30
16	3.40	109.17	0.36	0.44	17.23	16.74
17	3.36	111.18	0.37	0.47	17.83	18.15
18	3.33	113.13	0.37	0.50	18.38	19.55
19	3.29	115.00	0.38	0.53	18.87	20.93
20	3.26	116.81	0.38	0.56	19.33	22.28
21	3.22	118.55	0.39	0.59	19.74	23.60
22	3.19	120.23	0.39	0.62	20.13	24.91
23	3.16	121.86	0.39	0.64	20.47	26.19
24	3.14	123.44	0.39	0.67	20.79	27.44
25	3.11	124.96	0.39	0.69	21.09	28.67
26	3.08	126.43	0.40	0.72	21.36	29.88
27	3.06	127.86	0.40	0.74	21.60	31.06
28	3.04	129.25	0.40	0.77	21.83	32.22
29	3.01	130.59	0.40	0.79	22.04	33.35
30	2.99	131.90	0.40	0.81	22.23	34.46

WHEEL PATH NO. 3
DISTANCE FROM CENTER OF THE PAVEMENT (ft) = 5.00

ROUGHNESS CONSTANTS
THE COEFFICIENT ,As = 476.5531
THE COEFFICIENT ,Bs = 24.8608
THE COEFFICIENT ,Rhos = 261.8163
THE COEFFICIENT ,Ai = 940.2037
THE COEFFICIENT ,Bi = 49.2369
THE COEFFICIENT ,Rhoi = 514.9161

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	75.25	0.00	0.00	0.05	0.00
2	4.18	75.93	0.02	0.00	0.65	0.08
3	4.13	77.46	0.06	0.01	1.88	0.38
4	4.07	79.57	0.10	0.03	3.41	0.96
5	4.01	82.01	0.14	0.05	5.02	1.79
6	3.94	84.62	0.18	0.08	6.60	2.82
7	3.88	87.28	0.21	0.12	8.09	3.99
8	3.81	89.94	0.24	0.15	9.46	5.28
9	3.75	92.55	0.26	0.19	10.72	6.63
10	3.69	95.11	0.28	0.23	11.87	8.04
11	3.64	97.59	0.30	0.26	12.91	9.48
12	3.59	99.99	0.31	0.30	13.86	10.94
13	3.54	102.31	0.33	0.33	14.72	12.40
14	3.49	104.55	0.34	0.37	15.50	13.85
15	3.45	106.71	0.35	0.40	16.21	15.30
16	3.41	108.79	0.35	0.44	16.86	16.74

17	3.37	110.80	0.36	0.47	17.45	18.15
18	3.33	112.73	0.37	0.50	17.98	19.55
19	3.30	114.60	0.37	0.53	18.47	20.93
20	3.26	116.40	0.38	0.56	18.92	22.28
21	3.23	118.14	0.38	0.59	19.33	23.60
22	3.20	119.82	0.38	0.62	19.71	24.91
23	3.17	121.44	0.38	0.64	20.05	26.19
24	3.14	123.01	0.39	0.67	20.37	27.44
25	3.12	124.53	0.39	0.69	20.66	28.67
26	3.09	126.00	0.39	0.72	20.93	29.88
27	3.07	127.43	0.39	0.74	21.17	31.06
28	3.04	128.81	0.39	0.77	21.39	32.22
29	3.02	130.15	0.39	0.79	21.60	33.35
30	3.00	131.45	0.39	0.81	21.79	34.46

Input File Name: Fort Worth SectionB Rigid Treat

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  COMPLETE OUTPUT FILE

  PROJECT NAME               :Fort Worth Section B_Rigid Treatment
  PROJECT DATE               :June 26th 2006
  CSJ     NUMBER             :0000-00-000
  PROJECT ENGINEER           :Gyeong Taek Hong

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

  PAVEMENT TYPES             : RIGID PAVEMENTS

  SOIL PROPERTIES

            LAYER #    1
  SOIL TYPE                          =  STABILIZED SOIL
  THICKNESS (ft)                     =     1.00
  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 (%)                =     6.00

            LAYER #    2
  SOIL TYPE                          =  NATURAL SOIL
  THICKNESS (ft)                     =     3.00
  LIQUID LIMIT (%)                   =    60.00
  PLASTICITY INDEX (%)               =    36.00
  PERCENT PASSING # 200 (%)          =    85.00
  LESS THAN 2 MICRONS (%)            =    30.00
  DRY UNIT WEIGHT (lb/ft3)           =   100.00

            LAYER #    3
  SOIL TYPE                          =  NATURAL SOIL
  THICKNESS (ft)                     =     1.50
  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
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LIQUID LIMIT (%)                    =    45.00
PLASTICITY INDEX (%)                =    15.00
PERCENT PASSING # 200 (%)           =    99.00
LESS THAN 2 MICRONS (%)             =    37.00
DRY UNIT WEIGHT (lb/ft3)            =   100.00


ELEMENT DATA

LAYER NO.   LAYER THICK.(ft)   NO. OF ELEMENTS
    1           1.00                  6
    2           3.00                 16
    3           1.50                  8
    4           4.00                 20
    5           0.50                  3
    6           1.50                  8
    7           4.00                  6

ENVIRONMENTAL AND GEOMETRIC CONDITION

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             4.50        65.40

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             =  5820.00

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)         =   620.00
DRAINAGE COEFFICIENT                              =     1.00
LOAD TRANSFER COEFFICIENT                         =     2.90
TERMINAL SERVICEABILITY INDEX FOR THE CONCRETE
PAVEMENT                                          =     2.80


TRAFFIC DATA

                    WHEEL PATH NO.   1
TRAFFIC ANALYSIS PERIOD (Years)                   =     30.0
ADT IN ONE DIRECTION WHEN T=0                     =  13712.0
ADT IN ONE DIRECTION WHEN T=C                     =  21744.0
18 kip SINGLE AXLES  WHEN T=C                     =  8415520.0

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


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

SUCTION COMPRESSION INDEX (SCI)
LAYER NO.   ZONE         SCI      alpha(cm^2/s)
     1        3        0.0212       0.00252000
     2        3        0.0706       0.00252000
     3        3        0.0469       0.00336000
     4        3        0.0565       0.00330400
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5	2	0.0257	0.00344000
6	2	0.0547	0.00386400
7	4	0.0262	0.00304400

SUCTION PROFILE(h), VOL. WATER CONTENT(m), AND VERTICAL MOVEMENT

DEPTH(ft)	h(EQ.)	h(WET)	h(DRY)	m(WET)	m(DRY)	SWELL(IN)	SHRINK(IN)	TOTAL(IN)
0.00	3.45	2.50	4.50	0.1259	0.0540	1.4931	1.0560	2.5491
0.17	3.45	3.45	4.47	0.0917	0.0551	1.4527	1.0415	2.4942
0.33	3.45	3.45	4.43	0.0917	0.0563	1.4527	1.0274	2.4801
0.50	3.45	3.45	4.40	0.0917	0.0574	1.4527	1.0134	2.4660
0.67	3.45	3.45	4.37	0.0917	0.0585	1.4527	0.9993	2.4520
0.83	3.45	3.45	4.34	0.0917	0.0595	1.4527	0.9853	2.4380
1.00	3.45	3.45	4.32	0.0917	0.0605	1.4527	0.9714	2.4241
1.19	3.45	2.69	4.29	0.5263	0.2535	1.4527	0.9222	2.3748
1.38	3.45	2.72	4.26	0.5217	0.2586	1.3341	0.8734	2.2075
1.56	3.45	2.75	4.23	0.5173	0.2635	1.2208	0.8252	2.0460
1.75	3.45	2.77	4.20	0.5130	0.2682	1.1125	0.7776	1.8901
1.94	3.45	2.79	4.17	0.5089	0.2727	1.0090	0.7307	1.7397
2.13	3.45	2.82	4.15	0.5050	0.2771	0.9100	0.6845	1.5945
2.31	3.45	2.84	4.12	0.5012	0.2813	0.8154	0.6390	1.4544
2.50	3.45	2.86	4.10	0.4975	0.2854	0.7248	0.5944	1.3192
2.69	3.45	2.88	4.08	0.4939	0.2893	0.6382	0.5506	1.1888
2.88	3.45	2.90	4.06	0.4905	0.2931	0.5553	0.5076	1.0629
3.06	3.45	2.92	4.03	0.4872	0.2968	0.4759	0.4655	0.9414
3.25	3.45	2.94	4.01	0.4840	0.3003	0.3999	0.4242	0.8242
3.44	3.45	2.96	3.99	0.4809	0.3037	0.3287	0.3839	0.7126
3.63	3.45	2.98	3.97	0.4779	0.3070	0.2646	0.3444	0.6091
3.81	3.45	2.99	3.96	0.4751	0.3102	0.2073	0.3059	0.5132
4.00	3.45	3.01	3.94	0.4723	0.3132	0.1565	0.2683	0.4247
4.19	3.45	3.02	3.92	0.4472	0.2996	0.1268	0.2433	0.3701
4.38	3.45	3.04	3.91	0.4450	0.3020	0.1006	0.2188	0.3195
4.56	3.45	3.05	3.89	0.4430	0.3043	0.0779	0.1949	0.2728
4.75	3.45	3.06	3.88	0.4409	0.3065	0.0583	0.1717	0.2300
4.94	3.45	3.07	3.87	0.4390	0.3087	0.0417	0.1502	0.1920
5.13	3.45	3.08	3.85	0.4371	0.3108	0.0281	0.1303	0.1584
5.31	3.45	3.10	3.84	0.4352	0.3128	0.0173	0.1120	0.1293
5.50	3.45	3.11	3.83	0.4335	0.3148	0.0091	0.0953	0.1044
5.70	3.45	3.12	3.82	0.4817	0.3544	0.0028	0.0770	0.0798
5.90	3.45	3.13	3.81	0.4797	0.3566	0.0000	0.0607	0.0607
6.10	3.45	3.14	3.79	0.4777	0.3587	0.0000	0.0464	0.0464
6.30	3.45	3.15	3.78	0.4759	0.3608	0.0000	0.0341	0.0341
6.50	3.45	3.16	3.77	0.4741	0.3627	0.0000	0.0237	0.0237
6.70	3.45	3.17	3.76	0.4723	0.3647	0.0000	0.0153	0.0153
6.90	3.45	3.18	3.75	0.4707	0.3665	0.0000	0.0087	0.0087
7.10	3.45	3.19	3.74	0.4690	0.3683	0.0000	0.0040	0.0040
7.30	3.45	3.20	3.73	0.4675	0.3701	0.0000	0.0011	0.0011
7.50	3.45	3.20	3.72	0.4659	0.3718	0.0000	0.0000	0.0000
7.70	3.45	3.21	3.71	0.4645	0.3734	0.0000	0.0000	0.0000
7.90	3.45	3.22	3.70	0.4630	0.3750	0.0000	0.0000	0.0000
8.10	3.45	3.23	3.70	0.4617	0.3765	0.0000	0.0000	0.0000
8.30	3.45	3.23	3.69	0.4603	0.3780	0.0000	0.0000	0.0000
8.50	3.45	3.24	3.68	0.4590	0.3794	0.0000	0.0000	0.0000
8.70	3.45	3.25	3.67	0.4578	0.3808	0.0000	0.0000	0.0000
8.90	3.45	3.26	3.67	0.4566	0.3821	0.0000	0.0000	0.0000
9.10	3.45	3.26	3.66	0.4554	0.3834	0.0000	0.0000	0.0000
9.30	3.45	3.27	3.65	0.4543	0.3846	0.0000	0.0000	0.0000
9.50	3.45	3.27	3.64	0.4532	0.3858	0.0000	0.0000	0.0000
9.67	3.45	3.28	3.64	0.3026	0.2582	0.0000	0.0000	0.0000
9.83	3.45	3.28	3.63	0.3020	0.2589	0.0000	0.0000	0.0000
10.00	3.45	3.29	3.63	0.3015	0.2595	0.0000	0.0000	0.0000
10.19	3.45	3.29	3.62	0.3816	0.3301	0.0000	0.0000	0.0000
10.38	3.45	3.30	3.62	0.3809	0.3309	0.0000	0.0000	0.0000
10.56	3.45	3.30	3.61	0.3802	0.3317	0.0000	0.0000	0.0000
10.75	3.45	3.31	3.61	0.3796	0.3324	0.0000	0.0000	0.0000
10.94	3.45	3.31	3.60	0.3789	0.3331	0.0000	0.0000	0.0000
11.13	3.45	3.31	3.60	0.3783	0.3338	0.0000	0.0000	0.0000
11.31	3.45	3.32	3.60	0.3777	0.3345	0.0000	0.0000	0.0000
11.50	3.45	3.32	3.59	0.3771	0.3351	0.0000	0.0000	0.0000
12.17	3.45	3.34	3.58	0.4724	0.4258	0.0000	0.0000	0.0000
12.83	3.45	3.35	3.56	0.4700	0.4285	0.0000	0.0000	0.0000
13.50	3.45	3.36	3.55	0.4678	0.4309	0.0000	0.0000	0.0000
14.17	3.45	3.37	3.54	0.4659	0.4330	0.0000	0.0000	0.0000
14.83	3.45	3.38	3.53	0.4642	0.4349	0.0000	0.0000	0.0000
15.50	3.45	3.45	3.45	0.4503	0.4503	0.0000	0.0000	0.0000

TOTAL POTENTIAL VERTICAL SWELLING = 0.124 ft
TOTAL POTENTIAL VERTICAL SHRINKAGE = 0.088 ft

TOTAL 1-D VERTICAL MOVEMENT = 0.212 ft

THE DEPTH OF MOVEMENT ACTIVE ZONE FOR WETTEST = 5.70 ft
THE DEPTH OF MOVEMENT ACTIVE ZONE FOR DRYIEST = 7.30 ft

DEPTH OF VERTICAL BARRIER = 0.00ft

DEPTH OF AVAILABLE MOISTURE dam (ft) = 1.48
PARAMETERS FOR VERTICAL MOVEMENT
XI-1 = 0.3710
XI-2 = 0.8917
XI-3 = 3.2025

EQUATION FOR 2D VERTICAL MOVEMENT
VM = 24.02 * EXP((0.8917 * d/D) ** 3.2025) mm

VERTICAL MOVEMENT
DISTANCE FROM CENTER ,d, (ft) VERTICAL MOVEMENT,VM,(inches)
27.00 1.13

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

ROUGHNESS CONSTANTS
THE COEFFICIENT ,As = 903.9343
THE COEFFICIENT ,Bs = 24.8608
THE COEFFICIENT ,Rhos = 192.5963
THE COEFFICIENT ,Ai = 1877.2769
THE COEFFICIENT ,Bi = 49.2369
THE COEFFICIENT ,Rhoi = 468.4679

ESTIMATED ROUGHNESS WITH TIME

YEAR	PSI	IRI(in/mi)	dPSI(SOILS)	dPSI(TRAFFIC)	dIRI(SOILS)	dIRI(TRAFFIC)
0	4.50	65.40	0.00	0.00	0.00	0.00
1	4.49	65.48	0.01	0.00	0.08	0.00
2	4.44	66.42	0.06	0.00	1.02	0.00
3	4.35	68.39	0.15	0.00	2.97	0.02
4	4.25	70.99	0.24	0.00	5.50	0.08
5	4.15	73.91	0.34	0.01	8.30	0.21
6	4.06	76.96	0.43	0.01	11.16	0.40
7	3.97	80.04	0.51	0.02	13.97	0.67
8	3.88	83.08	0.58	0.04	16.66	1.02
9	3.81	86.05	0.64	0.05	19.22	1.42
10	3.74	88.92	0.70	0.07	21.63	1.89
11	3.67	91.69	0.75	0.09	23.88	2.41
12	3.61	94.36	0.79	0.10	25.99	2.97
13	3.55	96.92	0.83	0.12	27.95	3.58
14	3.50	99.39	0.86	0.14	29.78	4.21
15	3.45	101.75	0.89	0.16	31.48	4.88
16	3.40	104.03	0.92	0.19	33.06	5.57
17	3.35	106.21	0.94	0.21	34.54	6.27
18	3.31	108.31	0.96	0.23	35.92	7.00
19	3.27	110.33	0.98	0.25	37.20	7.73
20	3.24	112.28	0.99	0.27	38.40	8.48
21	3.20	114.15	1.00	0.29	39.52	9.23
22	3.17	115.96	1.02	0.32	40.56	10.00
23	3.14	117.70	1.03	0.34	41.54	10.76
24	3.11	119.38	1.04	0.36	42.46	11.53
25	3.08	121.01	1.04	0.38	43.31	12.30
26	3.05	122.58	1.05	0.40	44.12	13.07
27	3.02	124.10	1.06	0.42	44.87	13.83
28	3.00	125.58	1.06	0.44	45.58	14.60
29	2.98	127.01	1.07	0.46	46.24	15.37
30	2.95	128.39	1.07	0.48	46.86	16.13