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no action

Date: February 4, 1977

Project Title: Implementation of a N-Layer Computer Program for Pavement Design

Project No: E-20-611

Project Director: Dr. James S. Lai

Sponsor: Federal Highway Administration

Agreement Period: From 1/21/77 Until 4/20/77

Type Agreement: Purchase Order No. 7-3-0031

Amount: $5,900

Reports Required: Computer Program; Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters (thru OCA)

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Defense Priority Rating: None

Assigned to: Civil Engineering (School/Laboratory)

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CA–3 (3/76)

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Date: June 20, 1977

Project Title: "Implementation of a N-Layer Computer Program for Pavement Design. (Vesys G)"

Project No: E-20-611

Project Director: Dr. J. S. Lai

Sponsor: DOT, Federal Highway Administration

Effective Termination Date: May 20, 1977

Clearance of Accounting Charges: May 20, 1977

Grant/Contract Closeout Actions Remaining:

- X Final Invoice aXXXXXXXXXXXXXXX
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
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Project Code (GTRI)
Other ______

CA-4 (3/76)

E-20-611
Final

SCEGIT-77-43

IMPLEMENTATION OF A N-LAYER COMPUTER PROGRAM FOR PAVEMENT DESIGN (VESYS G)

by

James S. Lai

Prepared for

Federal Highway Administration
U. S. Department of Transportation
Washington, D.C. 20590

April 30, 1977

School of Civil Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle Implementation of a N-Layer Computer Program for Pavement Design (VESYS G)	5. Report Date April 30, 1977 6. Performing Organization Code
7. Author(s) James S. Lai	8. Performing Organization Report No.
9. Performing Organization Name and Address School of Civil Engineering Georgia Institute of Technology Atlanta, Georgia 30332	10. Work Unit No. (TRAIS) 11. Contract or Grant No. Order No. 7-3-0031
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington, D.C. 20590	13. Type of Report and Period Covered Final 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents the information needed for use of the computer program VESYS G which integrates the n-layer viscoelastic closed form probabilistic primary response model with the current FHWA version of VESYS IIM flexible pavement structural design subsystem.

A limited sensitivity analysis was conducted on the VESYS G and the primary response model (PRIME). Results of these analyses were presented.

The theoretical formulation of the viscoelastic closed-form probabilistic solution for the primary response predictions in VESYS G was also included in this report.

17. Key Words	18. Distribution Statement
Flexible Pavement Analysis, Probabilistic solution, viscoelastic solution, sensitivity analysis, permanent deformation, cracking, rutting, slope variance, Present Serviceability Index.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This report presents the information needed for the use of the computer program VESYS G which integrates the n-layer viscoelastic closed form probabilistic primary response model developed by the University of Utah with the current FHWA version of VESYS IIM structural subsystem.

Support for the work was provided by the Federal Highway Administration, Office of Research and Development, Order No. 7-3-0031. The author wishes to thank Mr. William J. Kenis and James Sherwood for the valuable technical assistance.

The program listing for VESYS G and the printouts for sensitivity analysis of PRIME are included in a separate volume.

TABLE OF CONTENTS

CHAPTER 1

DESCRIPTION OF VESYS G

Work in the FHWA Project 5C entitled "New Methodology for Flexible Pavements" has developed a new flexible pavement design procedure called the VESYS design system. One part of this system is the pavement analysis computer program VESYS IIM which will predict flexible pavement response, distress and performance from a set of mechanistic model formulations. The overall flow chart for the computer program is shown schematically in Figure 1. The primary response model in the computer program uses a three-layer viscoelastic and probabilistic model. This three-layer model is not highly practical considering today's pavement types which are made up of from three to six layers of different materials. In addition, subdivision of any of these layers, where moisture and temperature gradients exist, is desirable and these given pavement systems could be considered to consist of even more numbers of layers.

The N-layer Viscoelastic closed form probabilistic primary response computer program, developed under FHWA contract with the University of Utah has the capabilities to analyze any number of layers and is ideally suited for use in the VESYS design system.

Thus, the main objective of this research effort is to integrate the Utah N-layer primary response model with the current VESYS IIM computer program. The approach is illustrated in Fig. 2a and Fig. 2b. Figure 2a shows the current VESYS IIM Marco program structure. In addition to MAIN program, the VESYS IIM consists of three tasks, CURVIT STATIC, and RANDOM where:

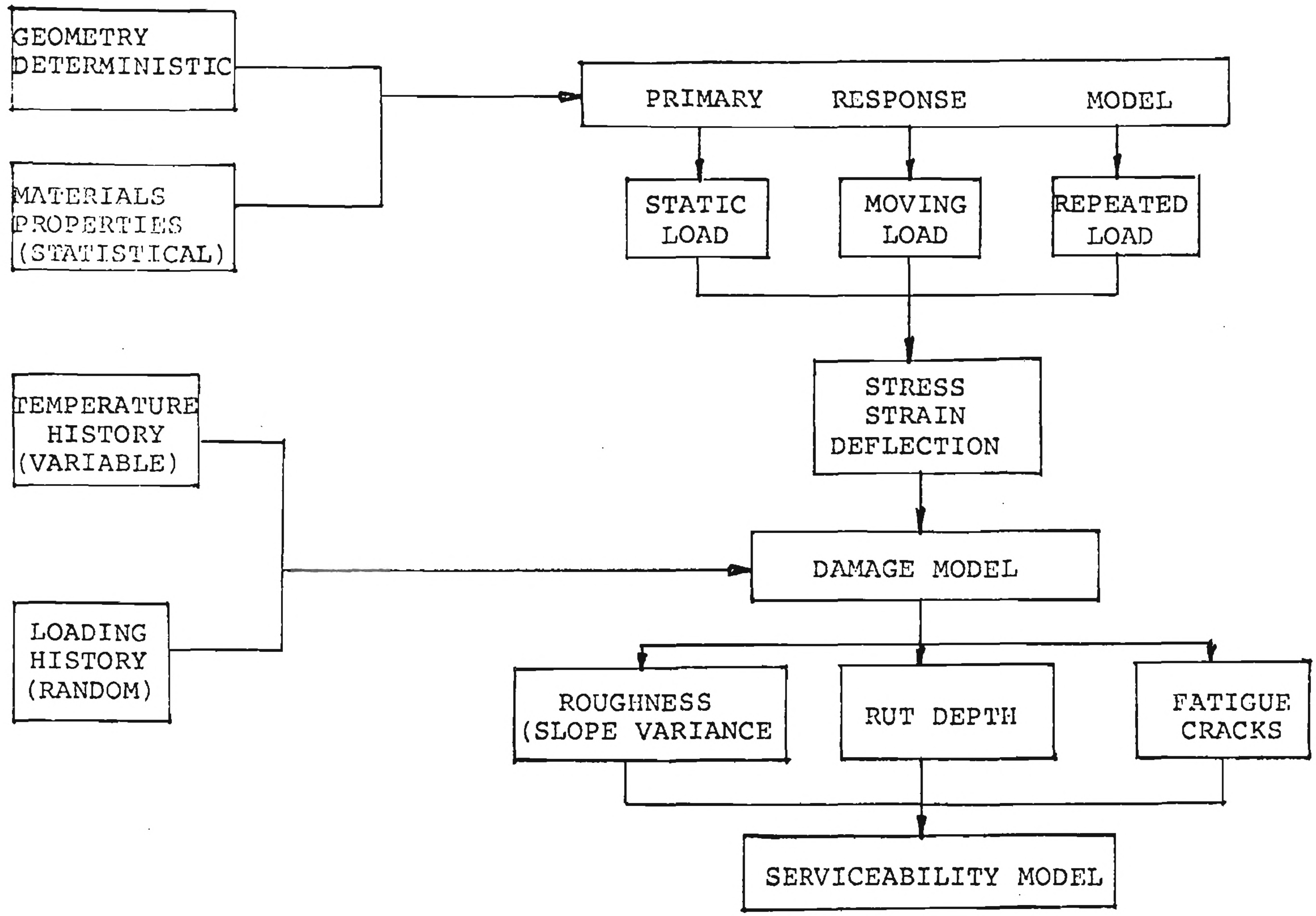

Figure 1. Flow Chart of VESYS IIM Computer Program.

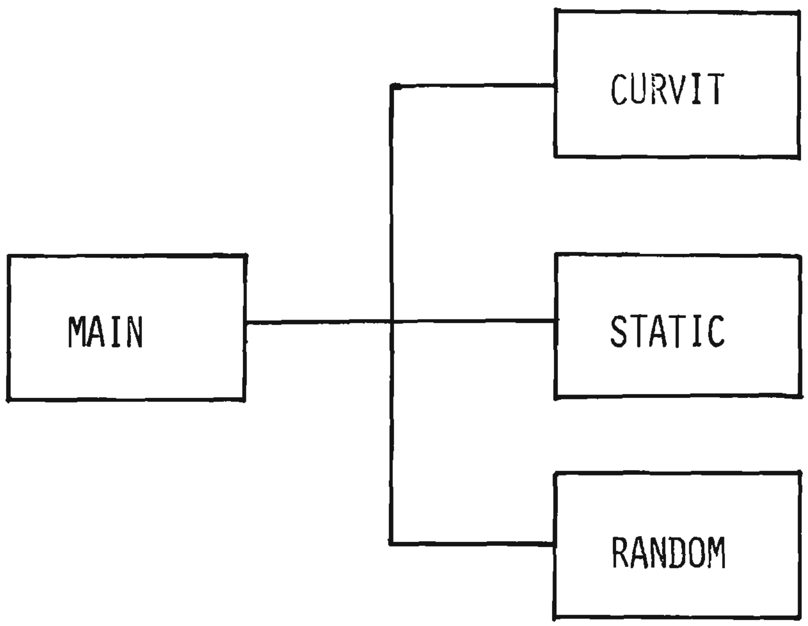

Figure 2A. VESYS IIM Marco Program Structure

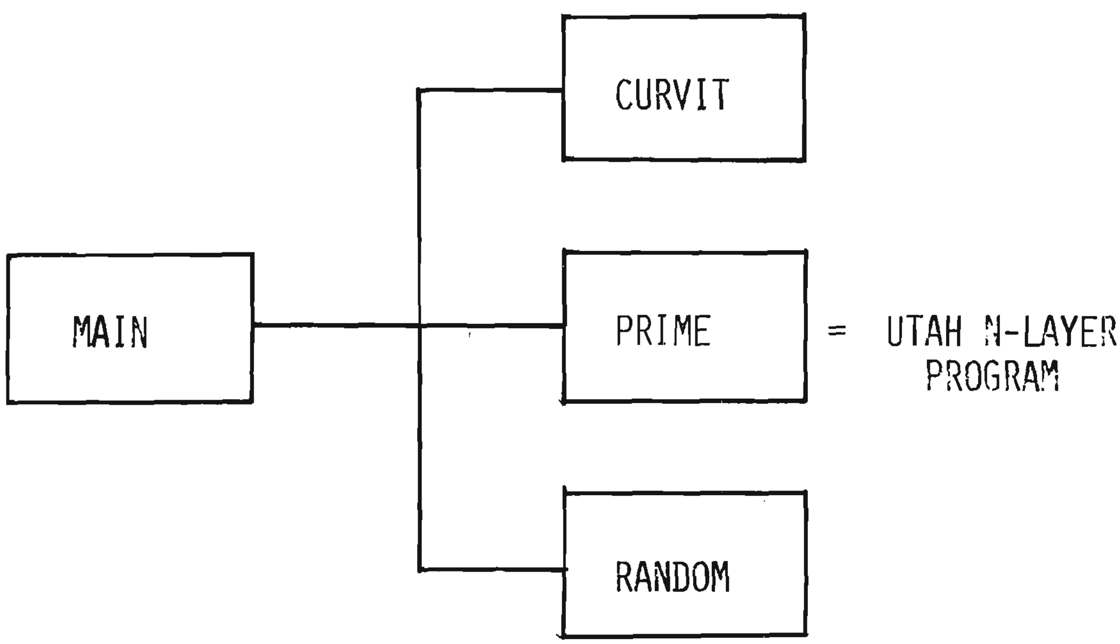

Figure 2B. VESYS G Marco Program Structure

MAIN - handles all data input and stores it in a form suitable for use by the other subcomponents.

CURVIT - performs a least square curve-fitting technique using Dirichlet Series.

STATIC - computes the closed form probabilistic solution, mean and deviation of the stress, strain and deflection at the prescribed positions of a three-layer viscoelastic pavement system.

RANDOM - computes the pavement response to a repeated load, the pavement distresses (rutting, cracking and slop variance), and the pavement serviceability.

In Fig. 2b, the integrated system (VESYS G), the Utah n-layer program (PRIME) was substituted for the STATIC. Thus, PRIME will perform the similar function as the STATIC does in computing the closed form probabilistic solution of the stress, strain and deflection at the prescribed positions in the pavement system. The main difference is that PRIME can handle pavement systems with the number of layers in the system greater than 3,* while STATIC can only handle three layer pavement systems.

---

* The program version listed in the Appendix has the capability to handle systems up to 7 layers. However, the program is designed to solve systems of any number of layers. For solving problems of more than 7 layers, layer-number related variable dimensions should be changed for all subroutines.

CHAPTER 2

OPERATING INSTRUCTIONS

The operating instructions for VESYS G are similar to the current VESYS IIM version. It is recommended that anyone planning to use this program should first familiarize himself with the VESYS USER'S MANUAL for VESYS IIM prepared by FHWA, Office of Research.*

---

* VESYS USER'S MANUAL, Prepared by the Federal Highway Administration, Office of Research, Developed under FCP Prospect 5C.

2.1 VESYS SOURCE CODE

Developed on: IBM 360/65 under OS

Compiler: IBM FORTRAN G Level 21

Typical Statistics:

Step	CPU Seconds	Core (Bytes)
COMPILE	60.55	144 K
GO (Execute)	168.99 (5 layers)	582 K
	54.96 (3 layers)	

Machine-Dependent Considerations:

Word Size - 32 bits

Input/Output Files:

- Input is via logical unit 5 (card reader)
- Output is via logical unit 6 (line printer)

2.2 INPUT DATA

2.2.1 Commands

Input data values for VESYS are read from cards. Each input variable is associated with a "command" word, which is punched before the value of the variable on the data card. The program reads the command first, and then uses it as a keyword for matching the subsequent data value to the proper variable. This allows some flexibility in the order to input data.

After the value of a variable is read, it is checked against a predefined "reasonable" range of values. If the value of any variable lies outside this range, an error message is printed and the program is terminated.

Because many of the input variables have predefined "default" values stored within the program, it is not necessary to input a value for every variable. VESYS automatically assumes the default value for any of these variables which are not input.

VESYS is designed to cycle back to its own starting point so that multiple sets of data may be run with one execution of the program. The data for each separate problem is terminated in the input deck by an ENDOFRUN command. This command signals the program to begin executing with the data that has been read thus far. When the problem is complete, VESYS begins reading data for the next "run" with the first card after the previously read ENDOFRUN command. The last ENDOFRUN command in a data deck is followed immediately by an ENDOFRUN command, which causes the program to cease processing.

When a "job" is submitted with multiple "runs", the first run uses the default values, supplanted where indicated by the input data. Each subsequent run begins with the data values left over from the previous run and supplants where necessary with its own input data. It may be useful to think of each run of a job as having the values used in the previous run by default. Any variables to be changed can be explicitly input. Others will remain the same. This feature allows the user to see the effect of changing a few variables without having to reread all of the data deck.

The input commands recognized by VESYS are of 3 basic types:

1. LOGICAL - No data value is needed. The presence or absence of the command indicates which way a decision is to be made in the program.
2. SCALAR - One data value is read in the field immediately following the command. Absence of the command causes the default value, if any, to be assumed. Absence of a data value following the command will cause "zero" to be assumed, since blanks are read as zeroes.
3. ARRAY (or "Vector") - An array of several data values are read on the card(s) following this command. (No defaults exist for array values). No other commands or values can be on the same cards as an ARRAY COMMAND. The number of data values stored in the array is either determined by an associated SCALAR COMMAND.

2.2.2 Formats

There are only two input formats; one for reading commands and the values associated with scalar commands, and another for reading the array values following an array command.

All commands, and the values with scalar commands, are read with FORMAT (4(A8,E12.4),

1	9	21	29	41	49	61	69 80
COMMAND	VALUE	COMMAND	VALUE	COMMAND	VALUE	COMMAND	VALUE

After an array command, the subsequent card(s) contain the array values in this format: FORMAT (6E12.4), that is

1	13	25	39	49	61 72
VALUE	VALUE	VALUE	VALUE	VALUE	VALUE

2.2.3 General Instructions and Suggestions for Command Use

1. All commands must begin in the first column of the command field. All commands consist of eight (8) characters, including trailing blanks. All 8 characters, including blanks, must be correct for a command to be recognized.
2. All data values must have a decimal point punched in the field. This includes integers.
3. Blank command fields are ignored. Blanks in data fields are read as zeros.
4. When an array (or vector) command is read, the data value field is ignored. Data values for the array are read from subsequent cards.
5. Each array command must appear on a card by itself. No other commands may appear on this card.
6. There are no default values for arrays.

2.2.4 Deck Structure

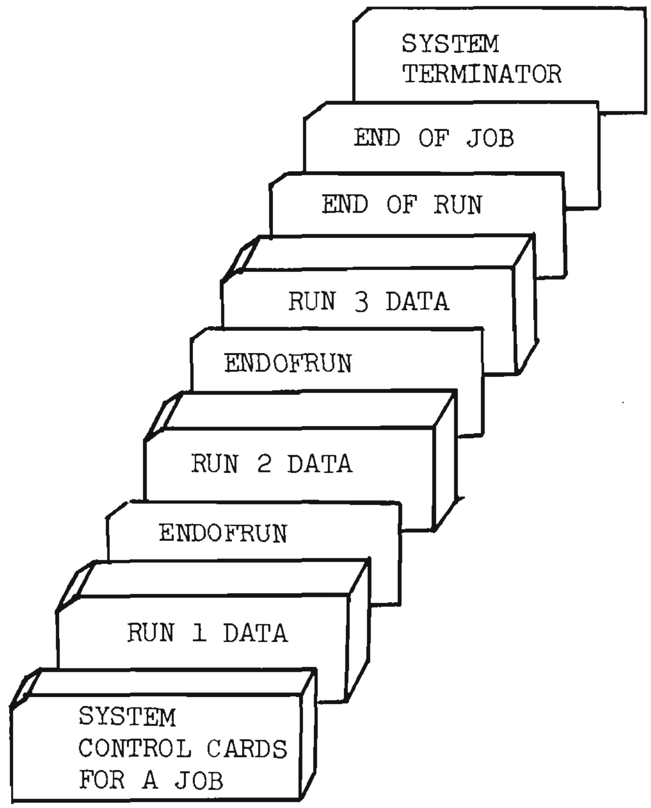

Figure 3. Example of a VESYS "job" with three "runs".

2.3 TYPES OF RUNS AVAILABLE

There are four types of runs available to the user of VESYS. The particular analysis desired is selected by specifying the appropriate value for the TYPE command:

Value of TYPE	Analysis Performed
1.0	Primary Response and Damage/Performance
2.0	Primary Response Only
3.0	Damage/Performance Only
4.0	Curve-Fitting Only

2.3.1 Type 1 Analysis:

This calls for a full run which produces predictions of pavement response and expected lifetime on the basis of system geometry, materials characteristics, and environment. The primary response model passes primary response information to the damage model. Serviceability predictions are then made, based on the primary response information and the various environmental parameters. The following variables will ordinarily be supplied by the user for a TYPE 1 run:

TITLE TYPE 1.0 INDEX	}	Control Variables
NLAYER* THICK* LOADING RADIUS	}	System Geometry

---

* Variables added in VESYS G. The meaning of these variables will be discussed in Section 2.4.

Variables	Group	Category
NZPOINTS* NRPOINTS* ZPOINTS* RPOINTS*	Output Positions	
ZCRACK		
NTSTATIC TSTATIC LAYER1* LAYER2* : LAYER7*	Creep Compliance	Materials Properties
POISSON*		Materials Properties
STRNCOEF STRNEXP COEFK1 COEFK2 K1K2CORL GNU ALPHA CORLOEF CORLEXP	Fatigue and Damage Variables	Materials Properties
TOLERNCE QUALITYO STDEVO PSIFAIL	Serviceability Bounds	System Environment
NTRANDOM TUNITS TRANDOM LAMBDA AMPLITUD VCAMP DURATION	Traffic Variables	System Environment
VCDUR		System Environment
NTEMPS TEMPS REFTEMP BETA	Temperature Variables	System Environment

ENDOFRUN   Signals end of inputs, begins execution of run.

The primary response information is computed in the primary response model and passed to the damage model.

Subsequent TYPE 3 runs (damage/performance only) may use the values which are generated for these variables. The advantage of this is that it permits analysis of the same pavement under several different traffic, temperature and serviceability conditions without recomputing the primary response information. A considerable amount of computer time can be saved in this way, because the static load analysis requires a significant computational effort.

A sample input/output for Type 1 analysis is shown in Appendix 1.

2.3.2 TYPE 2 Analysis:

This calls for primary response calculations only. It produces values for stresses, strains and deflections in a N-layered linear viscoelastic system.

2.3.3 TYPE 3 Analysis:

It is recommended that TYPE 3 runs be made only after the primary response variables have been calculated in a TYPE 1 run. For a user to input all the required information requires a good understanding of the program. Primary response values can be passed directly from a TYPE 1 run to subsequent TYPE 3 runs of the same job. This is explained above for the TYPE 1 analysis.

2.3.4 TYPE 4 Analysis:

This runs the curve-fitting routines on a set of data. The coefficients and DELTAS for a Dirichlet series which approximates the input curve are printed out. The approximation used is based on a least-squares fit. This type of analysis may be used in order to find the user input DELTA values which result in accurate curve fits for the creep compliance data from layer materials. Although VESYS will compute values for DELTAS when they are not specifically input, a better set of curve fits may be obtained by a carefully chosen set of DELTAS.

2.4 DIRECTORY OF NEW COMMANDS

The meaning of the new commands used in VESYS G that are not found in VESYS IIM will be explained in this section. The meaning of the other commands that are common for VESYS G and VESYS IIM were explained in the VESYS USER'S MANUAL cited before.

NLAYER (Default 1.0)
The number of layers in a pavement system including subgrade

THICK (Array-no default)
The array of layer thicknesses, excluding subgrade

NZPOINTS (Default 1.0)
The number of vertical positions for output

NRPOINTS (Default 1.0)
The number of radial positions for output

ZPOINTS (Array - no default)
The array of vertical positions from the surface at which the primary response information is desired

RPOINTS (Array - no default)
The array of radial positions from the center of the load at which the primary response information is desired.

LAYER1
LAYER2
.
.
.
LAYERX (Array - no default)
The array of the master creep compliance curves, mean and coeff. of variation, for layer 1 to layer X where X equals to NLAYER.
Mean value and the coeff. of variation of the creep compliance are read in as a pair. Thus, the first two numbers in the array of LAYER1 represent the mean of coeff. of variation of the creep compliance for layer 1 material at time corresponding to the first point in TSTATIC. Similarly the third and fourth numbers represent the mean and coeff. of variation at time corresponding to the second point in TSTATIC.

The array for each layer should consist of exactly two times NTSTATIC elements (maximum 2 X 25), and NTSTATIC must be input before any of these arrays. The format for the array is 6E12.4. See Appendix 1. Sample Input/Output for the Input of LAYER1 to LAYER<u>X</u>.

ZCRACK (Default to depth of layer 1)
Depth at which strain is obtained to determine cracking index.

POISSON (Array - No Default)
Poisson's Ratio for each layer, including subgrade.

Commands in VESYS IIM that are not used in VESYS G are:

ITYPES
THICK1
THICK2
LAYER1
LAYER2
LAYER3
VARCOEF1
VARCOEF2
VARCOEF3

CHAPTER 3

PROGRAM DOCUMENTATION

3.1 Macro Program Structure

The VESYS G package contains the following four major programs which are further divided into subroutines.

MAIN - handles all data input and stores it in a form suitable for use by the other subcomponents.

CURVIT - performs a least square curve-fitting technique using Dirichlet series.

PRIME - computes closed-form probabilistic solution, mean and deviation of the stress, strain and deflection at the prescribed positions of a n-layer viscoelastic pavement system.

RANDOM - computes the pavement response to a repeated load, the pavement distress (rutting, cracking and slop variance), and the pavement serviceability.

The macro flow chart of the overall program is shown in Fig. 4.

Since the major difference between VESYS IIM and VESYS G is in PRIME, the remaining part of this chapter will be concentrated on discussion of the PRIME program.

3.2 PRIME Program

The Primary Response Program consists of the following subroutines:

PRIME - reads in all input data.

NLAYER - computes closed-form solutions (mean and deviation) of stresses, strains and deflections.

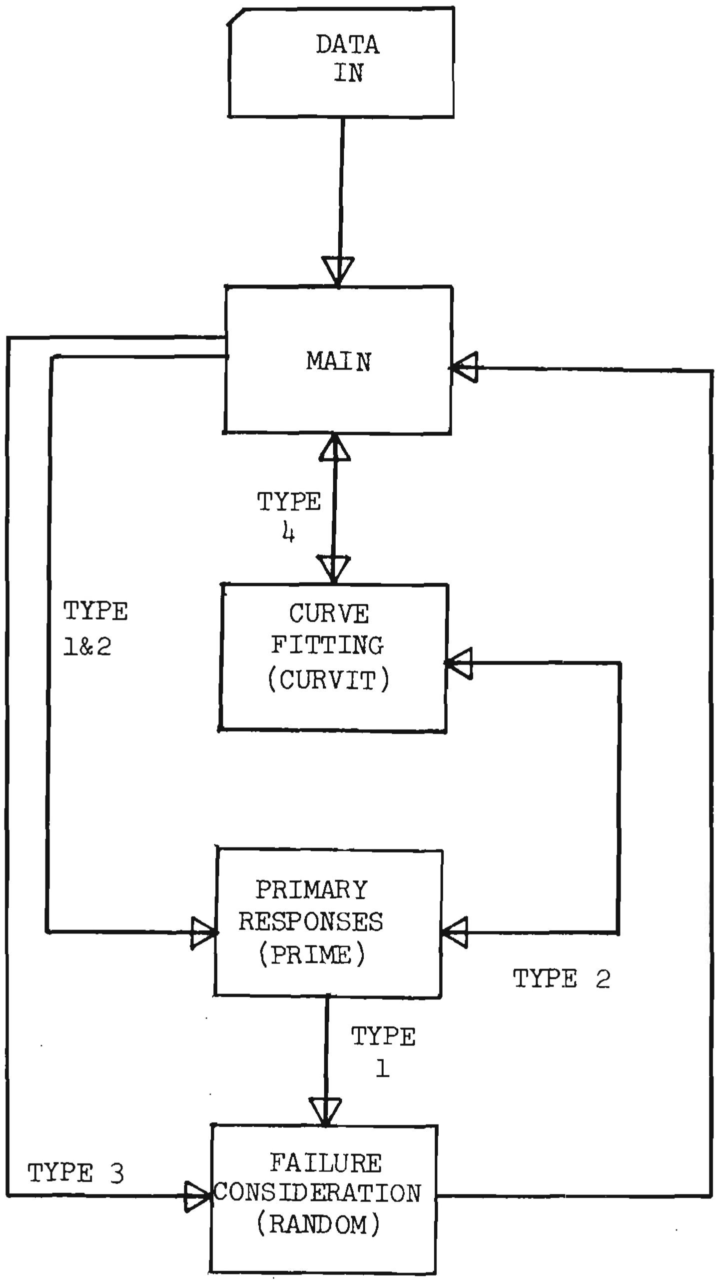

FIGURE 4. MACRO FLOW CHART OF VESYS G

PART - computes integration m, see eq. (9) of Appendix 3.

COEF - computes A_i, B_i, C_i, D_i, dA_i, dB_i, dC_i, dD_i, see Eq. (5) and eq. (19).

TERMS - computes matrix X_i and $\partial X_i/\partial E_j$, see eq. (8) and (18)

DMULT - matrix multiplication

BESSEL - evaluates Bessel functions J_o and J_1

FINTG1 - evaluates integration and performs deterministic calculation of stresses, strains, and deflection, see eq. (9) and (23).

FINTG2 - evaluates integration and performs probabilistic solution of deviations of stresses, strains and deflection, see eq. (24).

PROBL - evaluates variances, see eq. (12).

The interrelationship of these subroutine is illustrated in Fig. 5. The main PRIME program acts essentially as a supervisor program handling all input and output operations. It also computes the permanent deformation and systems GNU and ALF which are to be used in RANDOM for pavement rut depth computation. A flow chart for this subroutine is shown in Fig. 6. The NLAYER subroutine is the main subroutine which computes the stresses, strains and deflections. A flow chart for this subroutine is shown in Fig. 7.

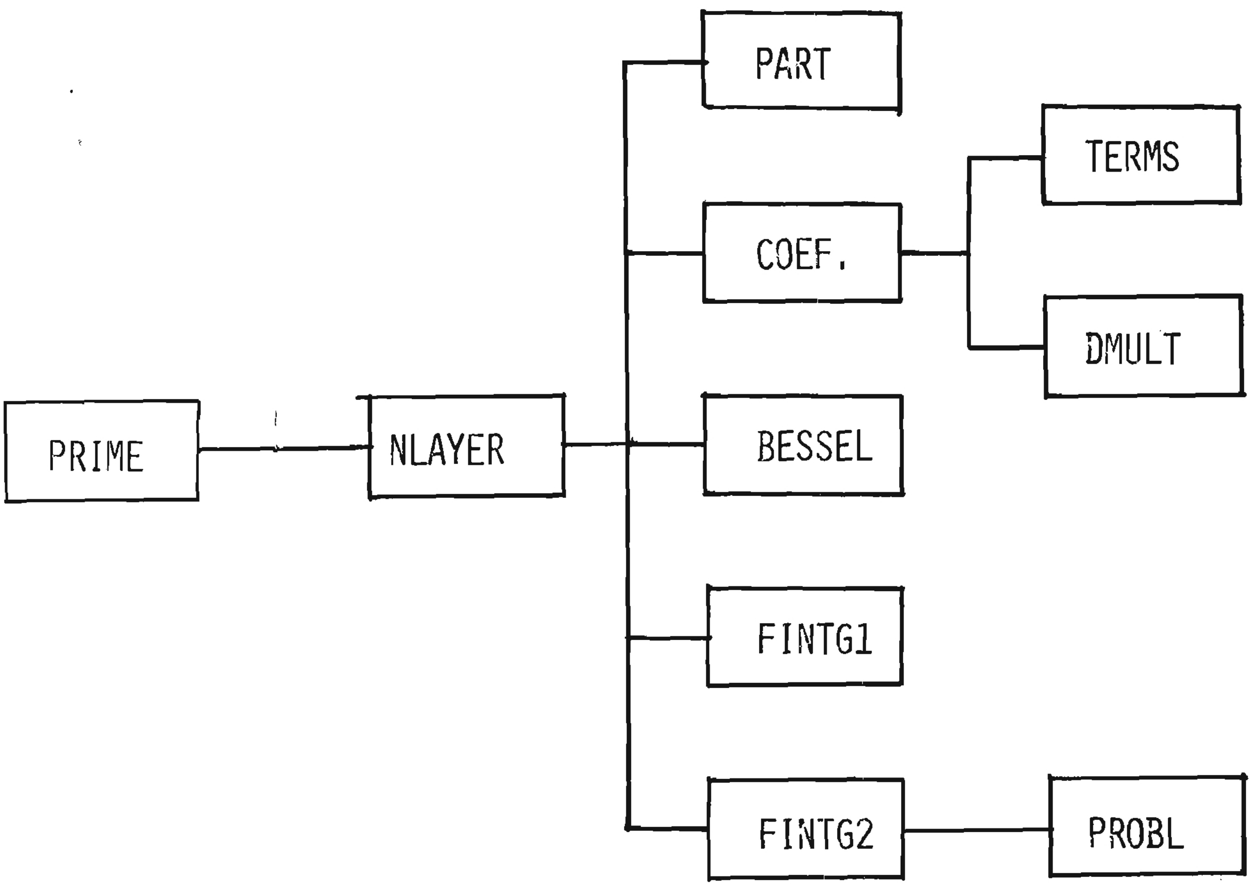

FIGURE 5. PROGRAM STRUCTURE OF PRIME

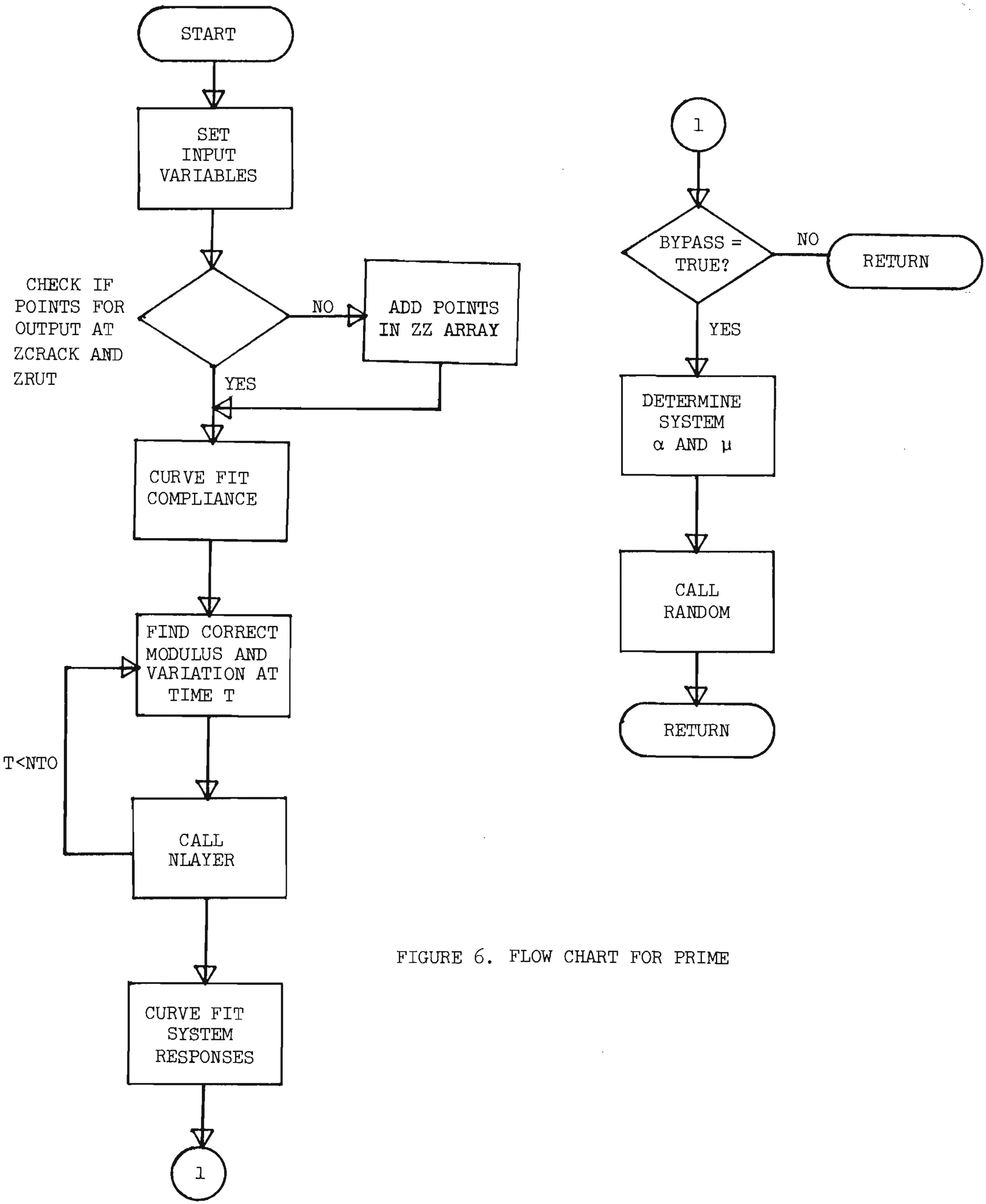

FIGURE 6. FLOW CHART FOR PRIME

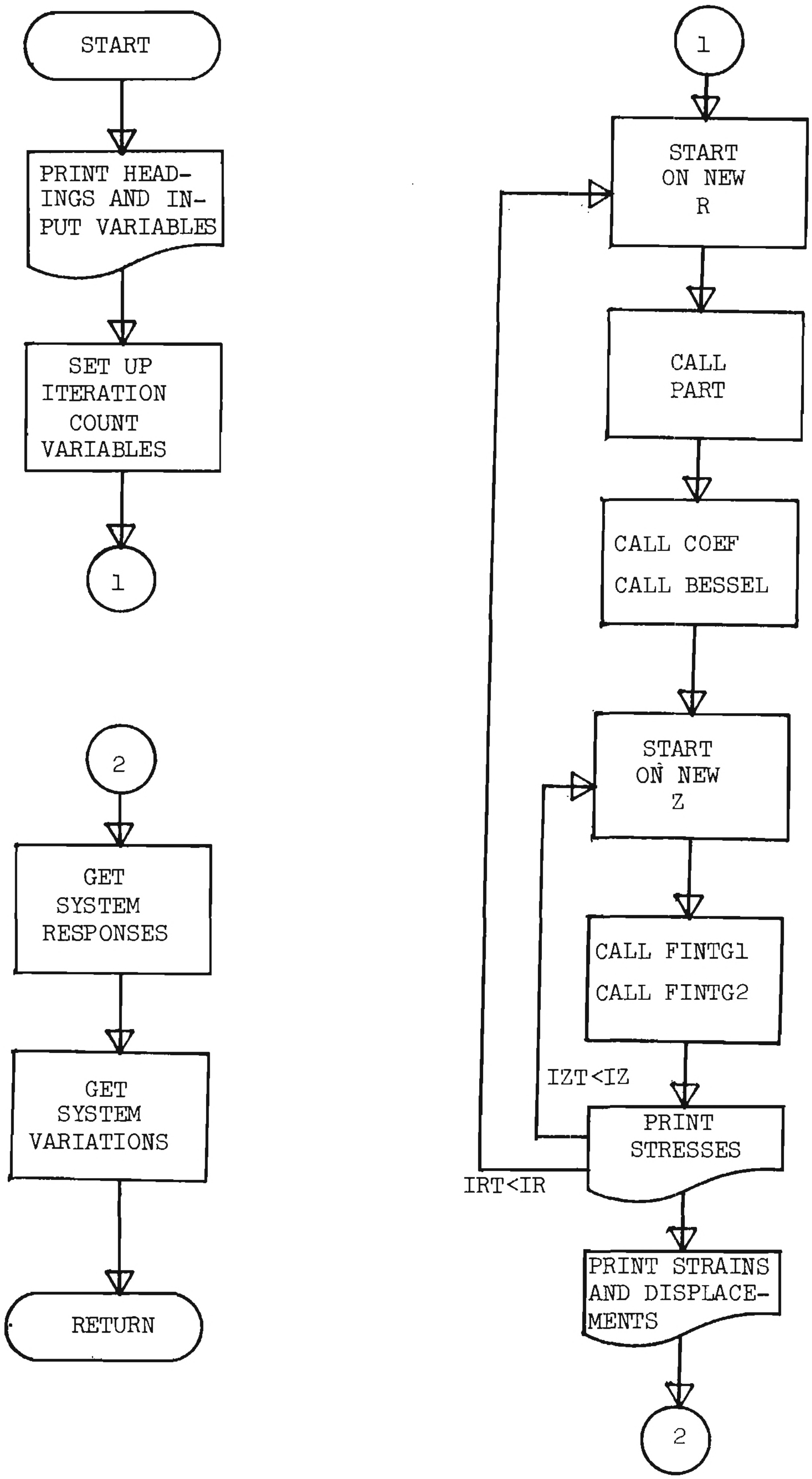

FIGURE 7. FLOW CHART FOR NLAYER

CHAPTER 4

SENSITIVITY ANALYSIS

Brief sensitivity analyses were performed on VESYS G. The objective of these analyses is to determine the accuracy of the system's response. Two types of sensitivity analyses were performed. The first type was to determine the accuracy of the VESYS G system's response as comparison with the current VESYS IIM system. The second type was to do a limited sensitivity analysis of the primary responses (mean and standard deviation) from the PRIME.

4.1 Sensitivity Analysis of VESYS G

In order to compare the outputs from the VESYS G and the VESYS IIM, data from the original VESYS IIM design sample as included in the VESYS USER'S MANUAL was used as the inputs to the VESYS G program. The geometry of the pavement system for the design sample consists of 6 inches of surface course, and 8 inches of base course and a semi-infinite subgrade.

In the first run, the identical inputs from the VESYS IIM design samples were used. In the second run, the 6 inches surface course of the design sample was divided into two 3-inch layers and the 8 inch base course was divided into two 4-inch layers and the other inputs were the same. Thus, the second run could be considered as a 5-layer pavement system. The inputs and outputs of these two cases are included in Appendix 1 together with the outputs from the original VESYS IIM design sample.

The results from these three cases can be summarized as follows:

(1) The outputs from the run 1 (3-layer) and run 2 (5-layer) are almost identical. The main differences are in the primary responses. This will be discussed in Section 4.2.

(2) The primary responses between the VESYS G and VESYS IIM are very close. VESYS G tends to yield higher values (5% to 10% higher).

(3) The rutting, cracking and slope variance predicted from VESYS G are very close to the values predicted by VESYS IIM.

4.2 Sensitivity Analysis of PRIME

The objective of this part of sensitivity analysis is to determine the accuracy of the primary responses and the effect of the number of layers, and the probabilistic properties of layer materials on the probabilistic pavement responses. Four pavement systems as shown in Fig. 8 were used for the sensitivity analysis. The layer thickness and the material properties of each layer for these four pavement systems were so chosen such that Case B (5-layers), Case C (6-layers) and Case D (7-layers) are equivalent to Case A (3-layers). The additional layers other than the basic 3-layers can be considered as the imaginary ones. To determine the effect of the material variability on the pavement responses, different coefficients of variations (COV) of materials in each pavement layers were input to the program. The other input parameters including loading, and mean material properties were kept constant.

The input data for all cases other than the coefficient of variation are shown in the following:

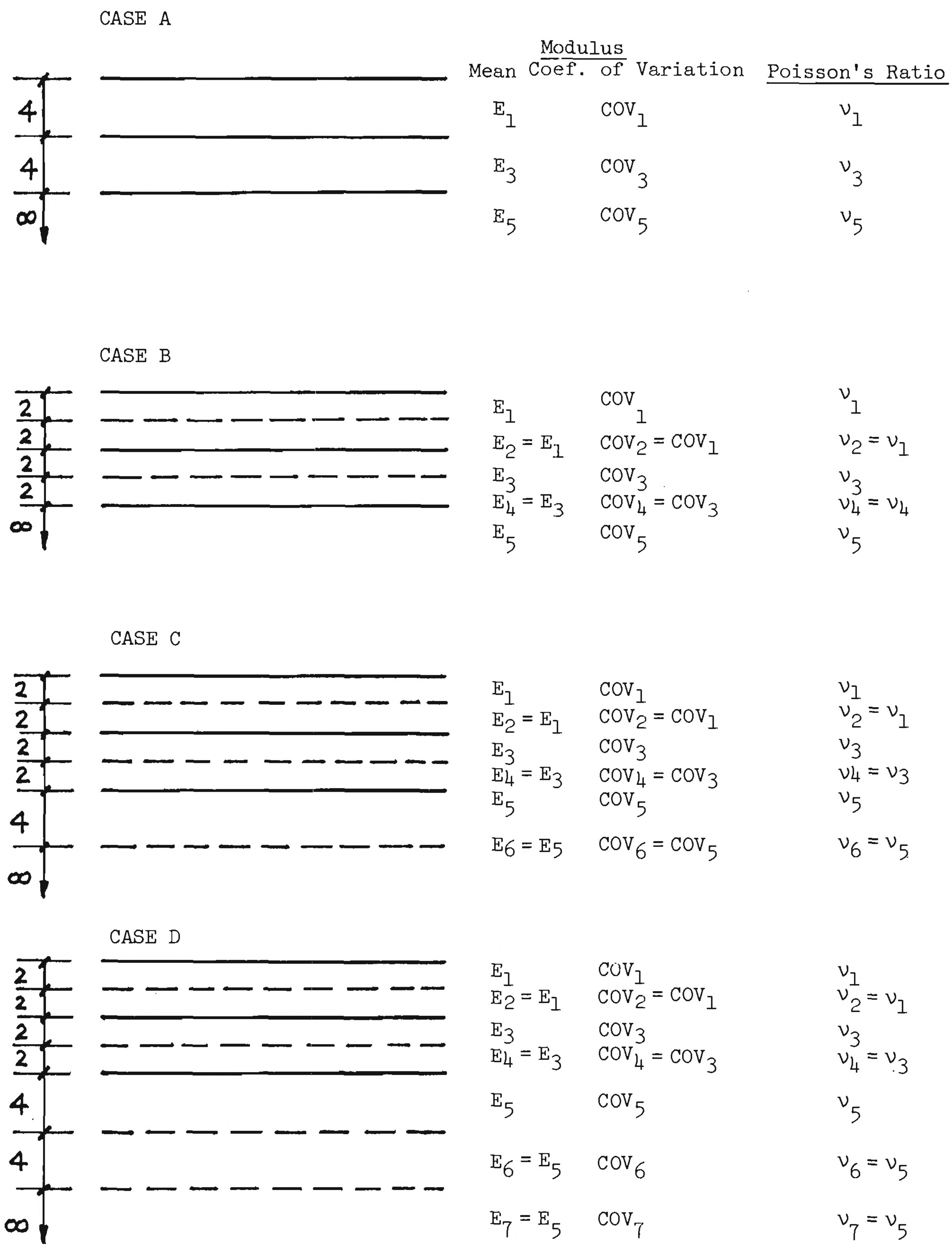

Figure 8. Pavement Systems for Sensitivity Analysis

Total Load (lbs.) = 5654.87

Tire Pressure (psi) = 50.00

Load Radius (in.) = 6.00

$E_1 = 27915$	$\nu_1 = 0.4$	E's for different problem sets are slightly different than the values shown here. See printouts in Appendix II.
$E_2 = 10{,}000$	$\nu_3 = 0.5$	
$E_5 = 3225$	$\nu_5 = 0.5$	

Four sample problem sets eaah with different combinations of coefficient of variation were run. The vertical surface deflections are summarized in Table 1. Detailed computer prinout for all responses is included in Appendix II.

The expected value for surface deflections in all cases are almost the same. The standard deviations are significantly dependent on the input coefficients of variation (COV). For a given pavement system, for example Case A, the standard deviation of the surface deflection depends on the COV of all layer materials. Comparing the difference in the standard deviation between sample set 2 and 3 and sample set 3 and 4 from Table 1 indicates that COV in the subgrade has a more significant effect on the standard deviation of the surface deflection than the COV in the surface course.

On the other hand, results shown in Appendix II indicate that the standard deviations for the stresses and strains at a given position are most sensitive to the COV of the material occupying that position.

Another interesting finding worth to point out here is that for a given set of COV's, the mean responses, such as the surface deflection as shown in Table 1, are the same among four pavement systems. On the other hand, the standard deviations are different for different pavement

Table 1. Surface Deflection (Mean and Deviation)

Pavement System	Sample Problem 1 $COV_1 = 0.1$ $COV_2 = 0.0$ $COV_3 = 0.0$		Sample Problem 2 $COV_1 = 0.1$ $COV_2 = 0.0$ $COV_3 = 0.05$		Sample Problem 3 $COV_1 = 0.27$ $COV_2 = 0.0$ $COV_3 = 0.05$		Sample Problem 4 $COV_1 = 0.27$ $COV_2 = 0.0$ $COV_3 = 0.20$	
	Mean (inch)	Standard Deviation	Mean (inch)	Standard Deviation	Mean (inch)	Standard Deviation	Mean (inch)	Standard Deviation
A	0.0785	0.00148	0.0783	0.00267	0.0767	0.00404	0.0733	0.00829
B	0.0785	0.00075	0.0783	0.00235	0.0767	0.00280	0.0733	0.00778
C	0.0785	0.00075	0.0783	0.00209	0.0767	0.00259	0.0733	0.00686
D	0.0785	0.00075	0.0783	0.00186	0.0767	0.00242	0.0733	0.00603

systems. Increasing number of layers, such as from Case A to Case D, wil result in a smaller standard deviation for the surface deflection even though Case A-D are supposed to represent the same pavement system. This difference in the standard deviations can be attributed to the basic assumption made in deriving the closed-form probabilistic solution. In the original formulation of the solution, see Appendix 3, the properties of each layer were assumed to be independent. This assumption is reasonable for Case A in which the properties of the three different layers, E_1, E_3, and E_5 can be assumed mutually independent. On the other hand, for example in Case D, E_5, E_6 and E_7 are actually the same layer, thus, the probabilistic properties of these three layers should be perfectly correlated instead of mutually independent. Therefore it is possible that the predicted standard deviation for Case D to be smaller than the standard deviation for Case A, due to the fact that some cross correlation terms which should be included in Case D were neglected.

CHAPTER 5

RECOMMENDATIONS

It is not the intent of this chapter to discuss and recommend improvements for the predictability of VESYS system, although there are undoubtedly room for improvementsin this respect. Rather, the recommendations presented herein are mainly for streamlining the operation of the VESYS G and for improving computer run time efficiency.

1. Determine minimum ITG (in subroutine NLAYER) currently 46 is used to reduce the computation time without sacrificing the accuracy of the outputs.
2. Reduce array dimensions to no more than necessary, and get rid of unused variables.
3. Inputing small tire pressures (PSI) and large modulus (small compliance) may cause overflow in subroutine TERMS. If the small values of PSI input is multiplied by a constant (say 50) and the output from that is divided by the same constant, it may help to avoid the overflow problem. This is especially helpful in IBM 360 systems, since range on such is very limited.
4. Output formats need improving.
5. Use more meaningful upper and lower bounds for input error check.

APPENDIX 1

SAMPLE INPUT/OUTPUT

VESYS G SAMPLE PROBLEM 1

PROGRAM TITLE 3 LAYER INPUT ☐ VERIFY 1/3

CHAR. SET 026 ☐ 029 ☐ OTHER ☐

NAME ____ CHARGE OR REFERENCE NUMBER ____ DATE ____

```
TITLE
DESIGN EXAMPLE      12-31-75
TYPE     1.
LOADING  1.           NTSTATIC  11.          NLAYER    3.           NRPOINTS  2.
NZPOINTS 2.
RPOINTS
0.0       6.0
THICK
6.0       8.0
POISSON
0.5       0.5       0.5
ZPOINTS
0.0       6.0
TSTATIC
     1.0E-03   3.0E-03   1.0E-02   3.0E-02   1.0E-01   3.0E-01
     1.0E 00   3.0E 00   1.0E 01   3.0E 01   1.0E 02
LAYER1
     .37E-06   .27E 00   .52E-06   .27E 00   .86E-06   .27E 00
     .14E-05   .27E 00   .25E-05   .27E 00   .40E-05   .27E 00
     .62E-05   .27E 00   .86E-05   .27E 00   .1[illegible]E-[illegible]   .27E 00
```

PROGRAM TITLE 3LAYER INPUT ☐ VERIFY 2/3

CHAR. SET 026 ☐ 029 ☐ OTHER ☐

NAME ______ CHARGE OR REFERENCE NUMBER ______ DATE ______

```
     .176E-04     .276E 00     .176E-04     .276E 00
LAYER2
     .176E-04     .200E 00     .176E-04     .200E 00     .176E-04     .200E 00
     .176E-04     .200E 00     .176E-04     .200E 00     .176E-04     .200E 00
     .176E-04     .200E 00     .176E-04     .200E 00     .176E-04     .200E 00
     .176E-04     .200E 00     .176E-04     .200E 00
LAYER3
     .220E-04     .325E 00     .220E-04     .325E 00     .220E-04     .325E 00
     .220E-04     .325E 00     .220E-04     .325E 00     .220E-04     .325E 00
     .220E-04     .325E 00     .220E-04     .325E 00     .220E-04     .325E 00
     .220E-04     .325E 00     .220E-04     .325E 00     .220E-04     .325E 00
QUALITY0  4.8       STDEV0    .29
NTEMPS    12.
TEMPS
    49.7      53.3      59.5      68.6      75.2      81.6
    84.6      84.7      78.9      70.1      59.1      52.3
STRNEXP
    2.69      2.65      2.67      2.64      2.63      2.61
    2.60      2.60      2.62      2.64      2.67      2.69
STRNCOEF
```

PROGRAM TITLE 3 LAYER INPUT ☐ VERIFY 3/3

CHAR. SET 026 ☐ 029 ☐ OTHER ☐

NAME

CHARGE OR REFERENCE NUMBER

DATE

```
    .462E-04    .728E-04    .155E-03    .777E-03    .242E-02    .121E-01
    .284E-01    .293E-01    .568E-02    .932E-03    .151E-03    .657E-04
                    AMPLITUD  74.43     VCAMH     558.          DURATION  .1
VCDUR     .00005H   CORLCOEF  1.                  CORLEXP   .058
TUNITS    6.                COEFK1    .3          COEFK2    .01           KINZORL   -.867
ALPHA
    .756      .055      .0075
GNU
    .318      .055      .0075
NTRANDOM  10.
TRANDOM
    .5        1.0       1.5       2.0       3.0       4.0
  8.0       12.0      16.0      20.0
LAMBDA
  2000.     2000.     2000.     2000.     2000.     2000.
  2500.     3000.     3500.     4000.
NDELTAS   7.
DELTAS
100.      30.       8.        1.        .1        .03
0.0
ENDOFRUN
ENDOFJOB
```

```
F [illegible] A

PREDICTIVE  DESIGN  PROCEDURES

VESYS [illegible] : A PROBABILISTIC PREDICTIVE MODEL
                    [illegible] PAVEMENT DESIGN

LATEST REVISION: [illegible] APRIL 1977
                 [illegible] TECH

DESIGN EXAMPLE       1[illegible]-[illegible]-75

INPUT DATA VALUES FOR [illegible]

     >>>> TYPE                     [illegible]
          [illegible]

     >>>> [illegible]       .1[illegible]  E+[illegible]1

          [illegible]       .64   E+[illegible]1

     >>>> [illegible]                  [illegible]

          2C[illegible]ACK

     >>>> [illegible]
                              .[illegible]E+[illegible]1

     >>>> [illegible]

     >>>> [illegible]
                              .[illegible]E+ 1

     >>>> [illegible]LAYER

     >>>> T[illegible]
             .[illegible]E+[illegible]1   .[illegible]E+[illegible]1

     >>>> [illegible]
             .[illegible]   .[illegible]E+[illegible]   .5[illegible]E+00

     >>>> [illegible]STATIC            11

     >>>> TSTATIC
             .1[illegible]E-[illegible]2   .3[illegible]E- 2   .10[illegible]E-01   .3000E-[illegible]1   .10[illegible]E+[illegible]   .3000E+00   .10[illegible]E+01   .3[illegible]00E+01   .10[illegible]E+02   .3000E+02
             .10[illegible]E+[illegible]3

     >>>> LAYER1
             .[illegible]7[illegible]E-[illegible]   .[illegible]200E-0[illegible]   .8[illegible]E-0[illegible]   .1450E-05   .2[illegible]E-05   .4000E-05   .6200E-0[illegible]   .[illegible]E-05   .12[illegible]E-[illegible]4   .1600E-[illegible]4
             .1[illegible]E-[illegible]4

          V[illegible]STATI[illegible]
             .27[illegible]E+[illegible]   .27[illegible]E+[illegible]   .270[illegible]E+0[illegible]   .2700E+00   .27[illegible]0E+00   .27 [illegible]E+00   .2700E+00   .2700E+00   .27[illegible]E+0[illegible]   .27[illegible]E+[illegible]0
             .27[illegible] + [illegible]

     >>>> LAYER[illegible]
             .17[illegible]E-[illegible]4   .1700E-04   .1700E-04   .17[illegible]0E-04   .17[illegible]0E-[illegible]4   .1700E-04   .1700E-04   .1700E-04   .17[illegible]E-04   .170[illegible]E-04
             .17[illegible]E-[illegible]4
```

```
      VARIATION
        .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00
        .2000E+00
>>>>> LAYERS
        .22[illegible]E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04
        [illegible]E-04
      VARIATION
        [illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00   .325[illegible]E+00
        .325[illegible]E+[illegible]
>>>> [illegible]LTS
>>>>> [illegible]LTAS
        .1[illegible]E+[illegible]   .[illegible]E+[illegible]   .[illegible]E+01   .1[illegible]E+01   .1000E+[illegible]   .3[illegible]E-01   0.
```

```
>>>> STR[illegible]
      .26[illegible]E+01   .26[illegible]E+01   .2570E+01   .2641E+01   .2630E+01   .2610E+01   .2600E+01   .2600E+01   .2620E+01   .2645E+01
      .2670E+01   .2650E+01

>>>> STRCOEF
      .4[illegible]E-04   .7[illegible]E-06   .15[illegible]E-0[illegible]   .7950E-03   .24[illegible]E-0[illegible]   .1200E-01   .2940E-01   .29[illegible]E-01   .5600E-02   .93[illegible]E-02
      .1[illegible]E-03   .[illegible]E-04
>>>> [illegible]   .3[illegible]E+0[illegible]
>>>> [illegible]   .4[illegible]E-01
>>>> [illegible]   -.[illegible]E+0[illegible]

>>>> [illegible]
      .1[illegible]E+0[illegible]   .5[illegible]E+01   .75[illegible]E+02

>>>> ALF[illegible]
      .7[illegible]E+0[illegible]   .73[illegible]E+0[illegible]   .95[illegible]E+0[illegible]

>>>> [illegible]   .1[illegible]E+01
>>>> [illegible]   .5[illegible]E-01


>>>> NTEMPS            12

>>>> TEMPS
      .49[illegible]E+02   .5[illegible]E+02   .595[illegible]E+02   .65[illegible]E+02   .752[illegible]E+02   .916[illegible]E+02   .84[illegible]E+02   .847[illegible]E+02   .78[illegible]E+02   .701[illegible]E+02
      .591[illegible]E+02   .5[illegible]E+02

   REFTEMP   .7[illegible]E+02
   BETA      .11[illegible]E+0[illegible]

>>>> [illegible]            1

>>>> [illegible]
      [illegible]   .1[illegible]E+01   .15[illegible]E+01   .2[illegible]E+01   .70[illegible]E+01   .4000E+01   .[illegible]E+01   .120[illegible]E+02   .1[illegible]E+02   .25[illegible]E+02

>>>> [illegible]            [illegible]

>>>> LAMDA
      .[illegible]E+04   .[illegible]E+04   .20[illegible]E+04   .2000E+04   .20[illegible]E+04   .2000E+04   .2500E+04   .3000E+04   .35[illegible]E+04   .40[illegible]E+04
>>>> AMPLITUD   .744[illegible]E+02
>>>> V[illegible]   .5[illegible]E+03
>>>> DURATION   .1[illegible]E+03
>>>> V[illegible]   .54[illegible]E-05

>>>> QUALITY[illegible]   .4[illegible]E+01
>>>> STREV[illegible]   .27[illegible]E+00
     PSIFAIL   .25[illegible]E+01
     TOLERNCE   .50[illegible]E+02
```

LABORATORY DATA -- CREEP COMPLIANCES

LAYER 1

TIME	VALUE	VARIATION
.100E-02	.370[illegible]	.270[illegible]E+00
.3[illegible]E-02	.520[illegible]	.270[illegible]E+00
.100[illegible]E-01	.860[illegible]	.270[illegible]E+00
.3[illegible]E-01	.145[illegible]	.270[illegible]E+00
.1[illegible]E+00	.250[illegible]	.270[illegible]E+00
[illegible]	.40[illegible]	.270[illegible]
.1[illegible]E+01	.620[illegible]	.270[illegible]
[illegible]E+01	.86[illegible]	.270[illegible]E+00
[illegible]	.12[illegible]	.270[illegible]E+00
[illegible]	.16[illegible]	.270[illegible]E+00
.1[illegible]	.130[illegible]	.27[illegible]E+0[illegible]

FITTED DATA DELTA G[illegible]

[illegible]	-.[illegible]
[illegible]	.1[illegible]
[illegible]1	-.[illegible]
.1[illegible]E+01	-.77[illegible]
.1[illegible]	-.[illegible]
[illegible]E-01	-.[illegible]
[illegible]	.1[illegible]

LAYER 2

TIME	VALUE	VARIATION
.1[illegible]	.17[illegible]	[illegible]
[illegible]	.17[illegible]	[illegible]
.1[illegible]	.17[illegible]	[illegible]
[illegible]	.17[illegible]	[illegible]
.1[illegible]	.17[illegible]	[illegible]
.3[illegible]	.17[illegible]	[illegible]
.1[illegible]	.17[illegible]	.2[illegible]
[illegible]	.17[illegible]	.20[illegible]
.1[illegible]	.17[illegible]	.2[illegible]
[illegible]	.17[illegible]	[illegible]
.1[illegible]	.17[illegible]	.200[illegible]

FITTED DATA DELTA G[illegible]

.1[illegible]	0.
[illegible]	0.
[illegible]	0.
.1[illegible]	0.
.1[illegible]	0.
[illegible]	0.
0.	.17[illegible]

LAYER 3

TIME	VALUE	VARIATION
.1[illegible]E-02	.22[illegible]E-04	.325[illegible]E+00
.3[illegible]E-02	.220[illegible]E-04	.325[illegible]E+00
.10[illegible]E-01	.22[illegible]E-04	.325[illegible]
.3[illegible]E-01	.220[illegible]	.325[illegible]
.1[illegible]E+00	.22[illegible]	.325[illegible]
.3[illegible]E+00	.22[illegible]	.325[illegible]
.1[illegible]E+01	.22[illegible]E-04	.3250[illegible]E+00
.3[illegible]E+01	.22[illegible]E-04	.325[illegible]E+00
.1[illegible]E+02	.22[illegible]E-04	.325[illegible]E+00
.3[illegible]E+02	.220[illegible]E-04	.325[illegible]E+00
.1[illegible]E+03	.22[illegible]E-04	.325[illegible]

FITTED DATA DELTA G[illegible]

.1[illegible]	0.
[illegible]	0.
[illegible]	0.
.1[illegible]E+01	0.
.1[illegible]	0.
[illegible]E-01	0.
0.	.2[illegible]E-04

•••••••••••••••••••• DESIGN EXAMPLE 12-31-7[illegible] ••••••••••••••••••••••••

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 12[illegible].60
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) [illegible].4[illegible]

LAYER 1 - MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) [illegible].00
LAYER 2 - MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) [illegible].00
LAYER 3 - MODULUS [illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1.[illegible]E+02 SECONDS

PROBABLISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS [illegible].
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible].
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible].

		STRESSES								
		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
[illegible]	[illegible]	-.1[illegible]E+[illegible]	.19[illegible]E-14	-.779[illegible]E+[illegible]1	[illegible]	-.3[illegible]E+[illegible]1	.23[illegible]E-0[illegible]	0.	0.	SL[illegible]
[illegible]	6.00	-.17[illegible]E+[illegible]	.[illegible]4[illegible]E-01	-.[illegible]9[illegible]E-01	.[illegible]7[illegible]E-01	-.[illegible]94[illegible]E-01	.43[illegible]E-0[illegible]	0.	0.	SL[illegible]
[illegible]	[illegible]	-.3[illegible]E+[illegible]	.[illegible]E-15	-.71[illegible]E+01	[illegible]	-.[illegible]E+[illegible]1	.276E+00	.[illegible]23E-14	.11[illegible]E-14	SL[illegible]
[illegible]	[illegible]	-.1[illegible]E+[illegible]	.17[illegible]E-01	-.[illegible]39[illegible]E-01	.14[illegible]E-01	-.5[illegible]E-01	.1541-01	-.218E-[illegible]1	.5[illegible]7E-[illegible]2	

•••••••••••••••••••• DESIGN EXAMPLE 12-31-7[illegible] ••••••••••••••••••••••••

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
[illegible]	[illegible]	.[illegible]12E-[illegible]	.13[illegible]E-[illegible]	0.	0.	-.[illegible]E-0[illegible]	.124E-0[illegible]	-.[illegible]E-[illegible]6	.7[illegible]E-[illegible]7
[illegible]	[illegible]	.[illegible]E-[illegible]	.13[illegible]E-[illegible]	0.	0.	.[illegible]E-[illegible]	.427E-0[illegible]	.[illegible]E-[illegible]6	.2[illegible]E-[illegible]6
[illegible]	[illegible]	.[illegible]E-[illegible]	.1[illegible]E-0[illegible]	-.[illegible]E-[illegible]	.0[illegible]E-[illegible]	-.[illegible]E-[illegible]	.537E-07	-.[illegible]E-[illegible]6	.[illegible]E-[illegible]7
[illegible]	[illegible]	.[illegible]E-[illegible]	.1[illegible]E-[illegible]	.[illegible]1[illegible]E-[illegible]	.[illegible]E-[illegible]	.[illegible]E-[illegible]	.6[illegible]E-07	.[illegible]E-[illegible]6	.1[illegible]E-[illegible]6

******************** DESIGN EXAMPLE 12-71-75 ***********************

PROBLEM PARAMETERS

TOTAL LOAD (LBS) [illegible].00
TIRE PRESSURE (PSI) 1[illegible]
LOAD RADIUS (IN) 6.4

LAYER 1 - MODULUS 1057412., POISSON'S RATIO .[illegible] THICKNESS (IN) 6.00
LAYER 2 - MODULUS [illegible], POISSON'S RATIO .[illegible] THICKNESS (IN) [illegible]
LAYER 3 - MODULUS [illegible], POISSON'S RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .[illegible]-02 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]

		STRESSES								
		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+01	.255E-14	-.342E+01	.224E+[illegible]	-.342E+01	.271E-02	0.	0.	SLOW
[illegible]	6.00	-.1[illegible]E+[illegible]	.284E-01	-.673E-01	.319E-01	-.672E-01	.550E-03	0.	0.	SLOW
6.00	0.00	-.975E+00	.128E-14	-.286E+01	.216E+00	-.266E+01	.258E+00	.690E-14	.793E-15	SLOW
6.00	6.00	-.124E+00	.198E-01	-.564E-01	.113E-01	-.663E-01	.170E-01	-.221E-01	.793E-02	

******************** DESIGN EXAMPLE 12-71-75 ***********************

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.673E-04	.143E-04	0.	0.	-.616E-06	.159E-06	-.618E-06	.946E-07
0.00	6.00	.662E-04	.143E-04	0.	0.	.790E-06	.483E-06	.799E-06	.216E-06
6.00	0.00	.617E-04	.136E-04	-.317E-05	.583E-06	-.369E-06	.415E-07	-.529E-06	.495E-07
6.00	6.00	.617E-04	.137E-04	.795E-05	.752E-06	.416E-06	.726E-07	.658E-06	.128E-06

DESIGN EXAMPLE 12-31-[illegible]

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 1[illegible].6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) [illegible].4[illegible]

LAYER 1 - MODULUS 1144[illegible]0. POISSON'S RATIO .500 THICKNESS (IN) 6.00
LAYER 2 - MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) [illegible].00
LAYER 3 - MODULUS [illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1[illegible]-01 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	[illegible]	-.1[illegible]E+[illegible]1	.15[illegible]E-14	-.[illegible]E+01	.272E+[illegible]	-.[illegible]E+01	.347E-02	0.	0.	[illegible]
[illegible]	6.00	-.216E+[illegible]	.[illegible]E-01	-.917E-01	.[illegible]E-01	-.817E-01	.7[illegible]E-03	0.	0.	[illegible]
6.[illegible]	[illegible]	-.[illegible]E+[illegible]	.49[illegible]E-15	-.246E+01	.240E+[illegible]	-.227E+01	.228E+00	.413[illegible]-14	.37[illegible]E-15	[illegible]
6.[illegible]	6.00	-.1[illegible]E+[illegible]	.[illegible]E-01	-.[illegible]E-01	.1[illegible]E-01	-.811[illegible]-01	.195E-01	-.423[illegible]-01	.977E-[illegible]	

DESIGN EXAMPLE 1[illegible]-[illegible]1-7[illegible]

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.[illegible]	[illegible].00	.7[illegible]E-[illegible]4	.16[illegible]E-04	0.	0.	-.[illegible]E-06	.240E-06	-.[illegible]E-06	.144E-[illegible]
0.0[illegible]	[illegible]	.7[illegible]E-[illegible]4	.161E-04	0.	0.	.114E-0[illegible]	.5[illegible]E-06	.114E-[illegible]5	.[illegible]E-[illegible]
6.00	[illegible].00	.7[illegible]E-[illegible]4	.15[illegible]E-04	-.431E-05	.72[illegible]E-0[illegible]	-.47[illegible]E-06	.5[illegible]E-07	-.719E-[illegible]6	.659E-[illegible]7
6.[illegible]	[illegible]	.6[illegible]E-[illegible]4	.15[illegible]E-04	.56[illegible]E-0[illegible]	.994E-[illegible]	.53[illegible]E-[illegible]	.831E-07	.934E-[illegible]	.1[illegible]E-[illegible]

******************** DESIGN EXAMPLE 12-?1-7?

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 1??.??
TIRE PRESSURE (PSI) 1.??
LOAD RADIUS (IN) ?.4?

LAYER 1 = MODULUS ???????. POISSON'S RATIO .?00 THICKNESS (IN) 6.00
LAYER 2 = MODULUS ?????. POISSON'S RATIO .??0 THICKNESS (IN) ?.??
LAYER 3 = MODULUS ?????. POISSON'S RATIO .??0 SEMI-INFINITE THICKNESS

TIME = .3???? -01 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS ??.?
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS ??.?
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS ??.?

S T R E S S E S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
0.00	0.00	-.1??E+ 1	.165E-14	-.255E+ 1	.2??E+??	-.2??E+01	.424E-02	0.	0.	SLOW
0.00	6.00	-.2??E+ ?	.4??E-01	-.953E-01	.4??E-01	-.9??E-01	.104E-02	0.	0.	SLOW
6.00	0.00	-.9??E+ 0	.376E-15	-.211E+01	.211E+00	-.135E+01	.197E+00	.417E-14	.524E-15	SLOW
6.00	6.00	-.1??E+??	.247E-01	-.726E-01	.2?0E-01	-.959E-01	.212E-01	-.604E-01	.126E-01	SLOW

******************** DESIGN EXAMPLE 12-?1-7?

R	Z	DISPLACEMENTS VERTICAL MEAN	DISPLACEMENTS VERTICAL DEVIATION	DISPLACEMENTS RADIAL MEAN	DISPLACEMENTS RADIAL DEVIATION	STRAINS RADIAL MEAN	STRAINS RADIAL DEVIATION	STRAINS TANGENTIAL MEAN	STRAINS TANGENTIAL DEVIATION
0.00	0.00	.9??E-??	.17?E-?4	0.	0.	-.111E-05	.342E-06	-.111E-05	.219E-06
0.00	6.00	.876E-?4	.17?E-04	0.	0.	.1?7E-??	.671E-06	.157E-05	.4??E-?6
6.00	0.00	.797E-?4	.164E-04	-.551E-05	.326E-??	-.577E-0?	.795E-07	[illegible]	.846E-?7
6.00	6.00	.771E-?4	.16?E-04	.756E-05	.123E-05	.6??E-??	.855E-07	.126E-05	.203E-06

DESIGN EXAMPLE 12-21-7[illegible]

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 12[illegible].[illegible]
TIRE PRESSURE (PSI) 1[illegible]
LOAD RADIUS (IN) [illegible].4

LAYER 1 = MODULUS 4[illegible]. POISSON'S RATIO .[illegible]0 THICKNESS (IN) 6.00
LAYER 2 = MODULUS [illegible]. POISSON'S RATIO .[illegible]0 THICKNESS (IN) 8.00
LAYER 3 = MODULUS [illegible]. POISSON'S RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .1[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]

STRESSES

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
[illegible]	[illegible]	-.1[illegible]E+[illegible]1	.19[illegible]E-14	-.212[illegible]+01	.[illegible]E+[illegible]	-.212[illegible]+[illegible]1	.50[illegible]E-02	0.	0.	SLOW
[illegible]	[illegible]	-.[illegible]E+[illegible]	.[illegible]E-01	-.1[illegible]	.[illegible]E-[illegible]	-.1[illegible]	.13[illegible]E-0[illegible]	0.	[illegible]	SLOW
[illegible]	[illegible]	-.[illegible]E+[illegible]	.27[illegible]E-1[illegible]	-.177[illegible]+[illegible]1	.177E+[illegible]	-.1[illegible]E+[illegible]1	.161E+00	.[illegible]1E-14	.121[illegible]-14	SLOW
6.00	6.[illegible]	-.242E+[illegible]	.25[illegible]E-01	-.778[illegible]-01	.2[illegible]E-[illegible]1	-.113[illegible]	.214E-01	-.[illegible]58E-01	.157E-[illegible]1	SLOW

DESIGN EXAMPLE 12-21-7[illegible]

DISPLACEMENTS / STRAINS

R	Z	VERTICAL DISPLACEMENT MEAN	VERTICAL DISPLACEMENT DEVIATION	RADIAL DISPLACEMENT MEAN	RADIAL DISPLACEMENT DEVIATION	RADIAL STRAIN MEAN	RADIAL STRAIN DEVIATION	TANGENTIAL STRAIN MEAN	TANGENTIAL STRAIN DEVIATION
[illegible]	[illegible]	.1[illegible]E-[illegible]	.19[illegible]E-[illegible]	[illegible]	0.	-.139E-[illegible]	.4[illegible]E-0[illegible]	-.139E-[illegible]	.3[illegible]
[illegible]	[illegible]	.[illegible]E-[illegible]	.1[illegible]E-14	[illegible]	0.	.21[illegible]E-[illegible]	.737E-06	.216E-05	.41[illegible]-[illegible]6
[illegible]	[illegible]	.[illegible]1E-[illegible]	.17[illegible]E-[illegible]	-.[illegible]	.[illegible]	-.[illegible]	.111E-0[illegible]	-.113E-[illegible]	.115E-[illegible]
[illegible]	[illegible]	.[illegible]3E-[illegible]	.1[illegible]E-[illegible]	.1[illegible]E-[illegible]	.145E-[illegible]	.[illegible]E-[illegible]	.7[illegible]E-07	.16[illegible]E-05	.2[illegible]

DESIGN EXAMPLE 12-[illegible]-7[illegible]

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 1[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.[illegible]

LAYER 1 = MODULUS [illegible]A7G[illegible]A. POISSON'S RATIO .[illegible] THICKNESS (IN) 6.[illegible]
LAYER 2 = MODULUS [illegible]. POISSON'S RATIO .[illegible] THICKNESS (IN) [illegible]
LAYER 3 = MODULUS 4 [illegible]. POISSON'S RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .5 [illegible] SECONDS

[illegible] PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible].
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible].

S T R E S S E S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
[illegible]	[illegible]	-.1[illegible]E+[illegible]	.[illegible]E-14	-.179E+[illegible]	.1[illegible]E+[illegible]	-.17[illegible]E+[illegible]	.5[illegible]E-02	0.	0.	SLOW
[illegible]	[illegible]	-.444E+[illegible]	.[illegible]E-01	-.12[illegible]E+0[illegible]	.4[illegible]E-[illegible]	-.1[illegible]	.1[illegible]E-0[illegible]	0.	0.	SLOW
6.[illegible]	[illegible]	-.[illegible]E+[illegible]	.[illegible]E-15	-.15[illegible]E+[illegible]	.1[illegible]E+[illegible]	-.143E+[illegible]	.12[illegible]E+0[illegible]	.179E-14	.17[illegible]E-15	SLOW
6.[illegible]	5.[illegible]	-.[illegible]E+[illegible]	.21[illegible]E-01	-.792E-01	.1[illegible]E-[illegible]	-.127E+[illegible]	.154E-01	-.112E+00	.162E-01	SLOW

DESIGN EXAMPLE 12-[illegible]-7[illegible]

D I S P L A C E M E N T S / S T R A I N S

R	Z	VERTICAL DISPLACEMENT MEAN	VERTICAL DISPLACEMENT DEVIATION	RADIAL DISPLACEMENT MEAN	RADIAL DISPLACEMENT DEVIATION	RADIAL STRAIN MEAN	RADIAL STRAIN DEVIATION	TANGENTIAL STRAIN MEAN	TANGENTIAL STRAIN DEVIATION
[illegible]	[illegible]	.1[illegible]E-[illegible]	.[illegible]E-[illegible]	0.	0.	-.157E-[illegible]	.6[illegible]E-06	-.157E-05	.541E-[illegible]
[illegible]	[illegible]	.11[illegible]E-[illegible]	.[illegible]E-04	0.	0.	.2[illegible]E-0[illegible]	.751E-06	.275E-05	.375E-[illegible]
6.[illegible]	[illegible]	.[illegible]E-[illegible]	.1[illegible]E-04	-.746E-0[illegible]	.[illegible]E-0[illegible]	-.[illegible]E-0[illegible]	.14[illegible]E-06	-.124E-05	.1[illegible]E-[illegible]
6.[illegible]	6.[illegible]	.[illegible]E-[illegible]	.18[illegible]E-04	.127E-04	.1[illegible]E-0[illegible]	.9[illegible]E-0[illegible]	.537E-07	.212E-05	.249E-[illegible]

DESIGN EXAMPLE 12-31-75

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 128.[illegible]
TIRE PRESSURE (PSI) 1[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 = MODULUS [illegible]. POISSONS RATIO .[illegible] THICKNESS (IN) 6.00
LAYER 2 = MODULUS [illegible]. POISSONS RATIO .[illegible] THICKNESS (IN) 8.00
LAYER 3 = MODULUS 45[illegible]5. POISSONS RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .1[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]

STRESSES

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.[illegible]	-.1[illegible]	.212E-1[illegible]	-.151[illegible]	.1[illegible]	-.1[illegible]	.[illegible]E-02	0.	0.	SLOW
0.00	6.00	-.[illegible]	.[illegible]E-01	-.127[illegible]	.[illegible]E-01	-.127[illegible]	.11[illegible]E-02	0.	0.	SLOW
[illegible]	0.00	-.[illegible]	.612E-1[illegible]	-.1[illegible]	.120[illegible]	-.127[illegible]	.102E+0[illegible]	.33[illegible]E-14	.161[illegible]E-1[illegible]	SLOW
[illegible]	6.00	-.[illegible]	.1[illegible]E-01	-.77[illegible]E-01	.1[illegible]E-01	-.1[illegible]	.12[illegible]E-01	-.1[illegible]	.167[illegible]	SLOW

DESIGN EXAMPLE 12-31-75

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.[illegible]	.13[illegible]	.[illegible]	0.	0.	-.1[illegible]	.7[illegible]E-0[illegible]	-.157[illegible]	.77[illegible]
0.[illegible]	[illegible]	.1[illegible]	.[illegible]E-04	0.	0.	.3[illegible]	.62[illegible]	.37[illegible]E-05	.1[illegible]
[illegible]	0.00	.1[illegible]	.1[illegible]E-04	-.77[illegible]	.1[illegible]	-.6[illegible]	.1[illegible]E-06	-.12[illegible]E-05	.[illegible]
[illegible]	[illegible]	.[illegible]	.1[illegible]E-04	.151[illegible]E-04	.1[illegible]	.9[illegible]	.31[illegible]E-07	.251[illegible]E-05	.2[illegible]E-06

******************** DESIGN EXAMPLE 12-31-7[illegible] ***********************

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 1[illegible].6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) [illegible].[illegible]

LAYER 1 - MODULUS 11[illegible]15. POISSONS RATIO .[illegible] THICKNESS (IN) 6.00
LAYER 2 - MODULUS [illegible]. POISSONS RATIO .[illegible] THICKNESS (IN) 8.00
LAYER 3 - MODULUS [illegible]. POISSONS RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS [illegible]7.
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible].
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible].

S T R E S S E S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
0.00	0.00	-.1[illegible]E+0[illegible]	.150E-14	-.133E+01	.146E+0[illegible]	-.1[illegible]E+01	.540[illegible]E-02	0.	0.	[illegible]
[illegible]	6.00	-.572E+[illegible]	.43[illegible]E-01	-.131E+0[illegible]	.2[illegible]E-01	-.121[illegible]	.110E-02	0.	0.	[illegible]
[illegible]	[illegible]	-.[illegible]E+[illegible]	.991E-15	-.121E+01	.893E-[illegible]1	-.117E+01	.827E-01	.273E-14	.161E-15	[illegible]
[illegible]	6.00	-.[illegible]E+[illegible]	.17[illegible]E-01	-.75[illegible]E-01	.72[illegible]E-0[illegible]	-.14[illegible]	.973E-02	-.1[illegible]E+00	.1[illegible]E-01	[illegible]

******************** DESIGN EXAMPLE 12-31-7[illegible] ***********************

D I S P L A C E M E N T S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION
[illegible]	[illegible]	.14[illegible]E-0[illegible]	.03[illegible]E-0[illegible]	0.	0.
[illegible]	[illegible]	.1[illegible]E-[illegible]	.01[illegible]E-0[illegible]	0.	0.
6.[illegible]	[illegible]	.117E-[illegible]3	.197E-04	-.[illegible]5E-05	.1[illegible]E-[illegible]
[illegible]	6.00	.1[illegible]E-[illegible]3	.20[illegible]E-04	.169E-04	.164E-0[illegible]

S T R A I N S

R	Z	RADIAL MEAN	RADIAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION
[illegible]	[illegible]	-.14[illegible]E-0[illegible]	.812E-0[illegible]	-.14[illegible]E-05	.1[illegible]2E-[illegible]
[illegible]	[illegible]	.37[illegible]E-0[illegible]	.579E-06	.375E-05	.1[illegible]E-0[illegible]
6.[illegible]	[illegible]	-.54[illegible]E-0[illegible]	.217E-06	-.1[illegible]E-05	.335E-0[illegible]
[illegible]	6.00	.[illegible]5E-06	.233E-07	.282E-05	.239E-0[illegible]

******************** DESIGN EXAMPLE 12-11-7[illegible] ************************

PROBLEM PARAMETERS

TOTAL LOAD (LBS) [illegible]
TIRE PRESSURE (PSI) [illegible]
LOAD RADIUS (IN) [illegible]

LAYER 1 = MODULUS [illegible]. POISSONS RATIO .[illegible] THICKNESS (IN) [illegible]
LAYER 2 = MODULUS [illegible]. POISSONS RATIO .[illegible] THICKNESS (IN) [illegible]
LAYER 3 = MODULUS [illegible]. POISSONS RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .1[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS [illegible]7.
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible].
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible].

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+[illegible]	.[illegible]E-15	-.117E+01	.124E+01	-.117E+01	.5[illegible]E-02	0.	0.	SLOW
0.00	6.00	-.622E+[illegible]	.4[illegible]E-01	-.133E+0[illegible]	.222E-01	-.133E+0[illegible]	.1[illegible]E-02	0.	0.	SLOW
6.00	0.00	-.[illegible]E+[illegible]	.[illegible]E-15	-.111E+01	.[illegible]E-01	-.1[illegible]E+01	.657E-01	.418E-14	.132E-15	SLOW
6.00	6.00	-.355E+[illegible]	.152E-01	-.713E-01	.515E-02	-.157E+0[illegible]	.641E-02	-.178E+00	.162E-01	SLOW

******************** DESIGN EXAMPLE 12-11-7[illegible] ************************

		D I S P L A C E M E N T S				S T R A I N S			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.1[illegible]E-[illegible]	.258E-[illegible]	0.	0.	-.1[illegible]E-05	.8[illegible]E-0[illegible]	-.100E-05	.1[illegible]E-0[illegible]
0.00	6.00	.1[illegible]E-[illegible]	.21[illegible]E-[illegible]	0.	0.	.417E-0[illegible]	.51[illegible]E-06	.417E-05	.[illegible]E-07
6.00	0.00	.121E-[illegible]	.201E-[illegible]	-.674E-0[illegible]	.[illegible]E-0[illegible]	-.[illegible]E-0[illegible]	.256E-06	-.705E-06	.45[illegible]E-06
6.00	6.00	.1[illegible]E-[illegible]	.204E-[illegible]	.186E-[illegible]	.164E-0[illegible]	.1[illegible]E-0[illegible]	.390E-07	.311E-05	.22[illegible]E-06

•••••••••••••••••••••• DESIGN EXAMPLE   12-31-7[illegible]   ••••••••••••••••••••••

PROBLEM PARAMETERS

TOTAL LOAD (LBS)	1[illegible].6[illegible]
TIRE PRESSURE (PSI)	1.[illegible]
LOAD RADIUS (IN)	[illegible].4[illegible]

LAYER 1 - MODULUS [illegible]2475. POISSON'S RATIO .500 THICKNESS (IN) 6.00
LAYER 2 - MODULUS [illegible]. POISSON'S RATIO .5[illegible] THICKNESS (IN) 8.00
LAYER 3 - MODULUS [illegible]. POISSON'S RATIO .5[illegible] SEMI-INFINITE THICKNESS

TIME = .3[illegible]+02 SECONDS

PROBABLISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]

S T R E S S E S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
0.00	0.00	-.1[illegible]E+01	.[illegible]E-15	-.105[illegible]E+01	.1[illegible]E+00	-.1[illegible]E+01	.461[illegible]E-0[illegible]	0.	0.	SLOW
0.00	6.00	-.[illegible]E+[illegible]	.55[illegible]E-01	-.134[illegible]E+[illegible]	.1[illegible]E-[illegible]1	-.17[illegible]E+[illegible]	.[illegible]E-0[illegible]	0.	0.	SLOW
6.00	0.00	-.9[illegible]E+[illegible]	.[illegible]E-15	-.1[illegible]E+[illegible]1	.[illegible]6E-01	-.1[illegible]E+01	.5[illegible]E-01	.[illegible]E-14	.1[illegible]E-15	SLOW
6.00	6.00	-.[illegible]E+[illegible]	.13[illegible]E-01	-.[illegible]75[illegible]E-01	.372E-[illegible]	-.1[illegible]	.4[illegible]E-02	-.19[illegible]E+00	.1[illegible]E-01	SLOW

•••••••••••••••••••••• DESIGN EXAMPLE   12-31-7[illegible]   ••••••••••••••••••••••

		D I S P L A C E M E N T S				S T R A I N S			
R	Z	VERTICAL MEAN	VERTICAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION
0.00	0.00	.175E-[illegible]	.[illegible]7[illegible]E-[illegible]4	0.	0.	-.4[illegible]E-0[illegible]	.83[illegible]E-06	-.4[illegible]3[illegible]E-[illegible]6	.1[illegible]E-[illegible]
0.00	6.00	.17[illegible]E-[illegible]	.[illegible]1[illegible]E-[illegible]4	0.	0.	.4[illegible]E-0[illegible]	.45[illegible]E-0[illegible]	.45[illegible]E-[illegible]5	.45[illegible]E-17
6.00	0.00	.1[illegible]E-[illegible]	.[illegible]E-[illegible]4	-.[illegible]33[illegible]E-[illegible]	.3[illegible]6E-[illegible]	-.2[illegible]E-[illegible]	.2[illegible]6[illegible]E-06	-.[illegible]E-[illegible]6	.5[illegible]7[illegible]E-[illegible]
6.00	6.00	.1[illegible]E-[illegible]	.[illegible]7[illegible]E-[illegible]4	.20[illegible]E-[illegible]4	.1[illegible]2E-[illegible]	.1[illegible]2E-[illegible]5	.574[illegible]E-[illegible]7	.334[illegible]E-05	.214E-[illegible]6

********************** DESIGN EXAMPLE 12-71-7[illegible]

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 1[illegible].6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) [illegible].4[illegible]

LAYER 1 = MODULUS [illegible]5[illegible]7. POISSON'S RATIO .[illegible] THICKNESS (IN) 6.00
LAYER 2 = MODULUS [illegible]. POISSON'S RATIO .[illegible] THICKNESS (IN) [illegible].00
LAYER 3 = MODULUS [illegible]. POISSON'S RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .1[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 12.[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+ 1	.[illegible]E-14	-.[illegible]E+0[illegible]	.[illegible]7E-01	-.[illegible]E+[illegible]	.4[illegible]E-02	0.	0.	SLO[illegible]
0.00	6.00	-.[illegible]E+[illegible]	.[illegible]E-01	-.[illegible]E+0[illegible]	.167E-01	-.[illegible]E+[illegible]	.844E-03	0.	0.	SLO[illegible]
6.00	0.00	-.[illegible]E+0[illegible]	.737E-15	-.190E+ 1	.[illegible]E-01	-.101E+01	.469E-01	.424E-14	.157E-15	SLO[illegible]
6.00	6.00	-.[illegible]E+[illegible]	.11[illegible]E-01	-.[illegible]E-01	.[illegible]E-02	-.1[illegible]E+[illegible]	.40[illegible]E-02	-.[illegible]E+00	.142E-01	SLO[illegible]

********************** DESIGN EXAMPLE 12-71-7[illegible]

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.1[illegible]E- [illegible]	.[illegible]E-04	0.	0.	.4[illegible]E-[illegible]	.[illegible]E-06	.438E-17	.17[illegible]E-15
0.00	6.00	.137E- [illegible]	.[illegible]E-04	0.	0.	.4[illegible]E-[illegible]	.416E-06	.467E-05	.[illegible]E-07
6.00	0.00	.124E- [illegible]	.2[illegible]E-04	-.[illegible]32E-07	.4[illegible]E-[illegible]	-.1[illegible]E-[illegible]	.320E-06	-.135E-07	.6[illegible]E-[illegible]6
6.00	6.00	.1[illegible]E-[illegible]	.[illegible]E-0[illegible]	-.[illegible]E-0[illegible]	.1[illegible]E-[illegible]	-.1[illegible]E-[illegible]	.685E-07	.[illegible]5E-05	.2[illegible]E-[illegible]6

**** CURVE-FITTED SYSTEM RESPONSES

DETERMINATIVE FACTOR FOR CRACKING IS RADIAL STRAIN AT 6.00 IN.

FITTED DATA	DELTA	STD
	.1[illegible]E+03	-.2[illegible]E-[illegible]
	[illegible]E+02	-.[illegible]E-[illegible]
	[illegible]E+01	-.2[illegible]E-[illegible]
	.1[illegible]E+01	-.[illegible]E-[illegible]
	.1[illegible]E+[illegible]	-.[illegible]391E-07
	.[illegible]00E-01	.[illegible]35[illegible]E-0[illegible]
	0.	.1[illegible]E-[illegible]

DETERMINING FACTOR FOR RUTTING IS VERTICAL DISPLACEMENT AT 9.00 IN.

FITTED DATA	DELTA	STD
	.1[illegible]E+03	-.2[illegible]E-04
	[illegible]E+02	-.14[illegible]E-0[illegible]
	[illegible]0E+01	-.2[illegible]E-04
	.1[illegible]E+01	-.2[illegible]E-04
	.1[illegible]E+[illegible]	-.[illegible]357[illegible]E-04
	.[illegible]E-01	-.1[illegible]E-04
	0.	.1[illegible]00E-0[illegible]

PERMANENT DEFORMATION
SYSTEM RESPONSE FACTORS
GNU = .[illegible]E+0[illegible]
ALPHA = .[illegible]E+0[illegible]

F A T I G U E   C R A C K I N G

[illegible] STRAIN RESPONSE
DUE TO PEAK LOADING (HAVERSINE)

TEMPERATURE DEGREES-F	STRAIN INS./IN.	VAR STRAIN (INS./IN.)**2	NFAIL CYCLES	VAR NFAIL CYCLES**2	K1 CYCLES	K2 DIMENSIONLESS	GAMMA DIMENSIONLESS
49.7[illegible]	.[illegible]E-04	.773[illegible]E-10	.1[illegible]72E+[illegible]	.[illegible]E+1[illegible]	.[illegible]E-04	.26[illegible]E+01	.[illegible]
53.[illegible]	.[illegible]E-04	.[illegible]E-1[illegible]	.1[illegible]E+[illegible]	.6414[illegible]E+16	.7[illegible]E-04	.2[illegible]E+01	.1[illegible]E-1
[illegible]	.[illegible]E-04	.1[illegible]E-[illegible]	.2[illegible]	.1[illegible]E+17	.1[illegible]E-0[illegible]	.[illegible]E+01	.[illegible]E-1
[illegible]	.[illegible]E-04	.2[illegible]E-[illegible]	.[illegible]E+[illegible]	.1[illegible]E+17	.7[illegible]E-0[illegible]	.2[illegible]E+01	.[illegible]E+0[illegible]
7[illegible]	.[illegible]E-04	.[illegible]E-09	.3[illegible]E+[illegible]	.[illegible]E+17	.24[illegible]E-0[illegible]	.2[illegible]E+01	.3[illegible]E+1
[illegible]	.[illegible]E-04	.[illegible]E-09	.[illegible]E+[illegible]	.21[illegible]E+18	.12[illegible]E-01	.261[illegible]E+01	.2[illegible]E+[illegible]2
[illegible]	.71[illegible]E-04	.7[illegible]E-[illegible]	.17[illegible]72E+1[illegible]	.7[illegible]E+18	.2[illegible]40[illegible]E-01	.26[illegible]E+01	.44[illegible]E+2
[illegible]	.71[illegible]E-04	.7[illegible]E-[illegible]	.181[illegible]E+1[illegible]	.79476E+18	.29300E-01	.26[illegible]E+01	.4[illegible]E+2
[illegible]	.[illegible]E-04	.5[illegible]E-[illegible]	.[illegible]41[illegible]7F+[illegible]	.7[illegible]E+17	.[illegible]E-0[illegible]	.[illegible]E+01	.1[illegible]E+2
[illegible]	.[illegible]E-04	.3[illegible]E-[illegible]	.245[illegible]E+[illegible]	.1444[illegible]E+17	.[illegible]320[illegible]E-0[illegible]	.264[illegible]E+01	.1[illegible]E+01
[illegible]	.[illegible]E-04	.777[illegible]E-11	.2[illegible]72E+[illegible]	.13[illegible]E+17	.151[illegible]E-03	.267[illegible]E+01	.[illegible]E-1
[illegible]	.[illegible]E-0[illegible]	.7[illegible]74E-1[illegible]	.16[illegible]E+[illegible]	.[illegible]65[illegible]E+16	.65700E-04	.26[illegible]E+01	.[illegible]9977[illegible]E-0[illegible]

DAMAGE INDEX DIMENSIONLESS	VAR DAMAGE INDEX DIMENSIONLESS	AREA CRACKED SQ.YDS/1000SQ.YDS	TIME YEARS
.[illegible]E-0[illegible]	.1[illegible]E-[illegible]	[illegible]	.[illegible]
.447[illegible]E-02	.1[illegible]E-[illegible]	[illegible]	1.[illegible]
.71[illegible]E-02	.[illegible]E-[illegible]	[illegible]	1.[illegible]
.[illegible]E-02	.[illegible]154[illegible]E-[illegible]	[illegible]	2.[illegible]
.1[illegible]41[illegible]E-01	.4732[illegible]E-[illegible]	[illegible]	[illegible]
.1[illegible]E-01	.[illegible]E-[illegible]	[illegible]	[illegible]
.4[illegible]E-01	.1[illegible]16[illegible]E-[illegible]	[illegible]	[illegible]
.[illegible]E-01	.[illegible]E-04	[illegible]	1[illegible]
.[illegible]E-01	.4[illegible]E-04	[illegible]	16.[illegible]
.1[illegible]41[illegible]E+[illegible]	.7[illegible]E-04	[illegible]	2[illegible]

R U T [illegible] E [illegible] T [illegible]

[illegible]
SYST[illegible] [illegible]F[illegible]CT[illegible]S
G[illegible] = .[illegible]3[illegible]
AL[illegible]A = .2420[illegible]

GENE[illegible]L [illegible]FFLECTI[illegible] [illegible]
[illegible] PEAK LOA[illegible] [illegible]STAT[illegible])

TEMP[illegible] [illegible]	[illegible]	VA[illegible] [illegible]
[illegible].7[illegible]	.44[illegible]E-0[illegible]	.[illegible]E-[illegible]
5[illegible].[illegible]	.44[illegible]E-02	.[illegible]E-[illegible]
[illegible]	.[illegible]71[illegible]E-[illegible]	.[illegible]E-[illegible]
[illegible]	.[illegible]E-02	.[illegible]7A1[illegible]E-[illegible]
7[illegible].[illegible]	.[illegible]E-02	.[illegible]E-[illegible]
[illegible]1.[illegible]	.[illegible]E-[illegible]	.1[illegible]7E-[illegible]4
[illegible].[illegible]	.[illegible]E-02	.14[illegible]7E-[illegible]4
[illegible]4.70	.[illegible]E-[illegible]	.14[illegible]E-[illegible]4
[illegible]	.[illegible]E-[illegible]	.11[illegible]E-[illegible]4
7[illegible].1[illegible]	.[illegible]E-[illegible]	.[illegible]E-[illegible]
[illegible].1[illegible]	.4[illegible]E-[illegible]	.[illegible]E-[illegible]
[illegible]	.[illegible]E-[illegible]	.[illegible]E-[illegible]

RUT [illegible] INC[illegible]	VAR RUT [illegible] [illegible]**2	TIME YEAR[illegible]
.[illegible]E-[illegible]1	.1[illegible]E-[illegible]2	.5[illegible]
.11[illegible]1[illegible]E+[illegible]	.17[illegible]E-[illegible]2	1.[illegible]
.11[illegible]E+[illegible]	.[illegible]1[illegible]E-[illegible]	1.[illegible]
.1[illegible]E+[illegible]	.[illegible]5[illegible]1E-[illegible]2	[illegible]
.14[illegible]1E+[illegible]	.[illegible]E-[illegible]2	[illegible]
.15[illegible]E+[illegible]	.[illegible]E-[illegible]2	4.[illegible]
.187[illegible]0E+[illegible]	.[illegible]2E-[illegible]2	[illegible].[illegible]
.21[illegible]1E+[illegible]	.[illegible]77E-[illegible]2	12.[illegible]
.2333[illegible]E+[illegible]	.[illegible]314E-[illegible]2	16.0[illegible]
.2516[illegible]E+[illegible]	.[illegible]376E-[illegible]2	20.0[illegible]

R [illegible] S S

SLOPE [illegible] [illegible]	VAR SLO[illegible] [illegible] ([illegible]*1[illegible])**2	TIME YEAR[illegible]
.[illegible]E+[illegible]	.[illegible]E-[illegible]1	.5[illegible]
.[illegible]1[illegible]E+[illegible]	.[illegible]111[illegible]E-[illegible]1	1.0[illegible]
.A[illegible]E+[illegible]	.[illegible]A1[illegible]E-[illegible]1	1.5[illegible]
.[illegible]1[illegible]E+[illegible]	.1[illegible]E+[illegible]	[illegible]
.5[illegible]E+[illegible]	.1[illegible]17[illegible]E+[illegible]	[illegible].0[illegible]
.7[illegible]E+[illegible]	.2[illegible]1[illegible]E+[illegible]	[illegible].[illegible]
.11[illegible]E+[illegible]1	.5[illegible]E+[illegible]	[illegible].0[illegible]
.1[illegible]4[illegible]E+[illegible]1	.7[illegible]E+[illegible]	1[illegible].[illegible]
.1[illegible]7[illegible]E+[illegible]1	.1[illegible]E+[illegible]1	1[illegible].[illegible]
.2[illegible]2[illegible]E+[illegible]1	.1[illegible]E+[illegible]1	[illegible].0[illegible]

PERFORMANCE

RUT DEPTH	VAR RUT DEPTH	SLOPE VAR	VAR SLOPE VAR	CRACKING	VAR CRACKING	TIME
[illegible]	[illegible]	[illegible]	.22[illegible]E-01	.27[illegible]E-02	.1[illegible]E-05	.50
.11[illegible]	.1[illegible]	[illegible]	[illegible]E-01	.44720[illegible]E-02	.15772E-05	1.00
.11[illegible]	[illegible]	.44[illegible]	[illegible]E-01	.71[illegible]E-02	.26[illegible]E-05	1.50
.13[illegible]	[illegible]	.54197E+01	.131[illegible]	.80458E-02	.31[illegible]E-05	2.00
.14[illegible]	[illegible]	[illegible]	[illegible]	.13419E-01	.47[illegible]E-05	3.00
.15[illegible]	[illegible]	.75[illegible]	.25[illegible]	.17892E-01	.63[illegible]E-05	4.00
.1[illegible]	[illegible]	.11255E+01	.56[illegible]	.40256E-01	.16[illegible]E-04	8.00
.21[illegible]	[illegible]	.14420E+01	[illegible]	.67194E-01	.3[illegible]E-04	12.00
[illegible]	[illegible]	.17776E+01	.13[illegible]	.98474E-01	.49[illegible]E-04	16.00
.25166E+00	[illegible]	.20220E+01	.18[illegible]	.13419E+00	.74[illegible]E-04	20.00

SERVICEABILITY	VARIANCE OF SERVICEABILITY	TIME
4.62727	.09[illegible]	.50
4.[illegible]	.10[illegible]	1.00
4.49[illegible]	.11[illegible]	1.50
4.43[illegible]	.12[illegible]1	2.00
[illegible]3	.13[illegible]	3.00
4.32945	.14[illegible]	4.00
4.17[illegible]1	.1[illegible]	8.00
[illegible]246	.19[illegible]	12.00
[illegible]307	.21164	16.00
[illegible]	.22[illegible]	20.00

SERVICEABILITY FAILURE LEVEL IS 2.5[illegible]

MARGINAL STATE PROBABILITIES

STATE UPPER BOUNDS = .1E+51 4.74889 4.46778 4.18667 3.90556 3.62444 3.34333 3.06222 2.78111 2.50000

STATE LOWER BOUNDS = 4.74889 4.46778 4.18667 3.90556 3.62444 3.34333 3.06222 2.78111 2.50000 -.1E+51

STATE1	STATE2	STATE3	STATE4	STATE5	STATE6	STATE7	STATE8	STATE9	STATE10	TIME	RELIABILITY
.56995	[illegible]	.10875	[illegible]	[illegible]	[illegible]	[illegible]	.00000	.00000	.00000	0.0	1.00000
.34615	.35197	[illegible]	.26644	[illegible]	[illegible]	[illegible]	.00000	[illegible]	.00000	.5	1.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00000	1.0	1.[illegible]
[illegible]	[illegible]	.28644	.142[illegible]	[illegible]	[illegible]	[illegible]	.00001	[illegible]	[illegible]	1.5	1.[illegible]
[illegible]	[illegible]	[illegible]	.172[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	1.[illegible]
.15771	[illegible]	.28717	[illegible]	[illegible]	.01741	.00012	.00015	[illegible]	[illegible]	3.0	1.[illegible]
.13[illegible]	.22749	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.0	1.[illegible]
[illegible]	[illegible]	.24[illegible]	[illegible]	.16727	.07[illegible]	[illegible]	[illegible]	.00077	.00003	8.0	[illegible]
[illegible]	.11593	.20746	[illegible]	[illegible]	.111[illegible]	[illegible]	.01[illegible]	.00173	.00021	12.0	[illegible]
[illegible]	[illegible]	.17426	.23535	[illegible]	.14[illegible]	[illegible]	[illegible]	.00463	.00079	16.0	.99921
[illegible]	[illegible]	.1472[illegible]	.21669	[illegible]	.16[illegible]	[illegible]	.03431	.00927	.00205	20.0	.99735

WARNING>> RELIABILITY EXCEEDS THE SPECIFIED TOLERANCE THROUGHOUT THE PERIOD OF THIS ANALYSIS. IF AN ACCURATE ESTIMATE OF SERVICE LIFE IS REQUIRED, THEN THIS RUN SHOULD BE RESUBMITTED WITH ADDITIONAL TRANSOM POINTS, EXTENDING THE ANALYSIS BEYOND THE TIME AT WHICH RELIABILITY DROPS BELOW THE MINIMUM ACCEPTABLE LEVEL.

VESYS G SAMPLE PROBLEM 2

PROGRAM TITLE 5 LAYER INPUT ☐ VERIFY

CHAR. SET 026 ☐ 029 ☐ OTHER ☐

NAME ______ CHARGE OR REFERENCE NUMBER ______ DATE ______

```
TITLE
DESIGN EXAMPLE      12-31-75
TYPE     1.
LOADING 1.          NSTATIC 1.          NLAYER  5.          NRPOINTS 3.
NZPOINTS 2.
THICK
3.0       3.0       4.0       4.0
POISSON
0.5       0.5       0.5       0.5       0.5
ZCRACK  6.0
```

REMAINING CARDS SAME AS IN 3 LAYER CASES

EXCEPT LAYER PROPERTIES ARE DUPLICATED,

AND THERE ARE 5 ALPHA'S AND GNU'S

```
F H [illegible] 4

P R [illegible] D I C T I V E   D E S I G N   P R O C E D U R E S

VESY[illegible]   : A PROBABILISTIC PREDICTIVE MODEL
                     FOR PAVEMENT DESIGN

LATEST REVISION:  2  APRIL 1977
                  [illegible]

[illegible] EXAMPLE      1[illegible]-31-7[illegible]

INPUT DATA VALUES FOR RUN        1

     >>>> TYPE                    1
          [illegible]

     >>>> LOADING       .1[illegible]E+01

          RADIUS        .[illegible]4[illegible]E+01

     >>>> [illegible]                 [illegible]

     >>>> ZCRACK        [illegible]E+01

     >>>> [illegible]
                           .[illegible]E+01

      >>> [illegible]                [illegible]

      >>> Z[illegible]
                           .[illegible]E+01

      >>> NLAYER

     >>>> T[illegible]
              .[illegible]E+01    .3[illegible]E+01    .4[illegible]E+01    .4[illegible]E+01

     >>>> POISSON
              .[illegible]E+[illegible]    .[illegible]E+[illegible]    .5[illegible]E+[illegible]    .5[illegible]E+0[illegible]    .5[illegible]E+[illegible]

     >>>> [illegible]STATIC          11

     >>>> TSTATIC
              .1[illegible]E-[illegible]    .3[illegible]E-[illegible]2    .1[illegible]E-[illegible]1    .3000E-01    .1000E+00    .3000E+00    .1000E+01    .3000E+01    .1000E+02    .3000E+02
              .1[illegible]E+[illegible]3

     >>>> LAYER1
              .[illegible]7[illegible]E-[illegible]    .52[illegible]E-[illegible]    .[illegible]E-06    .1[illegible]E-0[illegible]    .25[illegible]E-0[illegible]    .4000E-05    .6200E-05    .8600E-05    .1200E-04    .1600E-04
              .1[illegible]E-[illegible]4

          VARIATION
              .[illegible]E+[illegible]    .270[illegible]E+[illegible]    .27[illegible]E+0[illegible]    .270[illegible]E+0[illegible]    .2700E+0[illegible]    .2700E+00    .2700E+00    .2700E+00    .2700E+00    .27[illegible]E+[illegible]0
              .27[illegible]E+[illegible]

     >>>> LAYER[illegible]
              .[illegible]7[illegible]E-[illegible]6    .5200E-[illegible]6    .[illegible]E-06    .1450E-05    .25[illegible]E-0[illegible]    .4000E-05    .6200E-05    .8600E-05    .1200E-04    .1600E-04
              .1[illegible]E-[illegible]4

          [illegible]
```

```
      VARIATION
        .2700E+00   .2700E+00   .2700E+00   .2700E+00   .2700E+00   .2700E+00   .2700E+00   .2700E+00   .2700E+00   .2700E+00
        .2700E+00

>>>> LAYER3
        .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04
        .1700E-04

      VARIATION
        .2000E+00   .2001E+00   .2000E+00   .2000E+00   .2010E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00
        .2000E+00

>>>> LAYER4
        .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04   .1700E-04
        .1700E-04

      VARIATION
        .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00   .2000E+00
        .2000E+00

>>>> LAYER5
        .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04   .2200E-04
        .2200E-04

      VARIATION
        .3250E+00   .3250E+00   .3250E+00   .3250E+00   .3250E+00   .3250E+00   .3250E+00   .3250E+00   .3250E+00   .3250E+00
        .3250E+00

>>>> NDELTAS

>>>> DELTAS
        .1000E+03   .3000E+02   .8000E+01   .1000E+01   .1000E+00   .3000E-01  0.
```

```
>>>> STR[illegible]
      .269[illegible]E+01   .26[illegible]E+01   .2670E+01   .264[illegible]E+01   .26[illegible]E+01   .2610E+01   .26[illegible]0E+01   .2690E+01   .2620E+01   .264[illegible]E+01
      .267[illegible]E+01   .2690E+01

>>>> STR[illegible]COEF
      .[illegible]E-04   .7[illegible]E-04   .1550E-03   .7990E-03   .2490E-02   .1240E-01   .2840E-01   .2930E-01   .5680E-02   .932[illegible]E-03
      .151[illegible]E-03   .[illegible]E-04
>>>> [illegible]   .[illegible]E+[illegible]
>>>> [illegible]   .4[illegible]E-01
>>>> [illegible]   -.[illegible]E+[illegible]

>>>> [illegible]
      .31[illegible]E+00   .3120E+00   .55[illegible]0E-01   .5500E-01   .75[illegible]0E-02

>>>> [illegible]
      .756[illegible]E+00   .756[illegible]E+00   .73[illegible]E+00   .7300E+00   .850[illegible]E+[illegible]

>>>> [illegible]   .1[illegible]E+01
>>>> [illegible]   .[illegible]E-01

>>>> [illegible]   12

>>>> [illegible]
      .4[illegible]E+02   .5330E+02   .[illegible]E+02   .6860E+02   .[illegible]E+02   .8160E+02   .84[illegible]E+02   .[illegible]E+02   .7[illegible]E+02   .7[illegible]E+02
      .[illegible]E+02   .5230E+02

      [illegible]   .7[illegible]E+02
      [illegible]   .11[illegible]E+[illegible]

>>>> [illegible]   1

>>>> TR[illegible]
      .[illegible]E+00   .1[illegible]E+01   .1500E+01   .20[illegible]E+01   .[illegible]E+01   .4000E+01   .[illegible]000E+01   .120[illegible]E+02   .16[illegible]E+02   .20[illegible]E+02

>>>> [illegible]   [illegible]

>>>> LAMBDA
      .[illegible]E+04   .[illegible]E+04   .20[illegible]E+04   .2[illegible]E+04   .20[illegible]E+04   .2000E+04   .25[illegible]E+04   .3000E+04   .35[illegible]E+04   .40[illegible]E+04
>>>> AM[illegible]   .7[illegible]E+02
>>>> [illegible]   .[illegible]E+[illegible]
>>>> [illegible]   .1[illegible]E+[illegible]
>>>> [illegible]   .[illegible]E-[illegible]

>>>> QUALITY   .4[illegible]E+01
>>>> STDEV   .29[illegible]E+[illegible]
     PSIFAIL   .25[illegible]E+01
     TOLERNCE   .[illegible]E+02
```

•••••••••••••••••••• DESIGN EXAMPLE 12-31-75 ••••••••••••••••••••••

LABORATARY DATA -- CREEP COMPLIANCES

LAYER 1	TIME	VALUE	VARIATION
	.1[illegible]E-02	.370[illegible]E-0[illegible]	.27000E+00
	.3[illegible]E-02	.52[illegible]E-06	.27000E+00
	.1[illegible]E-01	.86[illegible]E-06	.27000E+00
	.3[illegible]E-01	.14[illegible]E-05	.27000E+00
	.1[illegible]E+00	.25[illegible]E-05	.27000E+00
	.3[illegible]E+00	.4[illegible]E-05	.27000E+00
	.1[illegible]E+01	.62[illegible]E-05	.27000E+00
	.3[illegible]E+01	.86[illegible]E-05	.27000E+00
	.1[illegible]E+02	.12[illegible]E-04	.27000E+00
	.3[illegible]E+02	.16[illegible]E-04	.27000E+00
	.1[illegible]E+03	.19[illegible]E-04	.27000E+00

FITTED DATA	DELT	GRS
	.10000E+03	-.5[illegible]234E-06
	.[illegible]0[illegible]E+02	.1[illegible]214E-07
	.[illegible]E+01	-.21[illegible]91[illegible]E-05
	.1[illegible]E+01	-.37[illegible]124[illegible]E-05
	.1[illegible]E+0[illegible]	-.[illegible]433[illegible]E-05
	.[illegible]E-01	-.[illegible]87[illegible]E-05
	0.	.19[illegible]E-04

LAYER 2	TIME	VALUE	VARIATION
	.1[illegible]E-02	.370[illegible]E-0[illegible]	.270[illegible]E+00
	.3[illegible]E-02	.52[illegible]E-06	.270[illegible]E+00
	.1[illegible]E-01	.86[illegible]E-06	.27[illegible]E+00
	.3[illegible]E-01	.14[illegible]E-05	.270[illegible]E+00
	.1[illegible]E+00	.25[illegible]E-05	.27[illegible]E+00
	.3[illegible]E+00	.4[illegible]E-05	.270[illegible]E+00
	.1[illegible]E+01	.62[illegible]E-05	.270[illegible]E+00
	.3[illegible]E+01	.86[illegible]E-05	.270[illegible]E+00
	.1[illegible]E+02	.12[illegible]E-04	.270[illegible]E+00
	.3[illegible]E+02	.16[illegible]E-04	.270[illegible]E+00
	.1[illegible]E+03	.19[illegible]E-04	.270[illegible]E+00

FITTED DATA	DELT	GRS
	.10000E+03	-.[illegible]234E-06
	.30000E+02	.1[illegible]214E-07
	.[illegible]0[illegible]E+01	-.21[illegible]91[illegible]E-05
	.10000E+01	-.37[illegible]124[illegible]E-05
	.1[illegible]E+0[illegible]	-.[illegible]54339[illegible]E-05
	.30000E-01	-.[illegible]87[illegible]E-05
	0.	.19[illegible]09[illegible]E-04

LAYER [illegible]	TIME	VALUE	VARIATION
	.1[illegible]E-[illegible]2	.17[illegible]E-[illegible]4	.2[illegible]E+0[illegible]
	[illegible]E-[illegible]2	.17[illegible]E-[illegible]4	.2[illegible]E+[illegible]
	.1[illegible]E-[illegible]1	.17[illegible]E-[illegible]4	[illegible]E+[illegible]
	.[illegible]E-[illegible]1	.17[illegible]E-[illegible]4	[illegible]E+0[illegible]
	.1[illegible]E+[illegible]	.17[illegible]E-[illegible]4	[illegible]E+[illegible]
	[illegible]E+[illegible]	.17[illegible]E-[illegible]4	[illegible]E+0[illegible]
	.1[illegible]E+[illegible]1	.170[illegible]E-[illegible]4	[illegible]0[illegible]E+0[illegible]
	[illegible]E+[illegible]	.17[illegible]E-[illegible]4	.2[illegible]E+0[illegible]
	.1[illegible]E+[illegible]2	.17[illegible]E-[illegible]4	.2[illegible]E+0[illegible]
	[illegible]E+[illegible]2	.17[illegible]E-[illegible]4	.2[illegible]00[illegible]E+0[illegible]
	.1[illegible]E+[illegible]3	.17[illegible]E-[illegible]4	[illegible]E+[illegible]

[illegible]ITTED DATA	DELTA	GAS
.1[illegible]E+0[illegible]	[illegible].	
[illegible]E+[illegible]	[illegible].	
[illegible]E+[illegible]1	0.	
.1[illegible]E+ 1	[illegible].	
.1[illegible]E+[illegible]	[illegible].	
[illegible]E- 1	[illegible].	
[illegible].		.17[illegible]E-[illegible]

LAYER [illegible]4	TIME	VALUE	VARIATION
	.1[illegible]E-[illegible]2	.17[illegible]E-[illegible]4	.2[illegible]0[illegible]E+0[illegible]
	.3[illegible]E-[illegible]2	.17[illegible]E-[illegible]4	[illegible]E+[illegible]
	.1[illegible]E-[illegible]1	.17[illegible]E-[illegible]4	.2[illegible]0[illegible]E+0[illegible]
	[illegible]E-[illegible]1	.17[illegible]E-[illegible]4	[illegible]0[illegible]E+0[illegible]
	.1[illegible]E+[illegible]	.17[illegible]E-[illegible]4	[illegible]E+0[illegible]
	.3[illegible]E+[illegible]	.17[illegible]E-[illegible]4	[illegible]E+0[illegible]
	.1[illegible]E+[illegible]1	.17[illegible]E-[illegible]4	[illegible]E+[illegible]
	[illegible]E+[illegible]1	.17[illegible]E-[illegible]4	[illegible]E+[illegible]
	.1[illegible]E+[illegible]2	.17[illegible]E-[illegible]4	[illegible]E+0[illegible]
	[illegible]E+[illegible]2	.17[illegible]E-[illegible]4	[illegible]E+[illegible]
	.1[illegible]E+[illegible]3	.17[illegible]E- [illegible]4	[illegible]E+[illegible]

[illegible]ITTED DATA	DELTA	GAS
.1[illegible]E+0[illegible]	[illegible].	
[illegible]E+[illegible]	[illegible].	
[illegible]E+ 1	[illegible].	
.1[illegible]E+[illegible]1	[illegible].	
.1[illegible]E+[illegible]	[illegible].	
[illegible]E-[illegible]1	[illegible].	
[illegible].		.17[illegible]E-[illegible]

LAYER [illegible]	TIME	VALUE	VARIATION
	.1[illegible]E-[illegible]2	.22[illegible]E-[illegible]4	.32[illegible]E+0[illegible]
	.3[illegible]E-[illegible]2	.22[illegible]E- 4	.325[illegible]E+0[illegible]
	.1[illegible]E-[illegible]1	[illegible]E-[illegible]4	.325[illegible]E+0[illegible]
	.3[illegible]E-[illegible]1	[illegible]E-[illegible]4	.325[illegible]E+0[illegible]
	.1[illegible]E+[illegible]	.2[illegible]E- 4	[illegible]E+0[illegible]
	.3[illegible]E+[illegible]	.22[illegible]E-[illegible]4	.325[illegible]E+0[illegible]
	.1[illegible]E+[illegible]1	.22[illegible]E-[illegible]4	.325[illegible]E+0[illegible]
	.3[illegible]E+[illegible]1	.22[illegible]E-[illegible]4	[illegible]25[illegible]E+0[illegible]
	.1[illegible]E+[illegible]	.22[illegible]E-[illegible]4	.325[illegible]0[illegible]E+0[illegible]
	.3[illegible]E+[illegible]	.22[illegible]E-[illegible]4	.325[illegible]E+0[illegible]
	.1[illegible]E+[illegible]	.22[illegible]E- 4	.325[illegible]E+0[illegible]

FITTED DATA	DELTA	GAS
.1[illegible]E+[illegible]	[illegible].	
[illegible]E+[illegible]	0.	
[illegible]E+ 1	[illegible].	
.1[illegible]E+ 1	[illegible].	
.1[illegible]E+[illegible]	0.	
[illegible]E-[illegible]1	0.	
0.		.22[illegible]00[illegible]E-[illegible]4

•••••••••••••••••••• DESIGN EXAMPLE 12-31-7[illegible] ••••••••••••••••••••••••

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 129.[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 = MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 = MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 = MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 = MODULUS [illegible] POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 = MODULUS [illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1 [illegible] SECONDS

PROBABLISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 32.[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+ 1	.1[illegible]E-14	-.373E+01	.497E+00	-.370E+01	.157E-01	0.	0.	SLOW
0.00	6.00	-.153E+[illegible]	.169E-01	-.594E-01	.256E-01	-.594E-01	.355E-03	0.	0.	SLOW
6.00	0.00	-.[illegible]E+[illegible]	.79[illegible]E-15	-.311E+01	.370E+00	-.283E+01	.327E+00	.623E-14	.173E-14	SLOW
6.00	6.00	-.1[illegible]E+[illegible]	.134E-01	-.509E-01	.157E-01	-.5[illegible]E-01	.158E-01	-.219E-01	.337E-02	

•••••••••••••••••••• DESIGN EXAMPLE 12-31-7[illegible] ••••••••••••••••••••••••

D I S P L A C E M E N T S / S T R A I N S

		VERTICAL (DISPLACEMENTS)		RADIAL (DISPLACEMENTS)		RADIAL (STRAINS)		TANGENTIAL (STRAINS)	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.612E-04	.125E-04	0.	0.	-.500E-06	.159E-06	-.500E-06	.117E-06
0.00	6.00	.[illegible]3E-04	.126E-04	0.	0.	.629E-06	.352E-06	.629E-06	.298E-06
6.00	0.00	.560E-04	.122E-04	-.260E-05	.357E-06	-.312E-06	.331E-07	-.474E-06	.353E-07
6.00	6.00	.561E-04	.127E-04	.318E-05	.324E-06	.337E-06	.547E-07	.529E-06	.635E-07

•••••••••••••••••••• DESIGN EXAMPLE 12-31-7[illegible]

PROBLEM PARAMETERS

TOTAL LOAD (LBS)	1[illegible].[illegible]
TIRE PRESSURE (PSI)	1.[illegible]
LOAD RADIUS (IN)	6.4[illegible]

LAYER 1 - MODULUS 1957412. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 1957412. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS 5[illegible]. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS 5[illegible]. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 454[illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .3[illegible]-02 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 32.[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+01	.11[illegible]E-14	-.742[illegible]E+01	.4[illegible]E+00	-.342E+01	.156E-01	0.	0.	SLOW
0.00	6.00	-.100E+[illegible]	.1[illegible]E-01	-.673E-01	.2[illegible]E-01	-.673E-01	.4[illegible]E-03	0.	0.	SLOW
6.00	0.00	-.[illegible]E+00	.1[illegible]E-14	-.[illegible]6E+01	.342E+00	-.265E+01	.299E+00	.690E-14	.163E-14	SLOW
6.00	6.00	-.124E+[illegible]	.14[illegible]E-01	-.[illegible]E-01	.176E-01	-.663E-01	.177E-01	-.281E-01	.414E-02	

•••••••••••••••••••• DESIGN EXAMPLE 12-31-7[illegible] ••••••••••••••••••••••

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.[illegible]73E-04	.135E-04	0.	0.	-.61[illegible]E-06	.202E-06	-.618E-06	.153E-06
0.00	6.00	.6[illegible]E-04	.137E-04	0.	0.	.7[illegible]E-0[illegible]	.39[illegible]E-06	.79[illegible]E-06	.337E-06
6.00	0.00	.617E-04	.132E-04	-.317E-05	.417E-06	-.30[illegible]E-0[illegible]	.41[illegible]E-07	-.529E-06	.[illegible]5E-07
6.00	6.00	.61[illegible]E-04	.133E-04	.395E-05	.375E-0[illegible]	.41[illegible]E-0[illegible]	.623E-07	.65[illegible]E-06	.730E-07

.... DESIGN EXAMPLE 12-31-75 ....

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 128.6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 - MODULUS 1144633. POISSONS RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 1144633. POISSONS RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS 58824. POISSONS RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS 58824. POISSONS RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 45455. POISSONS RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1 [illegible] -01 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 32.[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+01	.[illegible]E-15	-.296E+01	.419E+00	-.296E+01	.154E-01	0.	0.	SLOW
0.00	6.00	-.[illegible]E+[illegible]	.228E-01	-.817E-01	.343E-01	-.817E-01	.632E-03	0.	0.	SLOW
6.00	0.00	-.[illegible]E+[illegible]	.777E-15	-.246E+01	.293E+00	-.227E+01	.251E+00	.413E-14	.607E-15	SLOW
6.00	6.00	-.1[illegible]E+[illegible]	.161E-01	-.654E-01	.205E-01	-.811E-01	.207E-01	-.423E-01	.563E-02	

.... DESIGN EXAMPLE 12-31-75 ....

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.7[illegible]E-04	.152E-04	0.	0.	-.[illegible]E-[illegible]	.299E-06	-.956E-06	.239E-06
0.00	6.00	.7[illegible]E-04	.154E-04	0.	0.	.114E-0[illegible]	.469E-06	.114E-05	.431E-06
6.00	0.00	.7[illegible]E-04	.147E-04	-.431E-05	.519E-06	-.476E-06	.579E-07	-.719E-06	.658E-07
6.00	6.00	.683E-04	.149E-04	.560E-05	.460E-06	.577E-06	.739E-07	.934E-06	.880E-07

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 120.[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.[illegible]

LAYER 1 - MODULUS 63[illegible]. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 65[illegible]. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS [illegible]24. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS [illegible]4. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 40455. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1000[illegible]-01 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 32.

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+ 1	.545E-15	-.255E+01	.371E+00	-.255E+01	.151E-01	0.	0.	SLOW
0.00	6.00	-.2[illegible]E+ [illegible]	.253E-01	-.953E-01	.347E-01	-.953E-01	.831E-03	0.	0.	SLOW
6.00	0.00	-.[illegible]E+ [illegible]	.634E-15	-.211E+01	.248E+00	-.195E+01	.207E+00	.417E-14	.147E-14	SLOW
6.00	6.00	-.12[illegible]E+ [illegible]	.17[illegible]E-01	-.726E-01	.226E-01	-.959E-01	.228E-01	-.[illegible]04E-01	.716E-02	SLOW

		D I S P L A C E M E N T S				S T R A I N S			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.9[illegible]E- 4	.166E-04	0.	0.	-.111E-05	.419E-06	-.111E-05	.359E-06
0.00	6.00	.87[illegible]E- 4	.171E-04	0.	0.	.157E-05	.527E-06	.157E-05	.459E-06
6.00	0.00	.793E-04	.16[illegible]E-04	-.551E-05	.[illegible]03E-06	-.577E-06	.774E-07	-.914E-06	.5[illegible]2E-07
6.00	6.00	.77[illegible]E-04	.164E-04	.786E-05	.529E-06	.611E-06	.800E-07	.126E-05	.979E-07

•••••••••••••••••••• DESIGN EXAMPLE 12-31-75 ••••••••••••••••••••••••

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 12[illegible].60
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 - MODULUS 4[illegible]03. POISSON'S RATIO .[illegible] THICKNESS (IN) 3.00
LAYER 2 - MODULUS 4[illegible]3. POISSON'S RATIO .503 THICKNESS (IN) 3.00
LAYER 3 - MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS [illegible]. POISSON'S RATIO .50[illegible] THICKNESS (IN) 4.00
LAYER 5 - MODULUS [illegible]45. POISSON'S RATIO .[illegible] SEMI-INFINITE THICKNESS

TIME = .1[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS [illegible]2.[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+ 1	.442E-15	-.212E+01	.316E+0[illegible]	-.212E+01	.145E-01	0.	0.	SLOW
0.00	6.00	-.387E+[illegible]	.274E-01	-.109E+00	.410E-01	-.1[illegible]E+0[illegible]	.107E-02	0.	0.	SLOW
6.00	0.00	-.[illegible]E+[illegible]	.33[illegible]E-15	-.177E+01	.199E+00	-.165E+01	.159E+00	.691E-14	.141E-14	SLOW
6.00	6.00	-.242E+[illegible]	.169E-01	-.779E-01	.272E-01	-.117E+00	.236E-01	-.658E-01	.972E-02	SLOW

•••••••••••••••••••• DESIGN EXAMPLE 12-31-75 ••••••••••••••••••••••••

		D I S P L A C E M E N T S				S T R A I N S			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.106E-03	.189E-04	0.	0.	-.17[illegible]E-05	.587E-06	-.139E-05	.557E-06
0.00	6.00	.598E-04	.189E-04	0.	0.	.21[illegible]E-05	.562E-06	.216E-05	.472E-06
6.00	0.00	.871E-04	.172E-04	-.676E-05	.669E-06	-.654E-06	.103E-06	-.113E-05	.145E-06
6.00	6.00	.653E-04	.179E-04	.102E-04	.579E-06	.8[illegible]E-06	.817E-07	.169E-05	.190E-06

DESIGN EXAMPLE 12-31-7[illegible]

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 129.6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1	MODULUS	247574.	POISSON'S RATIO	.500	THICKNESS (IN)	3.00
LAYER 2	MODULUS	247554.	POISSON'S RATIO	.500	THICKNESS (IN)	3.00
LAYER 3	MODULUS	[illegible]4.	POISSON'S RATIO	.500	THICKNESS (IN)	4.00
LAYER 4	MODULUS	[illegible]4.	POISSON'S RATIO	.500	THICKNESS (IN)	4.00
LAYER 5	MODULUS	[illegible]	POISSON'S RATIO	.500	SEMI-INFINITE THICKNESS	

TIME = .3 [illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 12.[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.100E+ 1	.71[illegible]E-15	-.179E+01	.[illegible]8E+[illegible]	-.176E+01	.136E-01	0.	0.	SLOW
0.00	6.00	-.444E+[illegible]	.274E-01	-.120E+0[illegible]	.[illegible]5E-01	-.1[illegible]E+0[illegible]	.112E-02	0.	0.	SLOW
6.00	0.00	-.[illegible]E+[illegible]	.[illegible]E-15	-.15[illegible]E+01	.15[illegible]E+[illegible]	-.143E+01	.121E+00	.179E-14	.971E-15	SLOW
6.00	6.00	-.[illegible]E+[illegible]	.11[illegible]E-01	-.7[illegible]2E-01	.179E-[illegible]	-.127E+00	.184E-01	-.112E+0[illegible]	.[illegible]6E-0[illegible]	SLOW

DESIGN EXAMPLE 12-31-7[illegible]

		D I S P L A C E M E N T S				S T R A I N S			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.12[illegible]E-[illegible]	.1[illegible]E-[illegible]4	0.	0.	-.157E-0[illegible]	.[illegible]E-0[illegible]	-.157E-05	.[illegible]6E-06
0.00	6.00	.11[illegible]E- [illegible]	.201[illegible]E-[illegible]4	0.	0.	.2[illegible]E-[illegible]	.5[illegible]E-0[illegible]	.[illegible]75E-05	.443E-06
6.00	0.00	.57[illegible]E- 4	.181E-04	-.786[illegible]E-0[illegible]	.[illegible]9E-[illegible]	-.[illegible]E-0[illegible]	.127E-06	-.124E-[illegible]5	.213E-06
6.00	6.00	.91[illegible]E- 4	.1[illegible]E-[illegible]4	.127E-04	.[illegible]4E-0[illegible]	.[illegible]4E-07	.73[illegible]E-07	.212E-05	.[illegible]E-07

•••••••••••••••••••• DESIGN EXAMPLE 12-31-75 ••••••••••••••••••••••

PROBLEM PARAMETERS

TOTAL LOAD (LBS)	128.68
TIRE PRESSURE (PSI)	1.00
LOAD RADIUS (IN)	6.40

LAYER 1 - MODULUS 160005. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 160005. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS 54604. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS 54604. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 45405. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1 [illegible] +01 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 32.[illegible]

S T R E S S E S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
0.00	0.00	-.1[illegible]E+01	.[illegible]E-15	-.151E+01	.226E+00	-.151E+01	.126E-01	0.	0.	SLOW
0.00	6.00	-.515E+00	.212E-01	-.137E+00	.266E-01	-.137E+00	.938E-03	0.	0.	SLOW
6.00	0.00	-.9[illegible]E+00	.23[illegible]E-15	-.153E+01	.125E+00	-.127E+01	.915E-01	.376E-14	.726E-15	SLOW
6.00	6.00	-.312E+00	.[illegible]E-02	-.778E-01	.151E-01	-.1[illegible]E+00	.158E-01	-.138E+00	.658E-02	SLOW

•••••••••••••••••••• DESIGN EXAMPLE 12-31-75 ••••••••••••••••••••••

D I S P L A C E M E N T S / S T R A I N S

R	Z	DISPL. VERTICAL MEAN	DISPL. VERTICAL DEVIATION	DISPL. RADIAL MEAN	DISPL. RADIAL DEVIATION	STRAIN RADIAL MEAN	STRAIN RADIAL DEVIATION	STRAIN TANGENTIAL MEAN	STRAIN TANGENTIAL DEVIATION
0.00	0.00	.174E-03	.397E-04	0.	0.	-.157E-05	.876E-06	-.157E-05	.110E-05
0.00	6.00	.119E-03	.201E-04	0.	0.	.376E-05	.394E-06	.330E-05	.220E-06
6.00	0.00	.126E-03	.156E-04	-.739E-05	.125E-05	-.675E-06	.150E-06	-.123E-05	.371E-06
6.00	6.00	.767E-04	.192E-04	.151E-04	.644E-06	.947E-06	.438E-07	.251E-05	.114E-07

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 12[illegible].6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 - MODULUS 110023. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 110023. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS 15924. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS [illegible]. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 4[illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .[illegible]E+01 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS 32.[illegible]

S T R E S S E S

R	Z	VERTICAL MEAN	VERTICAL DEVIATION	TANGENTIAL MEAN	TANGENTIAL DEVIATION	RADIAL MEAN	RADIAL DEVIATION	SHEAR MEAN	SHEAR DEVIATION	
0.00	0.00	-.14[illegible]E+01	.3[illegible]E-15	-.133E+01	.193E+00	-.137E+01	.117E-01	0.	0.	SLOW
0.00	6.00	-.572E+[illegible]	.1[illegible]E-01	-.131E+00	.213E-01	-.131E+00	.79[illegible]E-03	0.	0.	SLOW
6.00	0.00	-.956E+[illegible]	.177E-15	-.121E+01	.100E+00	-.117E+01	.704E-01	.273E-14	.730E-16	SLOW
6.00	6.00	-.3[illegible]E+[illegible]	.764E-02	-.750E-01	.125E-01	-.146E+00	.130E-01	-.158E+00	.671E-02	SLOW

D I S P L A C E M E N T S / S T R A I N S

R	Z	DISPLACEMENTS VERTICAL MEAN	DISPLACEMENTS VERTICAL DEVIATION	DISPLACEMENTS RADIAL MEAN	DISPLACEMENTS RADIAL DEVIATION	STRAINS RADIAL MEAN	STRAINS RADIAL DEVIATION	STRAINS TANGENTIAL MEAN	STRAINS TANGENTIAL DEVIATION
0.00	0.00	.146E-[illegible]	.202E-04	0.	0.	-.140E-05	.965E-06	-.140E-05	.1[illegible]9E-05
0.00	6.00	.125E-[illegible]	.207E-04	0.	0.	.375E-05	.32[illegible]E-06	.375E-05	.215E-06
6.00	0.00	.113E-[illegible]	.1[illegible]E-04	-.[illegible]55E-05	.[illegible]3E-05	-.5[illegible]E-0[illegible]	.169E-0[illegible]	-.159E-05	.30[illegible]E-06
6.00	6.00	.1[illegible]E-[illegible]	.19[illegible]E-04	.169E-04	.7[illegible]E-0[illegible]	.[illegible]E-0[illegible]	.[illegible]56E-07	.242E-05	.7[illegible]9E-07

.... DESIGN EXAMPLE 12-31-7[illegible] ....

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 12[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 - MODULUS [illegible]3142. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS [illegible]7142. POISSON'S RATIO .50[illegible] THICKNESS (IN) 3.00
LAYER 3 - MODULUS [illegible]4. POISSON'S RATIO .5[illegible] THICKNESS (IN) 4.[illegible]
LAYER 4 - MODULUS [illegible]4. POISSON'S RATIO .5[illegible] THICKNESS (IN) 4.[illegible]
LAYER 5 - MODULUS [illegible]. POISSON'S RATIO .5[illegible] SEMI-INFINITE THICKNESS

TIME = .11[illegible] +02 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS [illegible]7.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS [illegible]7.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS [illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+01	.4[illegible]E-15	-.117E+01	.1[illegible]E+00	-.117E+01	.106E-01	0.	0.	SLOW
0.00	6.00	-.6[illegible]E+00	.147E-01	-.133E+00	.1[illegible]1E-01	-.1[illegible]E+00	.540E-03	0.	0.	SLOW
[illegible]	0.00	-.[illegible]E+[illegible]	.223E-15	-.111E+01	.791E-01	-.1[illegible]E+01	.527E-01	.418E-14	.433E-15	SLOW
[illegible]	6.00	-.3[illegible]E+[illegible]	.[illegible]93E-02	-.713E-01	.1[illegible]1E-01	-.1[illegible]E+[illegible]	.102E-01	-.178E+00	.590E-02	SLOW

.... DESIGN EXAMPLE 12-31-7[illegible] ....

D I S P L A C E M E N T S / S T R A I N S

		DISPLACEMENTS VERTICAL		DISPLACEMENTS RADIAL		STRAINS RADIAL		STRAINS TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.161E-[illegible]	.20[illegible]E-[illegible]	0.	0.	-.1[illegible]E-0[illegible]	.102E-05	-.100E-05	.174E-05
0.00	6.00	.131E-[illegible]3	.211E-04	0.	0.	.417E-0[illegible]	.249E-06	.417E-05	.153E-06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]E-06	-.785E-16	.524E-06

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 129.6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 - MODULUS 6[illegible]435. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 60435. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS 51824. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS 50824. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 4[illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .3[illegible] SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS [illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS [illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	0.00	-.1[illegible]E+01	.34[illegible]E-15	-.105E+01	.1[illegible]E+0[illegible]	-.1[illegible]E+01	.975E-02	0.	0.	SLOW
0.00	6.00	-.663E+[illegible]	.103E-01	-.134E+00	.1[illegible]7E-01	-.1[illegible]E+[illegible]	.265E-03	0.	0.	SLOW
6.00	0.00	-.998E+[illegible]	.14[illegible]E-15	-.194E+01	.6[illegible]2E-01	-.1[illegible]3E+01	.400E-01	.345E-14	.1[illegible]0E-15	SLOW
6.00	6.00	-.3[illegible]E+[illegible]	.46[illegible]E-02	-.675E-01	.[illegible]2E-02	-.1[illegible]E+[illegible]	.842E-02	-.19[illegible]E+00	.54[illegible]E-02	SLOW

		D I S P L A C E M E N T S				S T R A I N S			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	0.00	.175E-[illegible]	.214E-[illegible]	0.	0.	-.41[illegible]E-0[illegible]	.102E-0[illegible]	-.403E-06	.[illegible]E-05
0.00	6.00	.135E-[illegible]	.214E-04	0.	0.	.4[illegible]E-0[illegible]	.179E-06	.450E-05	.137E-06
6.00	0.00	.1[illegible]E-[illegible]	.194E-04	-.203E-05	.374E-05	-.223E-06	.206E-06	-.33[illegible]E-[illegible]6	.661E-06
6.00	6.00	.1[illegible]E-[illegible]	.20[illegible]E-04	.200E-04	.[illegible]E-0[illegible]	.1[illegible]E-05	.56[illegible]E-07	.334E-05	.810E-07

******************** DESIGN EXAMPLE 12-31-7[illegible] ********************

PROBLEM PARAMETERS

TOTAL LOAD (LBS) 1[illegible].6[illegible]
TIRE PRESSURE (PSI) 1.[illegible]
LOAD RADIUS (IN) 6.4[illegible]

LAYER 1 - MODULUS 535[illegible]7. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 2 - MODULUS 535[illegible]7. POISSON'S RATIO .500 THICKNESS (IN) 3.00
LAYER 3 - MODULUS [illegible]24. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 4 - MODULUS [illegible]24. POISSON'S RATIO .500 THICKNESS (IN) 4.00
LAYER 5 - MODULUS 454[illegible]. POISSON'S RATIO .500 SEMI-INFINITE THICKNESS

TIME = .1[illegible] [illegible]E+03 SECONDS

PROBABILISTIC PARAMETERS

LAYER 1--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 2--COEFFICIENT OF VARIATION OF MODULUS 27.[illegible]
LAYER 3--COEFFICIENT OF VARIATION OF MODULUS 20.[illegible]
LAYER 4--COEFFICIENT OF VARIATION OF MODULUS [illegible].[illegible]
LAYER 5--COEFFICIENT OF VARIATION OF MODULUS [illegible].[illegible]

S T R E S S E S

		VERTICAL		TANGENTIAL		RADIAL		SHEAR		
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	
0.00	3.00	-.1[illegible]E+[illegible]	.457E-1[illegible]	-.995E+00	.128E+0[illegible]	-.9[illegible]E+0[illegible]	.927E-02	0.	0.	SLOW
0.00	6.00	-.6[illegible]3E+[illegible]	.[illegible]E-02	-.134E+00	.1[illegible]E-01	-.124E+0[illegible]	.107E-03	0.	0.	SLOW
6.00	3.00	-.959E+[illegible]	.256E-15	-.100E+01	.556E-01	-.1[illegible]1E+01	.341E-01	.424E-14	.770E-16	SLOW
6.00	6.00	-.376E+[illegible]	.91[illegible]E-02	-.654E-01	.914E-02	-.161E+00	.[illegible]13E-02	-.222E+00	.526E-02	SLOW

******************** DESIGN EXAMPLE 12-31-7[illegible] ********************

		DISPLACEMENTS				STRAINS			
		VERTICAL		RADIAL		RADIAL		TANGENTIAL	
R	Z	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION	MEAN	DEVIATION
0.00	3.00	.154E-0[illegible]	.210E-04	0.	0.	.43[illegible]E-07	.101E-05	.43[illegible]E-07	.2[illegible]1E-05
0.00	6.00	.1[illegible]7E-[illegible]	.21[illegible]E-04	0.	0.	.4[illegible]7E-[illegible]	.15[illegible]E-0[illegible]	.467[illegible]E-05	.1[illegible]5E-0[illegible]
6.00	3.00	.134E-[illegible]3	.195E-04	-.632[illegible]E-07	.443E-05	-.1[illegible]1E-[illegible]	.21[illegible]E-06	-.105E-07	.747E-06
6.00	6.00	.1[illegible]E-[illegible]3	.[illegible]06E-04	.237E-04	.960E-1[illegible]	.1[illegible]2E-0[illegible]	.62[illegible]E-07	.34[illegible]E-05	.8[illegible]0E-07

**** CURVE-FITTED SYSTEM RESPONSES

DETERMINATING FACTOR FOR CRACKING IS RADIAL STRAIN AT 0.00 IN.

FITTED DATA	DELTA	SEE
	.1[illegible]E+ 3	-.284F[illegible]E-0[illegible]
	[illegible]E+ 2	-.5272[illegible]E-0[illegible]
	[illegible]E+ 1	-.25[illegible]E-0[illegible]
	.1[illegible]E+ 1	-.975[illegible]E-07
	.1[illegible]E+0[illegible]	-.2[illegible]E-07
	.1[illegible]E- 1	.6743[illegible]E-1[illegible]
	0.	.1[illegible]E-[illegible]

DETERMINING FACTOR FOR RUTTING IS VERTICAL DISPLACEMENT AT 0.00 IN.

FITTED DATA	DELTA	SEE
	.1[illegible]E+03	-.2[illegible]195E-04
	[illegible]E+ 2	-.14[illegible]E-0[illegible]
	[illegible]E+ 1	-.20[illegible]E-04
	.1[illegible]E+ 1	-.23[illegible]E-04
	.1[illegible]E+0[illegible]	-.2[illegible]357[illegible]E-0[illegible]
	[illegible]E-01	-.1[illegible]E-04
	0.	.1840051E-03

PERMANENT DEFORMATION
SYSTEM RESPONSE FACTORS
GNU = .5300E+00
ALPHA = .2429E+00

F A T I G U E   C R A C K I N G

GENERAL STRAIN RESPONSE
DUE TO PEAK LOADING (HAVERSINE)

TEMPERATURE DEGREES-F	STRAIN IN./IN.	VAR STRAIN (IN./IN.)**2	NFAIL CYCLES	VAR NFAIL CYCLES**2	K1 CYCLES	K2 DIMENSIONLESS	GAMMA DIMENSIONLESS
43.[illegible]	.277[illegible]E-04	.716[illegible]E-10	.121[illegible]E+[illegible]	.75[illegible]E+16	.46[illegible]E-04	.26[illegible]E+01	[illegible]E-02
57.[illegible]	.2424[illegible]E-04	.74467[illegible]E-10	.1[illegible]477[illegible]E+[illegible]	[illegible]E+16	[illegible]E-04	.26[illegible]E+01	.1[illegible]E-01
59.[illegible]	.[illegible]705[illegible]E-04	.927[illegible]E-10	.23[illegible]E+ [illegible]	.1[illegible]E+17	.15[illegible]E-03	.26707[illegible]E+01	[illegible]E- 1
64.[illegible]	.4[illegible]E-04	.243[illegible]E-09	.2[illegible]3E+ [illegible]	.1[illegible]177E+17	.709[illegible]E-03	.26[illegible]E+01	.[illegible]947[illegible]E+0[illegible]
75.[illegible]	.[illegible]E-04	.427[illegible]E-09	.34[illegible]E+09	.[illegible]E+17	.2420[illegible]E-02	.2[illegible]E+01	[illegible]E+ 1
81.[illegible]	.[illegible]E-04	.[illegible]E-09	.94[illegible]2E+[illegible]	.21366E+18	.1[illegible]E-01	.26100E+01	.2[illegible]E+ 2
84.[illegible]	.71[illegible]E-04	.[illegible]E-09	.17[illegible]E+1[illegible]	.7[illegible]E+18	.284[illegible]E-01	.2[illegible]E+01	.44[illegible]E+ 2
84.7[illegible]	.71[illegible]E-04	.6[illegible]131[illegible]E-09	.1[illegible]E+1[illegible]	.[illegible]E+18	.29[illegible]E-01	.2[illegible]E+01	.4[illegible]E+ 2
7[illegible].[illegible]0	.6[illegible]16[illegible]E-04	.3[illegible]E-09	.54[illegible]14[illegible]E+ [illegible]	.7156[illegible]E+17	.[illegible]E-0[illegible]	.2[illegible]E+01	.1917[illegible]E+ [illegible]
7[illegible].1[illegible]	.47[illegible]E-04	.[illegible]42[illegible]E-09	.247[illegible]9E+[illegible]	.14[illegible]E+17	.[illegible]20[illegible]E-0[illegible]	.264[illegible]E+01	.1[illegible]E+01
55.1[illegible]	.[illegible]67[illegible]E-04	.3[illegible]539[illegible]E-10	.2[illegible]9E+[illegible]	.13711E+17	.15100E-03	.267[illegible]0E+01	.5[illegible]E- 1
50.[illegible]	.[illegible]4[illegible]E-04	.73[illegible]12[illegible]E-10	.1[illegible]19E+ [illegible]	.6772[illegible]E+16	.6[illegible]70[illegible]E-04	.26800E+01	.9[illegible]7E-02

DAMAGE INDEX DIMENSIONLESS	VAR DAMAGE INDEX DIMENSIONLESS	AREA CRACKED SQ.YDS/1000SQ.YDS	TIME YEARS
.26782[illegible]E-02	.1[illegible]E- 5	0.0	.[illegible]
.441[illegible]E-0[illegible]	.1[illegible]211[illegible]E-0[illegible]	0.0	1.[illegible]
.7[illegible]E-0[illegible]	.[illegible]E-0[illegible]	0.0	1.[illegible]
.[illegible]E-02	.[illegible]E-0[illegible]	0.0	2.[illegible]
.1[illegible]E-01	.45[illegible]E-0[illegible]	0.0	3.[illegible]
.17[illegible]E-01	.[illegible]E-05	0.0	4.[illegible]
.3[illegible]E-01	.1[illegible]91[illegible]E-04	0.0	8.[illegible]
.5[illegible]21[illegible]E-01	.2[illegible]E-04	0.0	12.[illegible]
.97[illegible]E-01	.47[illegible]E-04	0.0	16.[illegible]
.1[illegible]43[illegible]E+00	.7225[illegible]E- 4	0.0	23.[illegible]

R U T   D E P T H

PERMANENT DEFORMATION
SYSTEM RESPONSE FACTORS
GNU = [illegible]
ALPHA = [illegible]

GENERAL DEFLECTION RESPONSE
DUE TO PEAK LOADING (HAVERSINE)

TEMPERATURE DEGREES F	DEFLECTION INCHES	VAR DEFLECTION INCHES**2
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

RUT DEPTH INCHES	VAR RUT DEPTH INCHES**2	TIME YEARS
[illegible]	[illegible]	.50
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1.50
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
.15402E+00	[illegible]	4.00
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	12.00
[illegible]	[illegible]	[illegible]
.25160E+00	[illegible]	[illegible]

R O U G H N E S S

SLOPE VARIANCE RADIANS*1.0**6	VAR SLOPE VARIANCE (RADIANS*1.0**6)**2	TIME YEARS
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

PERFORMANCE

RUT DEPTH	VAR RUT DEPTH	SLOPE VAR	VAR SLOPE VAR	CRACKING	VAR CRACKING	TIME
.53[illegible]E-01	.10[illegible]E-02	.2[illegible]E+00	.17[illegible]E-01	.26742E-02	.101[illegible]E-05	.50
.11[illegible]E+00	.17[illegible]E-02	.34[illegible]E+00	.52[illegible]E-01	.44144E-02	.15[illegible]E-05	1.00
.117[illegible]E+00	.19[illegible]E-02	.39[illegible]E+00	.697[illegible]E-01	.70[illegible]E-02	.25[illegible]E-05	1.50
.13[illegible]E+00	.24[illegible]E-02	.48425E+00	.10[illegible]E+00	.98[illegible]E-02	.3[illegible]E-05	2.00
.14[illegible]E+00	.2[illegible]E-02	.[illegible]E+00	.15[illegible]E+00	.13243E-01	.45[illegible]E-05	3.00
.154[illegible]E+00	.2[illegible]E-02	.67915E+00	.231[illegible]E+00	.17658E-01	.60[illegible]E-05	4.00
.18[illegible]E+00	.[illegible]E-02	.11[illegible]E+01	.44[illegible]E+00	.39[illegible]E-01	.15[illegible]E-04	8.00
.21[illegible]E+00	.64[illegible]E-02	.12[illegible]E+01	.72[illegible]E+00	.66216E-01	.2[illegible]E-04	12.00
.27[illegible]E+00	.77[illegible]E-02	.15525E+01	.1[illegible]E+01	.77117E-01	.47[illegible]E-04	16.00
.29[illegible]E+00	.96[illegible]E-02	.18350E+01	.14[illegible]E+01	.13243E+00	.72[illegible]E-04	20.00

SERVICEABILITY	VARIANCE OF SERVICEABILITY	TIME
4.[illegible]	.[illegible]54	.50
4.[illegible]	.1[illegible]412	1.00
4.51[illegible]	.1[illegible]	1.50
4.4[illegible]4	.11[illegible]43	2.00
4.4[illegible]	.1[illegible]	3.00
4.36[illegible]7	.13[illegible]3	4.00
4.[illegible]	.1[illegible]7	8.00
4.[illegible]1	.18172	12.00
4.[illegible]	.1[illegible]	16.00
[illegible].91969	.21[illegible]	20.00

SERVICEABILITY FAILURE LEVEL IS [illegible]

MARGINAL STATE PROBABILITIES

STATE UPPER BOUNDS = .1E+51 4.7[illegible] 4.46778 4.18667 3.9[illegible] 3.62444 3.34333 3.06222 2.78111 2.50000

STATE LOWER BOUNDS = 4.74[illegible] 4.46778 4.18667 3.90556 3.62444 3.34333 3.06222 2.78111 2.50000 -.1E+51

STATE1	STATE2	STATE3	STATE4	STATE5	STATE6	STATE7	STATE8	STATE9	STATE10	TIME	RELIABILITY
.[illegible]	.[illegible]7	.1[illegible]6	.01[illegible]	.[illegible]	.[illegible]	.[illegible]	.00000	.[illegible]	.00000	0.0	1.[illegible]
.363[illegible]	.[illegible]	.21[illegible]7	.0[illegible]	.[illegible]	.[illegible]	.[illegible]1	.00000	.00000	.00000	.5	1.[illegible]
.[illegible]	.[illegible]11[illegible]	.27[illegible]	.1[illegible]	.[illegible]	.[illegible]4	.[illegible]	.00000	.00000	.00000	1.0	1.[illegible]
.[illegible]1	.[illegible]	.[illegible]1	.1[illegible]	.[illegible]2	.[illegible]3	.[illegible]1[illegible]	.00001	.00000	.00000	1.5	1.[illegible]
.[illegible]	.[illegible]	.[illegible]	.1[illegible]2	.[illegible]	.[illegible]	.[illegible]	.00002	.00000	.00000	2.0	1.[illegible]
.1[illegible]	.[illegible]	.[illegible]	.1[illegible]	.[illegible]5	.01[illegible]	.[illegible]	.00007	.00000	.00000	3.0	1.[illegible]
.14[illegible]	.[illegible]139	.[illegible]4	.2[illegible]	.[illegible]4	.01[illegible]13	.0[illegible]	.00[illegible]	.00001	.00000	4.0	1.[illegible]
.[illegible]	.17174	.[illegible]	.[illegible]	.15[illegible]	.[illegible]	.01[illegible]	.00165	.00017	.00001	8.0	.9999
.[illegible]377	.12[illegible]1	.[illegible]513	.2[illegible]47	.19[illegible]	.[illegible]	.0[illegible]	.0[illegible]49	.00[illegible]	.00002	12.0	.99941
.247[illegible]	.1[illegible]67	.19[illegible]	.24647	.21[illegible]2	.1[illegible]	.0[illegible]	.01426	.00267	.00037	16.0	.99963
.[illegible]	.[illegible]1	.16397	.23[illegible]4	.22[illegible]1	.1[illegible]1	.07[illegible]	.02478	.00576	.00105	20.0	.99891

WARNINGS> RELIABILITY EXCEEDS THE SPECIFIED TOLERANCE THROUGHOUT THE PERIOD OF THIS ANALYSIS. IF AN ACCURATE ESTIMATE OF SERVICE LIFE IS REQUIRED, THEN THIS RUN SHOULD BE RESUBMITTED WITH ADDITIONAL TIME POINTS, EXTENDING THE ANALYSIS BEYOND THE TIME AT WHICH RELIABILITY DROPS BELOW THE MINIMUM ACCEPTABLE LEVEL.

VESYS IIM SAMPLE PROBLEM

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F H W A

P R E D I C T I V E   D E S I G N   P R O C E D U R E S

VESYS II-M :  A [illegible] ELASTIC PREDICTIVE MODEL
              FOR PAVEMENT DESIGN

LATEST REVISION:  [illegible] [illegible] 1976
                  FEDERAL HIGHWAY ADMINISTRATION

DESIGN EXAMPLE      [illegible]

INPUT DATA VALUES FOR [illegible]      1

          TYPE                  1
          ITYPES          1001000
          UNLOAD

      >>>> THICK1     [illegible] 01
      >>>> THICK2     [illegible] 01
      >>>> LOADING    [illegible] 01
           RADIUS     [illegible] 01
           ZPOINT     [illegible] 01
           [illegible]          1
           [illegible]
             0.0

      >>>> NTSTATIC             11

      >>>> TSTATIC
             [illegible]  0.3000E-02  0.1000E-01  0.3000E-01  0.1000E 00  0.3000E 00  0.1000E 01  0.3000E 01  0.1000E 02  0.3000E 02
             [illegible]

      >>>> LAYER1
             [illegible]  0.5200E-05  0.8000E-05  0.1450E-05  0.2500E-05  0.3000E-05  0.4200E-05  0.8500E-05  0.1200E-04  0.1600E-04
             0.1[illegible]

      >>>> LAYER2
             0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04  0.1700E-04
             0.17[illegible]

      >>>> LAYER3
             0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04  0.2200E-04
             0.2200E-04
      >>>> VARCEEF1   0.2700E 00
      >>>> VARCEEF2   0.2000E 00
      >>>> VARCEEF3   [illegible]

      >>>> NDELTAS              7

      >>>> DELTAS
             0.1000E [illegible]  0.3000E 02  0.5000E 01  0.1000E 01  0.1000E 00  0.[illegible]E-01  0.0
```

```
>>>> STAGE[illegible]
      0.26[illegible] 01  0.26[illegible] 01  0.2670E 01  0.2640E 01  0.2630E 01  0.2610E 01  0.2590E 01  0.2590E 01  0.2620E 01  0.2540E 01
      0.2670E 01  0.2690E 01

>>>> STR[illegible]
      0.46[illegible]E-04  0.72[illegible]E-04  0.13[illegible]E-03  0.7590E-03  0.2420E-02  0.1250E-01  0.2840E-01  0.2770E-01  0.5510E-02  0.7320E-03
      0.1510E-03  0.6570E-04
>>>> COEF[illegible]   0.[illegible] 00
>>>> C[illegible]   [illegible]E-01
>>>> [illegible]

>>>> GND
      0.[illegible] 00  0.5500E-01  0.7500E-02

>>>> ALPHA
      0.75[illegible] 00  0.7500E 00  0.35[illegible] 00

>>>> CE-LCO[illegible]   [illegible]E 01
>>>> CONEFA[illegible]   0.5[illegible]E-01

>>>> NTERMS   1

>>>> TEMPS
      0.4570E 02  0.5330E 02  0.5950E 02  0.6860E 02  0.7520E 02  0.9160E 02  0.8460E 02  0.8470E 02  0.7830E 02  0.7010E 02
      [illegible]  0.5230E 02

     REFTEM    0.7000E 02
     BETA      0.1130E 00

>>>> [illegible]   10

>>>> TRANGE
      0.5000E 00  0.1000E 01  0.1500E 01  0.2000E 01  0.3000E 01  0.4000E 01  0.8000E 01  0.1200E 02  0.1600E 02  0.2000E 02
>>>> TUNITS   [illegible]

>>>> LAMBDA
      0.2000E 04  0.2000E 04  0.2000E 04  0.2000E 04  0.2000E 04  0.2000E 04  0.2500E 04  0.3000E 04  0.3500E 04  0.4000E 04
>>>> ELEV[illegible]   0.7545E 02
>>>> VCA[illegible]   0.5[illegible]E 03
>>>> [illegible]   0.1000E 00
>>>> VC[illegible]   [illegible]

>>>> QUALITY[illegible]   0.[illegible]E 01
>>>> STEAV[illegible]   0.[illegible]E 00
     ESTEA[illegible]   0.[illegible]E 01
     T[illegible]   0.[illegible]E 02
```

C U R V E   F I T T I N G

FITTED [illegible] FUNCTIONS - DIRICHLET SERIES

I	G(I) LAYER 1	G(I) LAYER 2	G(I) LAYER 3	DELTA(I)
1	[illegible]	0.0	0.0	0.30000E 03
2	[illegible]E-07	0.0	0.0	0.30000E 02
3	[illegible]E-05	0.0	0.0	0.30000E 01
4	[illegible]E-05	0.0	0.0	0.10000E 01
5	[illegible]E-05	0.0	0.0	0.10000E 00
6	[illegible]E-05	0.0	0.0	0.30000E-01
7	[illegible]E-04	0.17000E-04	0.22000E-04	0.0

COEFFICIENTS
OF VARIATION: [illegible].27[illegible]E 00   0.200E 00   0.325E 00

VALUES OF [illegible] ... WITH RESIDUALS

TIME	LAYER 1			LAYER 2			LAYER 3		
(SECONDS)	MEASURED	PREDICTED	% ERR	MEASURED	PREDICTED	% ERR	MEASURED	PREDICTED	% ERR
0.10E-02	0.3[illegible]E-06	0.37182E-06	-0.49	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.30E-02	[illegible]	[illegible]	[illegible]	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.10E-01	[illegible]	0.73064E-06	-1.59	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.30E-01	0.1[illegible]E-05	0.14464E-05	0.66	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.10E 00	[illegible]	0.26921E-05	0.16	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.30E 00	[illegible]	0.40374E-05	-0.98	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.10E 01	[illegible]	0.61376E-05	1.01	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.30E 01	[illegible]	[illegible]	-0.23	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.10E 02	0.12[illegible]E-04	0.12125E-04	-0.24	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.30E 02	0.16[illegible]E-04	0.16019E-04	-0.12	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0
0.10E 03	0.1[illegible]E-04	0.19604E-04	1.74	0.17000E-04	0.17000E-04	0.0	0.22000E-04	0.22000E-04	0.0

P R I M A R Y   R E S P O N S E

LAYER 1 THICKNESS = [illegible] INCHES
LAYER 2 THICKNESS = [illegible] INCHES
RADIAL POSITION = [illegible] INCHES
VERTICAL POSITION = [illegible] INCHES
LAYER OF INTEREST = 1
LOADING IN PSI = 1.

[illegible] VERTICAL DISPLACEMENT

TIME (SEC)	MEAN VALUE	COEF OF VAR
0.10E-02	[illegible]	0.2215[illegible] 00
0.30E-02	[illegible]	[illegible] 00
.10E-01	[illegible]	0.17[illegible] 00
0.30E-01	[illegible]	0.1[illegible] 00
.10E 00	[illegible]	0.177[illegible] 00
0.30E 00	0.1[illegible]	0.1[illegible] 00
.10E 01	0.1[illegible]	0.160[illegible] 00
[illegible]	[illegible]	[illegible] 00
.10E 02	0.1[illegible]	0.1[illegible] 00
0.30E 02	0.1[illegible]	0.1[illegible] 00
0.10E 03	0.17[illegible]-03	0.127[illegible] 00

CURVE-FITTED SYSTEM [illegible] SERIES

I	G(I) SERIES	DELTA(I)
1	-0.2[illegible]-04	0.1000[illegible] 03
2	-0.1[illegible]-05	0.1[illegible] 02
3	[illegible]	[illegible]
4	-0.22[illegible]	0.1[illegible] 01
5	-0.201[illegible]	0.1[illegible] 00
6	-0.2571[illegible]	0.3[illegible]
7	0.17[illegible]-03	0.0

PERMANENT DEFORMATION
SYSTEM RESPONSE FACTORS
GNU = 0.5[illegible]
ALPHA = 0.[illegible]35[illegible] 00

P R I M A R Y [illegible]

LAYER 1 THICKNESS = [illegible] INCHES
LAYER 2 THICKNESS = [illegible] INCHES
RADIAL POSITION = [illegible] INCHES
VERTICAL POSITION = [illegible] INCHES
LAYER OF INTEREST = 1
LOADING IN PSI = [illegible]

[illegible] VARIABLE IS >>> [illegible] STRAIN <<<

TIME (SEC)	[illegible]	COEF OF VAR
[illegible].10E-02	0.[illegible]E-0[illegible]	0.2[illegible]962E 00
[illegible].30E-02	0.[illegible]	0.[illegible]E 00
0.10E-01	0.1[illegible]E-05	0.[illegible]640E-01
0.30E-01	0.[illegible]E-05	0.[illegible]1[illegible]E-01
[illegible].10E 00	0.[illegible]E-05	0.[illegible]611E-01
[illegible].30E 00	0.[illegible]E-05	0.[illegible]75[illegible]E-01
0.10E 01	0.[illegible]E-05	0.11357E 00
[illegible].30E [illegible]1	0.[illegible]	0.12[illegible]E 00
[illegible].10E 02	0.[illegible]E-05	0.146[illegible]3E 00
[illegible].30E 02	0.[illegible]E-05	0.15[illegible]E 00
[illegible]	0.4[illegible]E-05	0.15739E 00

CURVE-FITTED [illegible] [illegible] [illegible] STRAIN [illegible]

I	COEF [illegible]	DELTA(I)
1	-0.[illegible]E-0[illegible]	0.10000E 03
2	-0.1397[illegible]E-0[illegible]	0.30000E 02
3	-0.[illegible]E-0[illegible]	[illegible]0000E 01
4	-0.9[illegible]E-0[illegible]	[illegible].10000E 01
5	-0.7[illegible]11E-0[illegible]	0.10000E 00
6	-0.3[illegible]E-0[illegible]	0.30000E-01
7	[illegible]0.442[illegible]E-05	0.0

FATIGUE CRACKING

GENERAL STRAIN ANALYSIS
DUE TO PEAK LOADING (HAVERSINE)

TEMPERATURE DEGREES-F	STRAIN INS./INS.	VAR STRAIN (INS./IN.)**2	NFAIL CYCLES	VAR NFAIL CYCLES**2	K1 CYCLES	K2 DIMENSIONLESS	GAMMA DIMENSIONLESS
46.70	[illegible]	0.21647E-09	0.32453E 09	0.25323E 15	0.45700E-04	0.25700E 01	0.53321E-02
53.30	[illegible]	0.23096E-07	0.43567E 08	0.45806E 15	0.72800E-04	0.25800E 01	0.12969E-01
59.50	[illegible]-04	0.51674E-09	0.55672E 08	0.74722E 15	0.15500E-03	0.25700E 01	0.55033E-01
65.00	[illegible]-04	0.11759E-08	0.39283E 08	0.37183E 15	0.79900E-03	0.25400E 01	[illegible] 00
75.00	[illegible]	0.29145E-08	0.33630E 08	0.27182E 15	0.24200E-02	0.25500E 01	[illegible] 01
81.00	[illegible]-03	0.58442E-08	0.59302E 08	0.84569E 15	0.12400E-01	0.25100E 01	0.26455E 02
84.00	[illegible]-04	0.74159E-08	0.92178E 08	0.20422E 16	0.28400E-01	0.25000E 01	0.44543E 02
84.70	[illegible]-05	[illegible]713E-08	0.94196E 08	0.21320E 16	0.25300E-01	0.26000E 01	0.45825E 02
78.00	0.17715E-05	0.45346E-08	0.40880E 08	0.40209E 15	0.55800E-02	0.25200E 01	0.10132E 02
70.10	[illegible]-05	0.16707E-08	0.34272E 08	0.28291E 15	0.93200E-03	0.25400E 01	0.1026[illegible]E 01
59.10	[illegible]	[illegible]	0.56732E 08	0.77597E 15	0.15100E-03	0.25700E 01	[illegible]E-01
52.30	[illegible]-06	0.22617E-09	0.44582E 08	0.47920E 15	0.65700E-04	0.25900E 01	0.39977E-02

DAMAGE INDEX DIMENSIONLESS	VAR DAMAGE INDEX DIMENSIONLESS	AREA CRACKED SQ.YDS/1000SQ.YDS	TIME YEARS
0.14666E-01	0.255[illegible]7E-04	0.0	0.50
0.26453E-01	[illegible]-04	0.0	1.00
0.41125E-01	[illegible]E-04	0.0	1.50
0.52865E-01	[illegible]-04	0.0	2.00
0.79498E-01	0.12275E-03	0.0	3.00
0.10573E 00	0.17[illegible]E-03	0.0	4.00
0.23789E 00	0.44338E-03	0.0	8.00
0.39649E 00	0.82254E-03	0.0	12.00
0.58151E 00	0.13423E-02	0.0	16.00
0.79297E 00	0.20[illegible]E-02	0.0	20.00

R U T   D E P T H

PERMANENT DEFORMATION

SYSTEM RESPONSE FACTORS

GNU = [illegible]

ALPHA = 0.2455E [illegible]

GENERAL DEFLECTION [illegible]

DUE TO STAR LOADING [illegible]

TEMPERATURE DEGREES F	DEFLECTION INCHES	VAR-DEFLECTION INCHES**2
49.70	[illegible]	0.2250E-05
53.30	[illegible]	0.2304?E-05
59.50	[illegible]	0.259?E-05
68.60	[illegible]	[illegible]
75.20	[illegible]	0.6??E-05
[illegible]	[illegible]	[illegible]
84.60	[illegible]	0.1170E-04
84.7?	[illegible]	0.11??E-04
73.40	[illegible]	0.5??E-05
70.10	[illegible]	0.5??E-05
59.10	[illegible]	0.25??E-05
[illegible]	[illegible]	[illegible]

RUT DEPTH INCHES	VAR-RUT DEPTH INCHES**2	TIME YEARS
0.?2924E-01	[illegible]	0.50
0.1?925E 00	0.17??E-02	1.00
0.11699E 00	[illegible]	1.50
0.12941E 00	[illegible]	2.00
0.14210E 00	[illegible]	3.00
0.153??E 00	[illegible]	4.00
0.16675E 00	[illegible]	[illegible]
0.21154E 00	[illegible]	12.00
0.23226E 00	[illegible]	16.00
0.25052E 00	0.94??E-02	20.00

[illegible] FACTORS	[illegible]	TIME YEARS
.23003	[illegible]-01	0.50
.40052 00	[illegible]+01	1.00
0.4559 [illegible]	[illegible]-01	1.50
.5[illegible]	[illegible]	2.00
.63449 [illegible]	[illegible] 00	3.00
.78760 00	[illegible] 00	4.00
0.116970 01	[illegible] 00	6.00
.15[illegible] 01	[illegible] 01	12.00
.16[illegible] 01	[illegible] 01	16.00
.21[illegible]	[illegible]	[illegible]

[illegible]

[illegible] DEPTH	[illegible] DEPTH	SLOPE VAR	VAR SLOPE VAR	CRACKING	VAR CRACKING	TIME
[illegible]	[illegible]	0.2300[illegible] 00	0.24109E-01	0.1466[illegible]-01	0.25567E-04	0.50
[illegible]	[illegible]	-0.4005[illegible] 00	-0.72705E-01	0.2643[illegible]-01	0.43249E-04	1.00
[illegible]	[illegible]	0.45[illegible] 00	0.95506E-01	0.4110[illegible]-01	0.68816E-04	1.50
[illegible]	[illegible]	-0.5619[illegible] 00	0.14297E 00	0.523[illegible]-01	0.9549[illegible]-04	2.00
[illegible]	[illegible]	0.6664[illegible] 00	0.21234E 00	0.792[illegible]-01	0.12975E-03	3.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.11[illegible] 01	0.62012E 00	0.237[illegible]	0.44330E-03	3.00
[illegible]	[illegible]	-0.1500[illegible] 01	0.10209E 01	[illegible]	0.8325[illegible]-03	12.00
[illegible]	[illegible]	0.1[illegible] 01	0.14635E 01	0.5[illegible] 00	0.15623E-02	15.00
[illegible]	[illegible]	0.210[illegible] 01	0.20061E 01	0.792[illegible] 00	0.20543E-02	20.00

SERVICEABILITY	VARIANCE OF SERVICEABILITY	TIME
[illegible]	0.09911	0.50
4.[illegible]	0.10577	1.00
[illegible]	0.11516	1.50
[illegible]	0.12476	2.00
[illegible]	0.13[illegible]07	3.00
4.31734	0.14529	[illegible]
4.1[illegible]	0.17612	[illegible]
4.0[illegible]35	0.19[illegible]70	12.00
[illegible]	0.21677	15.00
[illegible]	0.2[illegible]	20.00

SERVICEABILITY FAILURE LEVEL IS 2.50000

[illegible]

STATE UPPER BOUNDS = [illegible] 4.74889 4.4[illegible] 4.13567 3.90555 3.62444 3.34333 3.06222 2.78111 2.50000

STATE LOWER BOUNDS = 4.74889 4.46778 4.18667 3.90555 3.62444 3.34333 3.06222 2.78111 2.50000 [illegible]

STATE1	STATE2	STATE3	STATE4	STATE5	STATE6	STATE7	STATE8	STATE9	STATE10	TIME	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.00000	0.0	[illegible]
0.34221	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00000	0.5	1.00000
0.24255	[illegible]	[illegible]	0.11[illegible]	[illegible]	0.00333	0.00015	[illegible]	0.00000	0.00000	1.0	1.00000
0.21715	[illegible]	[illegible]	[illegible]	[illegible]	0.00579	[illegible]	[illegible]	0.00000	0.00000	1.5	1.00000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.1497[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00001	0.00000	3.0	[illegible]
0.12675	0.21775	[illegible]	[illegible]	0.15543	[illegible]	[illegible]	[illegible]	[illegible]	0.00000	4.0	1.00000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.11[illegible]72	[illegible]	[illegible]	0.00215	[illegible]	12.0	[illegible]72
0.0[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.15031	[illegible]	[illegible]	[illegible]	[illegible]	15.0	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

WARNING [illegible] EXCEEDS THE SPECIFIED TOLERANCE THROUGHOUT THE [illegible]
THIS ANALYSIS. [illegible] ACCURATE ESTIMATE [illegible] SERVICE LIFE IS REQUIRED, THIS [illegible] WITH ADDITIONAL [illegible] POINTS, EXTENDING [illegible] BELOW THE MINIMUM ACCEPTABLE LEVEL.

APPENDIX 2

OUTPUT FOR SENSITIVITY ANALYSIS OF PRIME

Sample Problem Set 1

Sample Problem Set 2

Sample Problem Set 3

Sample Problem Set 4

NOTE: This part is included in a separate volume.

APPENDIX 3

VISCOELASTIC CLOSED-FORM PROBABILISTIC SOLUTION FOR PRIME

APPENDIX 3

Viscoelastic Closed Form Probabilistic Solution for PRIME

1. Introduction

The primary response model PRIME for the VESYS G is a viscoelastic closed form probabilistic solution for N-layered pavement systems.

The geometrical model is a multi-layered, semi-infinite half-space, see Fig. A2-1. Each layer has distinct material properties characterized as linear elastic or linear viscoelastic. The material properties can be random (mean and deviation) or deterministic (mean value only). The loading is considered to be uniform, normal to the surface and acting over a circular area. The responses of the pavement system are the stresses (normal stress, tangential stress, radial stress and shear stress), strains (normal, tangential and gradial) and vertical deflection at any specified radial position and vertical position. As pointed out in Chapter 3, the viscoelastic solution for the primary responses (stresses, strains and deflections) was obtained using the "quasi-elastic" solution. This method involves replacing elastic moduli in a N-layered elastic solution by instantaneous values of the relaxation moduli (or creep compliances). The method is based upon the work of Schapery (1) and is applicable to viscoelastic problems in which the derivative of the time-dependent solution with respect to logarithmic times is a slowly varying function of log t.

---

(1) Schapery, R. A., "A Method of Viscoelastic Stress Analysis Using Elastic Solutions", J. Franklin Institute, Vol. 279, pp. 268-289, 1965.

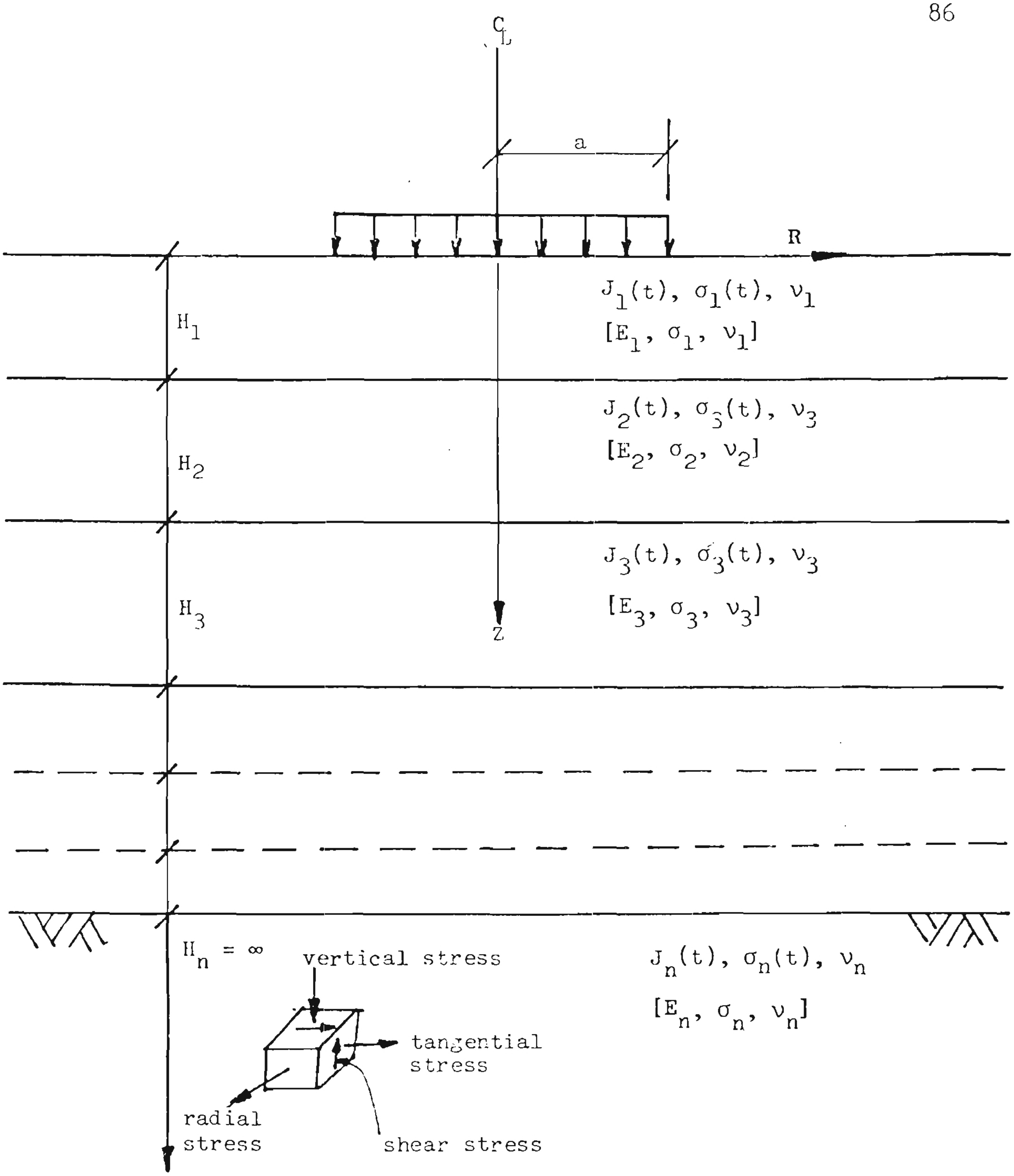

Figure 3-1. Schematic of N-Layered Viscoelastic System

Thus, the viscoelastic solution consists of a series of elastic solutions, with each elastic solution corresponding to the value of the viscoelastic solution at that specific time.

The quasi elastic solution consists of two parts, determining the expected values for the primary responses, and the deviations for the primary responses. CHEV5L (2) program was used in the first part to determine the expected values for the primary responses. Modifications were made on CHEV5L such that the program can handle any number of layers instead of a maximum of five layers.

In the following the formulations for determining the expected values and deviations of the primary responses for a N-layered pavement system are presented.

2. Primary Responses in an Elastic Layered System

The formulation presented in this section are based on the work of Warren and Dieckman (2). The reader is referred to the original work for more detailed derivations.

In an axially symmetric, cylindrical coordinate system, the stresses and displacements in each layer may be written in matrix form

$$S_i(z) = \begin{bmatrix} \sigma_z^i \\ \tau_{rz}^i \\ u^i \\ w^i \end{bmatrix} = K(\nu_i, E_i)\, M(z, \nu_i)\, D(z) \begin{bmatrix} A_i \\ B_i \\ C_i \\ D_i \end{bmatrix} \tag{1}$$

(2) Warren, H. and Dieckman, W. L., "Numerical Computation of Stresses and Strains in a Multiple Layer Asphalt Pavement System", Chevron Research Corp., Unpublished Internal Report, 1963.

where σ_z^i, τ_{rz}^i, u^i, and w^i refer to normal stress, shear stress, radial displacement and vertical displacment in the i^{th} layer, and

$$K(\nu, E) = \begin{bmatrix} -m J_o(mr) & -- & -- & -- \\ -- & m^2 J_1(mr) & -- & -- \\ -- & -- & \frac{1+\nu}{E} m J_1(mr) & -- \\ -- & -- & -- & -\frac{1+\nu}{E} m J_o(mr) \end{bmatrix} \quad (2)$$

$$M(z, \nu) = \begin{bmatrix} 1 & mz + 2\nu - 1 & -1 & -mz + 2\nu - 1 \\ 1 & mz + 2\nu & 1 & mz - 2\nu \\ 1 & mz + 1 & -1 & -mz + 1 \\ 1 & mz + 4\nu - 2 & 1 & mz - 4\nu + 2 \end{bmatrix} \quad (3)$$

$$D(z) = \begin{bmatrix} me^{mz} & -- & -- & -- \\ -- & e^{mz} & -- & -- \\ -- & -- & me^{-mz} & -- \\ -- & -- & -- & e^{-mz} \end{bmatrix} \quad (4)$$

and A_i, B_i, C_i, D_i are constants which are determined from boundary and continuity conditions between layers:

and A_i, B_i, C_i, D_i are constants which are determined from boundary and continuity conditions between layers:

$$\begin{bmatrix} A_i \\ B_i \\ C_i \\ D_i \end{bmatrix} = \frac{D^{-1}(h_i)\, X_i\, D(h_i)}{4(\nu_i - 1)} \begin{bmatrix} A_{i+1} \\ B_{i+1} \\ C_{i+1} \\ D_{i+1} \end{bmatrix}, \quad i = 1, 2, \ldots, n-1$$

$$= \prod_{j=i}^{n-1} \frac{D^{-1}(h_j)\, X_j\, D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix} \quad (5)$$

$$\begin{bmatrix} 0 \\ K(m) \end{bmatrix} = Q \prod_{j=1}^{n-1} \frac{D^{-1}(h_j)\, X_j\, D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix} \tag{6}$$

where $K(M) = 1/m^2$, and

$$Q = \begin{bmatrix} m & 2\nu_1 & m & -2\nu_1 \\ m & 2\nu_1 - 1 & -m & 2\nu_i - 1 \end{bmatrix} \tag{7}$$

$$X_i = 4M^{-1}(h_i, \nu_i)\, K^{-1}(\nu_i, E_i)\, K(\nu_{i+1}, E_{i+1})\, M(h_i, \nu_{i+1})\, (\nu_i - 1) \tag{8}$$

In the above equations m is a dummy variable; $J_o(mr)$, $J_1(mr)$ are Bessel functions, ν_i and E_i are Poisson's ratio, and the Elastic Modulus of the i^{th} layer; and σ_z^i, τ_{rz}, u^i, w^i are the normal stress, shear stress, radial displacement and vertical displacement of the i^{th} layer. Thus, given the number of layers n, E_i, ν_i (i = 1, ..., n) and with a unit load acting on the surface point, Equations (5) and (6) can be used to determine the coefficients A_i, B_i, C_i, D_i (i = 1, ..., n). Then substituting into Equation (1), the stresses and displacements in each layer can be determined.

For a circular load, acting over radius as with intensity p, the stresses and displacements are given by

$$\begin{aligned} \tilde{\sigma}_z^i &= a \int_0^\infty J_1(ma)\, \sigma_z^i\, dm \\ \tilde{\tau}_{rz}^i &= a \int_0^\infty J_1(ma)\, \tau_{rz}^i\, dm \\ \tilde{u}^i &= a \int_0^\infty J_1(ma)\, u^i\, dm \\ \tilde{w}^i &= a \int_0^\infty J_1(ma)\, w^i\, dm \end{aligned} \tag{9}$$

3. Probabilistic Closed Form Solution

The partial derivative method was used for developing closed form probabilistic solutions for the stationary load program.

The method involves expanding the desired function (stress, strain or deflection) in a Taylor's Series expansion about the mean and neglecting all moments greater than second order. For example, letting S_i represent the desired stress or displacement at the i^{th} layer of the pavement system and $E_1, E_2, \ldots, E_n$ the instantaneous values of the relaxation modulus of N-layers of different materials at the loading time of interest, one can write

$$S_i = g_i(E_1, E_2, \ldots, E_n) \tag{10}$$

The expected value of S_i may be approximated by the expression

$$E[S_i] = g_i(\bar{E}_1, \bar{E}_2, \ldots, \bar{E}_n) + \frac{1}{2}\sum_{j=1}^{n} \frac{\partial^2 g_i}{\partial E_j^2}\bigg|_{\bar{E}_j} \sigma^2_{E_j} \tag{11}$$

The variance of S_i is given by

$$Var[S_i] = \sum_{j=1}^{n} \left(\frac{\partial g_i}{\partial E_j}\bigg|_{\bar{E}_j} \right)^2 \sigma^2_{E_j} \tag{12}$$

The term $g_i(\bar{E}_1, \bar{E}_2, \ldots, \bar{E}_n)$ represents the mean value of S_i, i.e., the value of S_i obtained using mean moduli values $\bar{E}_i$. The terms

$$\frac{\partial^2 g_i}{\partial E_j^2}\bigg|_{\bar{E}_j} \sigma^2_{E_j} \qquad \text{and} \qquad \left(\frac{\partial g_i}{\partial E_j}\bigg|_{\bar{E}_j} \right)^2 \sigma^2_{E_j}$$

are the 2nd and 1st partial derivatives of S_i with respect to E_j evaluated at $\bar{E}_j$ and multiplied by $\sigma^2_{E_j}$ respectively. The $\bar{E}_j$ and $\sigma^2_{E_j}$ are assumed to have been determined from an experimental characterization program. Equation (11) and (12) were used assuming that E_i are mutually independent.

From Eq. (1)

$$\frac{\partial g_i}{\partial E_j} = \frac{\partial S_i}{\partial E_j} = \frac{\partial K(\nu_i, E_i)}{\partial E_j} M(z_i, \nu_i)\ D(z) \begin{bmatrix} A_i \\ B_i \\ C_i \\ D_i \end{bmatrix} + K(\nu_i, E_i)\ M(z_i, \nu_i)\ D(z) \begin{bmatrix} \frac{\partial A_i}{\partial E_j} \\ \frac{\partial B_i}{\partial E_j} \\ \frac{\partial C_i}{\partial E_j} \\ \frac{\partial D_i}{\partial E_j} \end{bmatrix} \qquad (13)$$

$$\frac{\partial^2 g_i}{\partial E_j^2} = \frac{\partial^2 S_i}{\partial E_j^2} = \frac{\partial^2 K(\nu_i, E_i)}{\partial E_j^2} M(z_i, \nu_i)\ D(z) \begin{bmatrix} A_i \\ B_i \\ C_i \\ D_i \end{bmatrix} + 2\frac{\partial K(\nu_i, E_i)}{\partial E_j} M(z_i, \nu_i)\ D(z) \begin{bmatrix} \frac{\partial A_i}{\partial E_j} \\ \frac{\partial B_i}{\partial E_j} \\ \frac{\partial C_i}{\partial E_j} \\ \frac{\partial D_i}{\partial E_j} \end{bmatrix}$$

$$+ K(\nu_i, E_i)\, M(z_i, \nu_i)\, D(z) \begin{bmatrix} \dfrac{\partial^2 A_i}{\partial E_j^2} \\ \dfrac{\partial^2 B_i}{\partial E_j^2} \\ \dfrac{\partial^2 C_i}{\partial E_j^2} \\ \dfrac{\partial^2 D_i}{\partial E_j^2} \end{bmatrix} \qquad (14)$$

where

$$\frac{\partial K(\nu_i, E_i)}{\partial E_j} = \begin{bmatrix} 0 & -- & -- & -- \\ -- & 0 & -- & -- \\ -- & -- & \dfrac{-(1+\nu)}{E_j^2}\,\delta_{ij}\, m\, J_1(mr) & -- \\ -- & -- & -- & \dfrac{+(1+\nu)}{E_j^2}\,\delta_{ij}\, m\, J_o(mr) \end{bmatrix} \qquad (15)$$

$$\frac{\partial^2 K(\nu_i, E_i)}{\partial E_j^2} = \begin{bmatrix} 0 & -- & -- & -- \\ -- & 0 & -- & -- \\ -- & -- & \dfrac{+2(1+\nu)}{E_j^3}\,\delta_{ij}\, m\, J_1(mr) & -- \\ -- & -- & -- & \dfrac{-2(1+\nu)}{E_j^3}\,\delta_{ij}\, m\, J_o(mr) \end{bmatrix} \qquad (16)$$

and

$$\delta_{ij} = \begin{cases} 1 & \text{when } i=j \\ 0 & \text{when } i \neq j \end{cases}$$

Differentiating Equation (6) and rearranging the terms

$$\prod_{j=1}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ \frac{\partial C_n}{\partial E_j} \\ \frac{\partial D_n}{\partial E_j} \end{bmatrix} =$$

$$\sum_{\ell=1}^{n-1} \frac{D^{-1}(h_\ell)\; \frac{\partial X_\ell}{\partial E_j}\; D(h_\ell)}{4(\nu_\ell - 1)} \prod_{\substack{j=1 \\ j \neq \ell}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \cdot \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix} \tag{17}$$

where $\frac{\partial X_i}{\partial E_j}$ is defined in Equation (18)

$$\frac{\partial X_i}{\partial E_j} = \begin{bmatrix} -\frac{\partial L_i}{\partial E_j} & \frac{\partial L_i}{\partial E_j} \cdot q(-h_i, \nu_{i+1}, \nu_i) & -(2mh_i + 4\nu_i - 1)\frac{\partial L_i}{\partial E_j} & \frac{-\partial L_i}{\partial E_j} p(-h_i, \nu_{i+1}, \nu_i) \\ 0 & \frac{\partial L_i}{\partial E_j}(4\nu_{i+1} - 3) & 2\frac{\partial L_i}{\partial E_j} & (2mh_i - 4\nu_{i+1} + 1)\frac{\partial L_i}{\partial E_j} \\ (2mh_i - 4\nu_i + 1)\frac{\partial L_i}{\partial E_j} & \frac{\partial L_i}{\partial E_j} p(h_i, \nu_{i+1}, \nu_i) & -\frac{\partial L_i}{\partial E_j} & -\frac{\partial L_i}{\partial E_j} q(h_i, \nu_{i+1}, \nu_i) \\ -2\frac{\partial L_i}{\partial E_j} & -(2mh_i + 4\nu_{i+1} - 1)\frac{\partial L_i}{\partial E_j} & 0 & (4\nu_{i+1} - 3)\frac{\partial L_i}{\partial E_j} \end{bmatrix} \qquad (18)$$

where

$$\frac{\partial L_i}{\partial E_j} = \frac{\partial \left[\frac{E_i}{E_{i+1}} \frac{1 + \nu_{i+1}}{1 + \nu_i}\right]}{\partial E_j} = \left(\frac{1 + \nu_{i+1}}{1 + \nu_i}\right) \left[\frac{1}{E_{i+1}} \delta_{ij} - \frac{E_i}{E_{i+1}^2} \delta_{\alpha j}\right] \quad ; \alpha = i+1$$

$$p(h,\nu,\mu) = m^2(2h^2) + 4mh(\nu-\mu) + (1-8\nu\mu + 2\mu)$$

$$q(h,\nu,\mu) = 2mh(2\nu-1) - (1 + 8\nu\mu-6\mu)$$

From Equation (5) we obtain

$$\begin{bmatrix} \frac{\partial A_i}{\partial E_j} \\ \frac{\partial B_i}{\partial E_j} \\ \frac{\partial C_i}{\partial E_j} \\ \frac{\partial D_i}{\partial E_j} \end{bmatrix} = \prod_{j=i}^{n-1} \frac{D^{-1}(h_j)\ X_j\ D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ \frac{\partial C_n}{\partial E_j} \\ \frac{\partial D_n}{\partial E_j} \end{bmatrix}$$

$$+ \sum_{\ell=i}^{n-1} \frac{D^{-1}(h_\ell)\ \frac{\partial X_\ell}{\partial E_j}\ D(h_\ell)}{4(\nu_\ell - 1)} \prod_{\substack{j=i \\ j\neq\ell}}^{n-1} \frac{D^{-1}(h_j)\ X_j\ D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix} \qquad (19)$$

Since C_n, D_n, A_i, B_i, C_i, D_i are determined using the mean values, $\overline{E}_i$, $\frac{\partial C_n}{\partial E_j}$, $\frac{\partial D_n}{\partial E_j}$, $\frac{\partial A_i}{\partial E_j}$, $\frac{\partial B_i}{\partial E_j}$, $\frac{\partial C_i}{\partial E_j}$, $\frac{\partial D_i}{\partial E_j}$ $(i = 1, \ldots, n-1)$ may be determined using Equations (17) and (19). The second partial derivatives of S_i with respect to E_j are obtained from Equations (17) and (19).

$$Q \prod_{j=1}^{n-1} \frac{D^{-1}(h_j)\ X_j\ D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ \frac{\partial^2 C_n}{\partial E_j^2} \\ \frac{\partial^2 D_n}{\partial E_j^2} \end{bmatrix}$$

$$= -2 \sum_{\ell=1}^{n-1} \frac{D^{-1}(h_\ell)\, \frac{\partial X_\ell}{\partial E_j}\, D(h_\ell)}{4(\nu_\ell - 1)} \prod_{\substack{j=1 \\ j\neq \ell}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ \frac{\partial C_n}{\partial E_j} \\ \frac{D_n}{E_j} \end{bmatrix}$$

$$- \sum_{\ell=1}^{n-1} \frac{D^{-1}(h_\ell)\, \frac{\partial^2 X}{\partial E_j^2}\, D(h_\ell)}{4(\nu_\ell - 1)} \prod_{\substack{j=1 \\ j\neq}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix}$$

$$- \sum_{\ell=1}^{n-1} \frac{D^{-1}(h_\ell)\, \frac{\partial X_\ell}{\partial E_j}\, D(h_\ell)}{4(\nu_\ell - 1)} \qquad \sum_{\substack{k=1 \\ k\neq \ell}}^{n-1} \frac{D^{-1}(h_j)\, \frac{\partial X_k}{\partial E_j}\, D(h_k)}{4(\nu_k - 1)}$$

$$\prod_{\substack{j=1 \\ j\neq k \\ j\neq \ell}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix} \qquad (20)$$

and

$$\begin{bmatrix} \dfrac{\partial^2 A_i}{\partial E_j^2} \\ \dfrac{\partial^2 B_i}{\partial E_j^2} \\ \dfrac{\partial^2 C_i}{\partial E_j^2} \\ \dfrac{\partial^2 D_i}{\partial E_j^2} \end{bmatrix} = \prod_{j=1}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ \dfrac{\partial^2 C_n}{\partial E_j^2} \\ \dfrac{\partial^2 D_n}{\partial E_j^2} \end{bmatrix}$$

$$+\; 2 \sum_{\ell=i}^{n-1} \frac{D(h_\ell)\; \dfrac{\partial X_\ell}{\partial E_j}\; D(h_\ell)}{4(\nu_\ell - 1)} \prod_{\substack{j=i \\ j\neq \ell}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; \quad (h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ \dfrac{\partial C_n}{\partial E_j} \\ \dfrac{\partial D_n}{\partial E_j} \end{bmatrix}$$

$$+ \sum_{\ell=i}^{n-1} \frac{D^{-1}(h_\ell)\; \dfrac{\partial^2 X_\ell}{\partial E_j^2}\; D(h_\ell)}{4(\nu_\ell - 1)} \prod_{\substack{j=i \\ j\neq \ell}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix}$$

$$+ \sum_{=i}^{n-1} \frac{D^{-1}(h_\ell)\; \dfrac{\partial X_\ell}{\partial E_j}\; D(h\quad)}{4(\nu_\ell - 1)} \sum_{\substack{k=i \\ k\neq \ell}}^{n-1} \frac{D^{-1}(h_k)\; \dfrac{\partial X_k}{\partial E_j}\; D(h_k)}{4(\nu_k - 1)}$$

$$\prod_{\substack{j=i \\ j\neq k \\ j\neq \ell}}^{n-1} \frac{D^{-1}(h_j)\; X_j\; D(h_j)}{4(\nu_j - 1)} \begin{bmatrix} 0 \\ 0 \\ C_n \\ D_n \end{bmatrix} \qquad (21)$$

where

$$\frac{\partial^2 X_i}{\partial E_j^2} = \begin{bmatrix} -\frac{\partial^2 L_i}{\partial E_j} & \frac{\partial^2 L_i}{\partial E_j^2} q(-h_i, \nu_{i+1}, \nu_i) & -(2mh_i + 4\nu_i - 1)\frac{\partial^2 L_i}{\partial E_j^2} & -\frac{\partial^2 L_i}{\partial E_j^2}(-h_i, \nu_{i+1}, \nu_i) \\ 0 & \frac{\partial^2 L_i}{\partial E_j^2}(4\nu_{i+1} - 3) & 2\frac{\partial^2 L_i}{\partial E_j^2} & (2mh_i - 4\nu_{i+1} + 1)\cdot\frac{\partial^2 L_i}{\partial E_j^2} \\ (2mh_i - 4\nu_i + 1)\frac{\partial^2 L_i}{\partial E_j^2} & \frac{\partial^2 L_i}{\partial E_j^2} p(h_i, \nu_{i+1}, \nu_i) & -\frac{\partial^2 L_i}{\partial E_j^2} & -\frac{\partial^2 L_i}{\partial E_j^2} q(h_i, \nu_{i+1}, \nu_i) \\ -2\frac{\partial^2 L_i}{\partial E_j^2} & -(2mh_i + 4\nu_{i+1} - 1)\frac{\partial^2 L_i}{\partial E_j^2} & 0 & \frac{\partial^2 L_i}{\partial E_j^2} \end{bmatrix} \quad (22)$$

and $$\frac{\partial^2 L_i}{\partial E_j^2} = 2\left(\frac{1 + \nu_{i+1}}{1 + \nu_i}\right)\left[\frac{-1}{E_{i+1}^2}\delta_{\alpha j} \quad \delta_{ij} + \frac{E_i}{E_{i+1}^3}\delta_{\alpha j}\right] ; \quad \alpha = i+1$$

Now that $\frac{\partial A_i}{\partial E_j}$, $\frac{\partial B_i}{\partial E_j}$, $\frac{\partial^2 C_i}{\partial E_j^2}$, $\frac{\partial^2 D_i}{\partial E_j^2}$ are known, these may be substituted into Equations (13) and (14) and then (11) and (12) to obtain $E[S_i]$ and $Var[S_i]$.

To obtain the solution for a circular load, the stresses or displacement must be integrated from zero to infinity with respect to m and multiplied by a. Hence

$$
\begin{aligned}
E[\tilde{S}_i] &= a\,E\left[\int_0^{\infty} J_1(ma)\,S_i\,dm\right] \\
&\simeq a\,E\left[\sum_{j=1}^{n} J_1(ma)_j\,S_{ij}\,\Delta\,(m_j)\right] \\
&\simeq a\left[\sum_{j=1}^{m} J_1(ma)_j\,E[S_i]_j\,\Delta\,(m_j)\right] \\
&= a\int_0^{\infty} J_1(ma)\,E[S_i]\,dm
\end{aligned}
\tag{23}
$$

where $J_1(ma)_j$, S_{ij} denote $J_1(ma)$, S_i evaluated at $m = m_j$.

Similiarly,

$$
\begin{aligned}
VAR\,[\tilde{S}_i] &= \sum_{j=1}^{N} (\sigma_j)^2\,a^2\left[\frac{\partial}{\partial E_j}\int_o^{\infty} J_1(ma)\,S_i(E_j,m)\,dm\right]^2 \\
&= \sum_{j=1}^{N} (\sigma_j)^2\,a^2\left[\int_o^{\infty} J_1(ma)\,\frac{\partial\,S_i(E_j,m)}{\partial\,E_j}\,dm\right]^2
\end{aligned}
\tag{24}
$$

APPENDIX 4

PROGRAM LISTING

NOTE: This part is included in a separate volume.