THE FLORIDA COMPREHENSIVE PAVEMENT ANALYSIS SYSTEM (COMPAS) - VOL. 2: USER'S GUIDE

FLORIDA DOT STATE PROJECT 99000-1712

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ABSTRACT

This report explains the use of the Florida Comprehensive Pavement Analysis System (COMPAS). This system was developed to assist the Florida Department of Transportation in evaluating the effects of different forecasted truck characteristics and truck use on flexible pavement performance and life-cycle costs. The evaluation of the effects of heavy vehicle characteristics is accomplished through the combined use of the following analytical models in Florida COMPAS:

1. a load-shift algorithm;
2. a vehicle simulation model;
3. a program for evaluating load equivalencies;
4. a program for evaluating cumulative 18-kip ESAL's;
5. a performance evaluation and overlay design procedure; and
6. a cost evaluation program.

In order to provide user support in applications of Florida COMPAS, data entry programs have been written to facilitate user input of required data. These programs serve as interfaces between the user, and the various analytical models given previously, and were specifically written to make the package user friendly. A user's guide to this comprehensive pavement analysis system is presented in this report. The general structure of the computer package is explained, the different input data screens are discussed, and separate input guides to the pavement performance, vehicle simulation, and cost analysis models are presented.

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Florida Department of Transportation. This report does not constitute a standard, specification, or regulation.

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CHAPTER 1. INTRODUCTION

Premature failures of flexible pavements can occur for a variety of reasons among which are: 1) increased vehicle loads; 2) changes in tire construction and recommended tire inflation pressures; 3) dynamic load amplification due to road roughness and differences in vehicle suspension characteristics; and 4) inadequate structural design. In view of the many possible causes of premature failures, a comprehensive understanding of why they occur can only be obtained with a system capable of handling the many different factors that affect pavement performance.

The objective of State Project 99000-1712 is to provide the Florida Department of Transportation (FDOT) with a system for assessing the impact of different forecasted truck characteristics and use on flexible pavement performance. Truck suspension, tire inflation pressure, axle load, and axle configuration are vehicle-related factors that influence the rate of pavement deterioration with time. The system developed in this study, Florida COMPAS, is intended to be a project level analysis tool for estimating not only the effects of heavy-vehicle characteristics on pavement performance, but also the economic and energy impact that changes in truck characteristics and use can bring about. Florida COMPAS is particularly useful for developing rational policies to regulate freight carriers on the State's highway network, for assessment of pavement damage responsibility and road user fees, and as a tool to the Department for formulating recommendations to the State Legislature concerning truck weight regulations. The system is even more relevant in view of the changes that have occurred in truck and tire technology over the years, the effects of which may no longer be evaluated using current empirical pavement performance relationships. These changes include: 1) the observed increase in recommended tire inflation pressures compared to those used during the time of the AASHO Road Test; 2) the predominant use of conventional radial tires in lieu of bias-ply tires; 3) the emerging acceptance of wide base radial tires, also known as "super-singles", in the United States; 4) the growing use of air bag and other recent suspension designs; and 5) the potential introduction of new vehicle configurations such as tractor-tanker combinations with triple axles on the trailing tanker. Only through a comprehensive approach that combines procedures for: 1) simulating the effects of vehicle characteristics on vehicle loadings; 2) evaluating pavement performance as a function of pavement material properties, layer thicknesses, axle loads, axle configuration, tire type, tire inflation pressure, and tire configuration; and 3) estimating user and pavement costs associated with different forecasted vehicle characteristics and truck use can the Department be truly responsive to the changes that have taken place in truck and tire technology and to those that will still occur in the future. The system developed for Florida on this research project was developed based on this approach. It is an integrated package that combines all of the aforementioned analysis procedures and is aptly named **Florida COMPAS** for **Florida COM**prehensive **P**avement **A**nalysis **S**ystem.

The systems framework of this comprehensive pavement analysis tool is shown in Figure 1. The purpose of this introduction is to provide an overview of Florida COMPAS by explaining the general structure of the package and the basic functions of each element of the framework. This overview will then be followed by descriptions of the various data entry screens built into the package to facilitate user input of required data. Only instructions on the use of the analysis package are provided in this

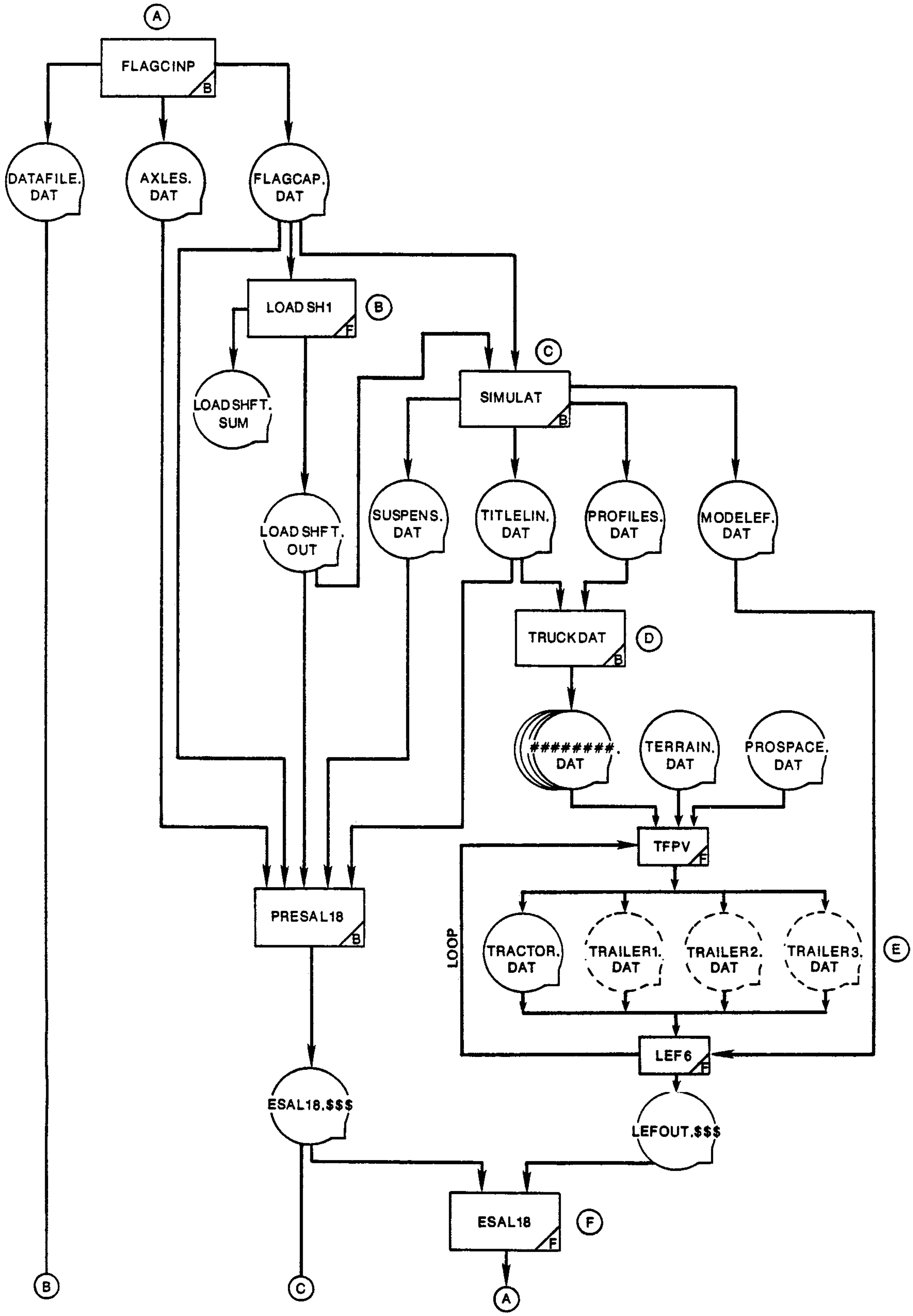


Figure 1. Systems Framework for Florida COMPAS.

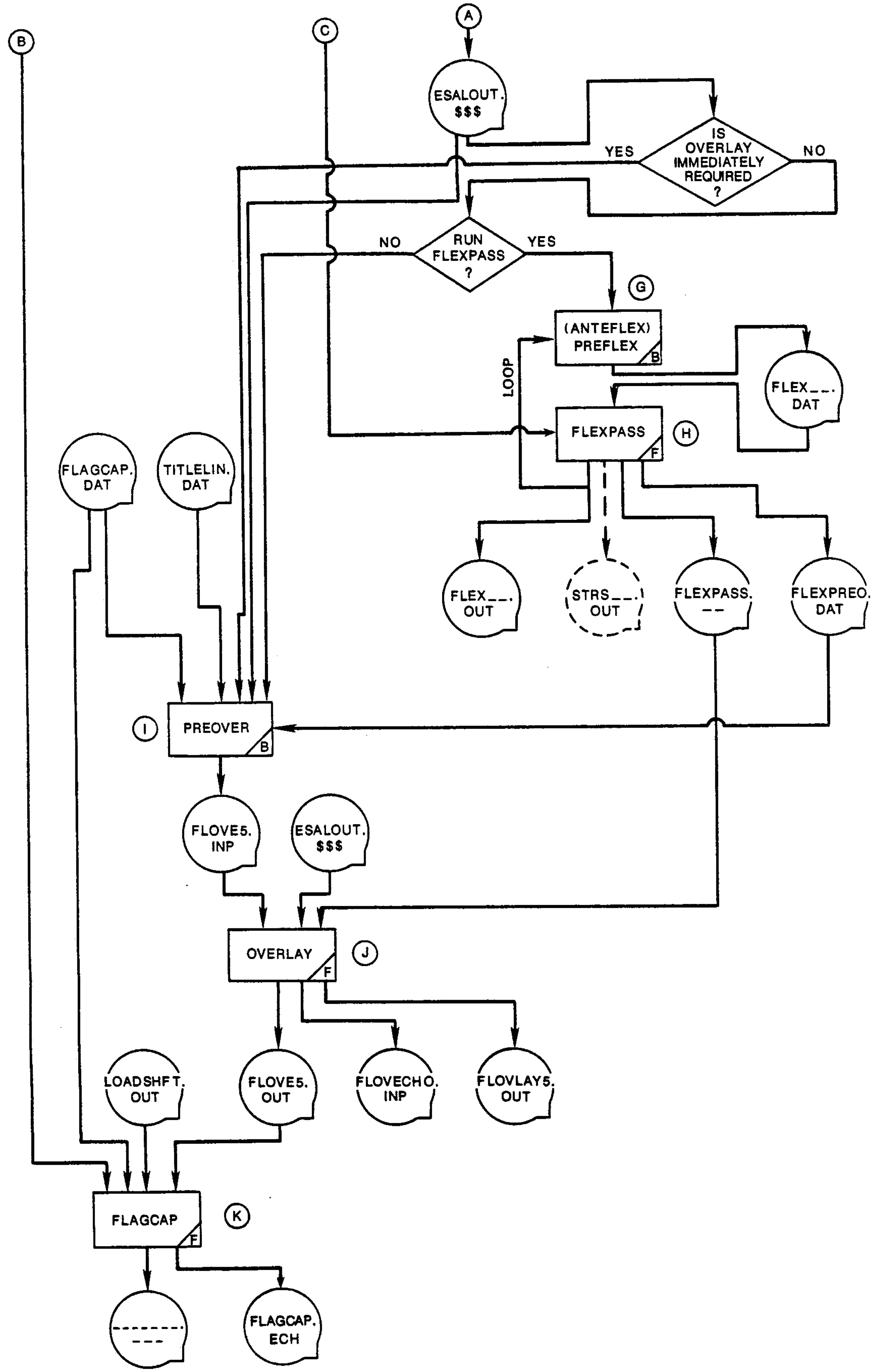


Figure 1. Systems Framework for Florida COMPAS (continued).

manual. Discussions on the development of the different analytical models are given in the accompanying volume to this User's Guide (1) entitled, "The Florida Comprehensive Pavement Analysis System (COMPAS) - Vol. 1: Development of Analytical Models."

OVERVIEW OF FLORIDA COMPAS

The evaluation of the effects of heavy vehicle characteristics on pavement performance and life-cycle costs is accomplished through the combined use of the following analytical models in Florida COMPAS:

1. A load-shift algorithm (LOADSH1);
2. A vehicle simulation model (TFPV; for Tire Force Prediction, Version V);
3. A program for evaluating load equivalencies (LEF6, for Load Equivalency Factors, Version 6);
4. A program for evaluating cumulative 18-kip ESALs (ESAL18);
5. A performance evaluation and overlay design procedure consisting of the programs FLEXPASS and OVERLAY; and
6. A cost evaluation program (FLAGCAP).

The above programs are considered to be the primary elements of the framework since each performs specific analytical functions that are important to achieving the overall purpose of Florida COMPAS as a tool for estimating the effects, of heavy vehicle characteristics and truck use, on pavement performance and life cycle costs. In order to provide user support in applications of Florida COMPAS, data entry programs have also been written to facilitate user input of required data. Thus, these programs serve as interfaces between the user, and the various analytical models and were specifically written to make the package user-friendly.

The following are the data entry programs in Florida COMPAS:

1. FLAGCINP - creates the data input file for the LOADSH1 and FLAGCAP programs.
2. SIMULAT - creates files that control the generation of input files to the vehicle simulation and load equivalency programs.
3. TRUCKDAT - uses files created by SIMULAT and data entered by the user to generate the required input files for the vehicle simulation and load equivalency programs.
4. PRESAL18 - creates the input file for the ESAL18 program.
5. PREFLEX - creates the input file for the FLEXPASS program.
6. PREOVER - creates the input file for the OVERLAY program.

The data entry programs are written in the BASIC programming language as denoted by the letter "B" in the lower right corner of each box representing these programs in the framework shown in Figure 1. On the other hand, the various analytical models are written in standard FORTRAN 77, as indicated by the letter "F", in the lower right corner of each box for these programs. Encircled letters alongside the boxes representing the different programs correspond to items in the menu that is displayed when the user executes the programs individually. In this way, the user can refer to Figure 1 to keep track of where he or she is at during execution of Florida COMPAS. The program menu is presented in the succeeding chapter of this User's Guide.

As indicated in Figure 1, FLAGCINP is initially executed, to prompt the user for the required input data to LOADSH1 and FLAGCAP. Both of these programs share a common input file, known as FLAGCAP.DAT, which is created by FLAGCINP from input provided by the user. The required input data are presented in a later chapter that describes the different data entry screens in Florida COMPAS. In addition, the format of the input file, FLAGCAP.DAT, is explained in Appendix A.

The FLAGCINP program also creates 2 additional files, known as DATAFILE.DAT and AXLES.DAT, which contain certain input data required by other programs. Specifically, DATAFILE.DAT contains information identifying the project to be analyzed, such as the District and county where the project is located, and the beginning and ending mileposts. This information is read by FLAGCAP and printed out as part of the program output. AXLES.DAT, on the other hand, contains data needed by PRESAL18 to create the input file for the ESAL18 program.

Once FLAGCAP.DAT is created, the load-shift algorithm is executed to predict the shift in gross vehicle and axle weight distributions resulting from a user-specified increase in legal load limits. Current and alternate scenarios are defined by the user in FLAGCINP that establishes, among other things: 1) the different vehicle categories in the traffic stream; 2) the current and proposed legal load limits; 3) estimates of the current and expected usage of the different tire types; 4) current and expected tire inflation pressures for the different tire types; and 5) the existing gross vehicle weight (GVW) distribution for each vehicle type. Default values for many of these variables are provided within FLAGCINP to facilitate user input.

The output from the load-shift program, LOADSHFT.OUT, contains estimates of axle loads for different GVW categories, which are required by the TFPV, LEF6, and ESAL18 programs. Consequently, LOADSHFT.OUT is read by SIMULAT and PRESAL18 in the creation of input files for these analysis programs. The format of LOADSHFT.OUT is explained in

Appendix B. In addition, a file called LOADSHFT.SUM is created, which provides a summary of the number of vehicles, the average GVW, and the average payload of each given vehicle category, for both base and alternate scenarios.

Input data screens in SIMULAT prompt the user for information that control the generation of input files to the vehicle simulation and load equivalency programs. For each vehicle type, the user has the option of specifying, in SIMULAT, which GVW categories to run with the simulation model and of specifying the types of suspensions that are used with a given vehicle type. In addition, for a divided highway, the user has the option of specifying whether two separate analyses will be made for each traffic direction. In this case, the user can specify individual analysis sections for the two traffic directions that may differ in terms of pavement surface profile, layer thicknesses, material properties, and initial Present Serviceability Index (PSI). In this instance, separate performance evaluations, overlay designs, and cost evaluations will be made for the prescribed analysis sections.

The number of simulation runs to be executed for any given vehicle category and scenario will depend on the number of GVW categories selected for the simulation, the number of prescribed suspension types and tire types, and whether the project to be analyzed is on a divided or an undivided highway. From the information provided by the user, SIMULAT creates a file called TITLELIN.DAT, which controls the number of vehicle simulation files to be generated, and thus, the number of vehicle simulation runs to be made. In particular, for each record in TITLELIN.DAT, a vehicle simulation input file is created by the TRUCKDAT data entry program. Thus, the number of records in TITLELIN.DAT corresponds to the number of vehicle simulation runs to be made. The format of this file is explained in Table 1. With the exception of the predicted axle weights from LOADSH1, the vehicle simulation flag, and the simulation speed all of the data in each record of TITLELIN.DAT are written in the first card of the vehicle simulation input file corresponding to the given record. The first card of the simulation input file is treated as a title card by the TFPV program, which explains the choice of the filename, TITLELIN.DAT.

The other files created by the SIMULAT program are briefly described as follows:

1. SUSPENS.DAT - contains the percentage of vehicles within a given vehicle category whose non-steering axles are of a given suspension type. Currently, the following 4 suspension categories are considered: (a) leaf spring; (b) air bag; (c) walking beam; and (d) "other" user-defined vehicle suspension system.
2. PROFILES.DAT - contains the name of the file having the surface profile data for a given run of the vehicle simulation program, and the simulation distance, in feet. A one-to-one correspondence exists between each record in PROFILES.DAT, and each record in TITLELIN.DAT.
3. MODELEF.DAT - contains switches for the LEF6 program that control how load equivalency factors will be adjusted for dynamic load effects, and whether load equivalencies will be calculated for the steering axles. The switches are specified by the user during the execution of the SIMULAT data entry

Table 1. Format of Each Record in TITLELIN.DAT.

Column(s)	Variable	Entry
2	ISCE	Scenario number which is 1 for current scenario, and 2 for alternate scenario.
3-4	VEHCAT	Vehicle category.
5-6	GVWCAT	Gross vehicle weight (GVW) category. If a percentile of the GVW distribution has been specified by the user, GVWCAT = 99.
7-16	VEHNO	Number of vehicles per day for the given scenario, vehicle category, and GVW category. This is the number of vehicles for both traffic directions.
17-18	TIRTYP	Tire type, which is 1 for conventional radial tires; 2 for bias-ply tires; and 3 for wide-base radial tires.
19-20	ISUS	Suspension category, which is 1 for leaf spring suspensions; 2 for air bag suspensions; 3 for walking beam suspensions; and 4 for "OTHER" user defined suspension system.
21-26	PCTTIR	Percent of vehicle in given vehicle category with given tire type, TIRTYP.
28-33	PCTSUS	Percent of vehicles in given vehicle category the non-steering axles of which are of the given suspension type, ISUS.
35-36	LANES	The number of lanes in both traffic directions.
38	KODE1	Code for divided (KODE1 = 1) or undivided (KODE1 = 2) highway.
40	KODE2	For a divided highway (KODE1 = 1), KODE2 specifies if the analysis is to be done based on just one selected section (KODE2 = 1), or for 2 selected sections (KODE2 = 2), one for each traffic direction. If LANES = 1 or if KODE1 = 2, then KODE2 = 0.
42	KODE3	IF KODE1 = 1, and KODE2 = 2, KODE3 specifies the traffic direction associated with the input data. KODE3 = 1 for data associated with the traffic direction first considered by the user. KODE3 = 2 for the opposite traffic direction.
43-46	PSII	Current Present Serviceability Index for given analysis section.

Table 1. Format of Each Record in TITLELIN.DAT. (Continued)

Column(s)	Variable	Entry
47-50	TS1	Terminal Serviceability Index for given analysis section.
51-55	T1	Asphalt concrete thickness, in inches, of given analysis section.
56-63	ES	Subgrade modulus, in psi, of given analysis section.
64-70	PFAXLE	Static axle load, in lbs., on the steering axle.
71-77	PRAXLE	Static axle load, in lbs., on each rear axle.
78-79	PRFLAG	Vehicle simulation flag which is 0 if vehicle category is skipped from the simulation, and 1 if the vehicle is simulated.
80-85	SIMSPEED	Vehicle simulation speed (mph).
86-93	FLFC	Failure level for fatigue cracking (ft^2/1,000 ft^2).
94-99	FLFR	Failure rut depth (inches).
100-105	PSIAO	PSI immediately after an overlay.
106-111	MOT	Maximum overlay thickness (inches).

program. The options available to the user are explained in a subsequent chapter.

Once the SIMULAT files have been created, the TRUCKDAT data entry program is executed to generate the required number of vehicle simulation files. The different input data screens in TRUCKDAT are used to prompt the user for vehicle characteristics required for the simulation. Default values for the different simulation parameters, such as suspension properties by suspension type, tire spring rates by tire type and tire inflation pressure, wheelbases, and vehicle inertial properties are provided within TRUCKDAT to assist the user in generating the required number of vehicle simulation files. These input files are represented in Figure 1 as 'nnnnnnnn.DAT' where the first eight characters of the file name are explained as follows:

1. The first character represents the scenario associated with the given simulation input file. It is 1 for the base scenario and 2 for the alternate scenario.
2. The second and third characters give the vehicle category associated with the simulation input file. This is a number in the range of 1-15 since there are 15 allowable vehicle categories in Florida COMPAS. For vehicle category numbers less than 10, a zero is prefixed to the vehicle category number, e.g., 4 is written as 04. The different vehicle categories are presented in the next chapter.
3. The fourth and fifth characters give the gross vehicle weight category. This is a number in the range of 1-28 since there are 28 GVW categories defined in Florida COMPAS for specifying the GVW distribution for any given vehicle. These 28 GVW categories

are shown in Table 2. Again, for GVW category numbers less than 10, a zero is prefixed to the number. In addition, if the user has specified a percentile of the GVW distribution, the GVW category number is set to 99. In this instance, the percentile is used to establish a representative vehicle for the given vehicle category. This representative vehicle will have axle loads associated with the given percentile of the GVW distribution.

4. The sixth character gives the tire type associated with the given simulation input file. It is 1 for conventional radial tires, 2 for bias-ply tires, and 3 for wide-base radial tires.
5. The seventh character gives the suspension type which is 1 for leaf spring suspensions, 2 for air bag suspensions, 3 for walking beam suspensions, and 4 for "other" user defined vehicle suspension system.
6. The eight character is the traffic direction which is 1 for the current traffic direction and 2 for the opposite direction as specified by the user.

The format of the vehicle simulation input files is explained in Appendix C.

In addition to the file containing the vehicle simulation parameters, the TFPV program also requires the surface profile of the road on which the vehicle to be simulated will be travelling. This information is read from a file called, TERRAIN.DAT, the format of which is explained in Appendix C. Prior to the execution of each vehicle simulation input file, the profile information for the given run are copied over into TERRAIN.DAT from the appropriate surface roughness file

Table 2. GVW Categories Defined in Florida COMPAS

GVW Category Number	GVW Range
1	$0 < GVW \leq 5$
2	$5 < GVW \leq 10$
3	$10 < GVW \leq 15$
4	$15 < GVW \leq 20$
5	$20 < GVW \leq 25$
6	$25 < GVW \leq 30$
7	$30 < GVW \leq 35$
8	$35 < GVW \leq 40$
9	$40 < GVW \leq 45$
10	$45 < GVW \leq 50$
11	$50 < GVW \leq 55$
12	$55 < GVW \leq 60$
13	$60 < GVW \leq 65$
14	$65 < GVW \leq 70$
15	$70 < GVW \leq 75$
16	$75 < GVW \leq 80$
17	$80 < GVW \leq 85$
18	$85 < GVW \leq 90$
19	$90 < GVW \leq 95$
20	$95 < GVW \leq 100$
21	$100 < GVW \leq 105$
22	$105 < GVW \leq 110$
23	$110 < GVW \leq 115$
24	$115 < GVW \leq 120$
25	$120 < GVW \leq 125$
26	$125 < GVW \leq 130$
27	$130 < GVW \leq 135$
28	$135 < GVW \leq 140$

specified in PROFILES.DAT. Default pavement surface profiles for different levels of PSI are provided within Florida COMPAS to handle situations where no profile measurements on a given project are available. The names of the files containing the default profile data for different levels of PSI are given in Table 3.

The spacing between successive points in the elevation profile is also required by both the TFPV and LEF6 programs. This information is stored in the file PROSPACE.DAT which contains a single number representing the constant spacing, in inches, between successive points in the elevation profile. This spacing is assumed to be applicable for all profiles to be used in the simulation. The profile spacing in PROSPACE.DAT is currently set at 6 inches, which is the spacing between successive elevation points in the default profiles used in Florida COMPAS.

Once all vehicle simulation input files have been created, the TFPV and LEF6 programs are run in sequence for each vehicle simulation input file. The LEF6 program uses the same input file as the TFPV program. However, LEF6 only uses certain information stored in a vehicle simulation file for calculating load equivalency factors. In particular, the data written on the first card of each input file are read and used by the LEF6 program, in contrast to TFPV which treats the first card only as a title card. Also, used are information on static axle loads, axle configuration, tire configuration, tire type, and tire inflation pressure.

The effects of heavy vehicle characteristics and initial pavement roughness on flexible pavement performance and life-cycle costs are thus estimated through the effects of these factors on the predicted vehicle

Table 3. Files Containing Default Profiles Used in Florida COMPAS.

File Name	Applicable PSI Range
PSILEV1.DAT	$4.2 \leq PSI \leq 5.0$
PSILEV2.DAT	$4.0 \leq PSI < 4.2$
PSILEV3.DAT	$3.8 \leq PSI < 4.0$
PSILEV4.DAT	$3.6 \leq PSI < 3.8$
PSILEV5.DAT	$3.4 \leq PSI < 3.6$
PSILEV6.DAT	$3.2 \leq PSI < 3.4$
PSILEV7.DAT	$3.0 \leq PSI < 3.2$
PSILEV8.DAT	$2.8 \leq PSI < 3.0$
PSILEV9.DAT	$2.0 \leq PSI < 2.8$
PSILEV10.DAT	$PSI < 2.0$

dynamic load profiles. For each vehicle that is simulated, the predicted dynamic load profiles are used to evaluate load equivalency factors for the different axles of the vehicle. The predicted dynamic load profiles are written by the TFPV program in separate files corresponding to the different units of the vehicle combination. Thus, the predicted dynamic loads associated with a straight truck or tractor of a combination vehicle are written by the TFPV program in the file TRACTOR.DAT. In addition, if the vehicle has semitrailers or semitrailers plus 1 or 2 full trailers, the files TRAILER1.DAT, TRAILER2.DAT, and TRAILER3.DAT are created as appropriate. TRAILER1.DAT contains the predicted dynamic loads for the semitrailer, while TRAILER2.DAT and TRAILER3.DAT contains the predicted dynamic loads for the first and second full trailers respectively.

The load equivalency program uses damage equations based on PSI fatigue cracking, and rutting for calculating load equivalencies as a function of: 1) axle load; 2) axle configuration (i.e., single, tandem, and triple axle assemblies); 3) tire configuration (i.e., single or dual tires); 4) tire type (i.e., conventional radial, bias-ply, and wide base radial tires); 5) tire inflation pressure; 6) asphalt layer thickness; and 7) subgrade stiffness. These damage equations were developed using predicted performance data generated from computer runs of the finite element pavement analysis program FLEXPASS (2) developed at Texas A&M for FDOT in a previous research study.

In generating the performance data base, a finite element tire model developed by Tielking at Texas A&M University (3) was used to predict tire contact pressure distributions for the various tire inflation pressures, tire loads, and tire types considered. The predicted contact pressure distributions were then used to establish the nodal forces that were input to the FLEXPASS computer program. In this way, the effects of tire inflation pressure and tire type were included in the development of the damage equations. In addition, a prediction equation for tire spring rate as a function of these two variables was developed in the process, and is used in TRUCKDAT to calculate default values for this vehicle simulation parameter.

The calculated load equivalency factors are adjusted for dynamic load effects through one of two possible approaches built into the load equivalency program. In one approach, the distribution of predicted dynamic axle loads are sampled using uniform random numbers, and the load equivalency factor for each sampled load is calculated from the damage equations. A distribution of sampled load equivalency factors is thus obtained and the expected value of this distribution is calculated and used as an adjusted load equivalency factor. In the other approach discussed in Reference (4), a dynamic load coefficient is used to adjust the load equivalency factor calculated from the damage equations. This load coefficient is a function of the standard deviation of the coefficient of impact, defined as the ratio of dynamic load to static load, and determined from the predicted dynamic load profile.

The 2 options available to the user for adjusting load equivalency factors are explained in more detail in the accompanying volume (1) to this User's Guide. At each run of the LEF6 program, the adjusted load equivalency factors are written to a file called LEFOUT.$$$, which is used by the ESAL18 program to calculate the daily 18-kip ESAL's for the first year of the analysis period. The format of the LEFOUT.$$$ file is explained in Appendix C.

Upon completion of all vehicle simulation and load equivalency program runs, the next phase in the analysis is the calculation of the daily 18-kip ESAL's for the first year of the analysis period. This is done by the ESAL18 program using the output file, LEFOUT.$$$, from the LEF6 program, and another file called, ESAL18.$$$, created by PRESAL18. PRESAL18 is actually executed after SIMULAT, before any of the vehicle simulation input files are created. There are no input data screens associated with PRESAL18. Data required for creating the input file, ESAL18.$$$, are read by PRESAL18 from already existing files created from earlier runs of the FLAGCINP, LOADSH1 and SIMULAT programs. The files used by PRESAL18 are shown in Figure 1. In addition, the format of the ESAL18.$$$ file created by this program is explained in Appendix D.

The ESAL18 program uses the adjusted load equivalency factors in LEFOUT.$$$, and the input data in ESAL18.$$$ to calculate the daily 18-kip ESAL's for the initial year of the analysis period. The traffic rates are calculated for the current and alternate scenarios, and as necessary, for each traffic direction. The possible increase in traffic rate from the initial value is accounted for through a user-specified traffic growth rate.

For vehicles associated with GVW categories that were not selected by the user for the vehicle simulation, the ESAL18 program uses ratios of adjusted to static load equivalency factors (LEF's) calculated by LEF6, and stored in LEFOUT.$$$ to estimate adjusted LEF's for these vehicles. Herein, adjusted LEF's are used to refer to load equivalencies that have been adjusted for dynamic load effects, using one of the approaches mentioned previously. Static LEF's, on the other hand, are those which are based solely on static axle loads.

For all vehicles for which the simulation model was executed, the load equivalency program calculates ratios of adjusted to static LEF's corresponding to the different scenarios, traffic directions, vehicle categories, tire types, and suspension types considered. For a given axle assembly of a particular vehicle category, ESAL18 uses an average of the load equivalency ratios determined for the various GVW categories included in the vehicle simulation to estimate an adjusted load equivalency factor for the given axle assembly. A bookkeeping feature is built into the program so that it uses LEF ratios appropriate for the particular scenario, traffic direction, vehicle category, tire category, suspension category, and axle assembly being considered. For vehicle categories in which no simulation runs were made, such as in cases where the user decided to skip certain vehicle categories in the simulation, the ESAL18 program calculates the appropriate static LEF's to evaluate the contributions of vehicles in these categories to the daily 18-kip ESAL's for the initial year of the analysis period. The traffic rates calculated are subsequently used in evaluating pavement performance for the current and alternate scenarios, and as necessary, for each traffic direction of the project being analyzed.

For the performance evaluation, the user has the option of using the damage equations for PSI, rutting, and fatigue cracking developed in this study, or the finite element program FLEXPASS developed by Texas A&M for FDOT in an earlier study. In the former case, the damage equations are used throughout the analysis period to predict serviceability loss, rutting, and fatigue cracking with cumulative load applications. This is a simplified option for evaluating pavement performance and is applicable for problems involving policy formulations.

In the other option, the FLEXPASS program is used to predict pavement performance up to the time of the initial overlay. From that point onwards, the damage equations are used to predict the performance of overlays. This latter option permits the user to more carefully address questions related to material requirements for pavements to be able to sustain forecasted changes in heavy vehicle characteristics and truck use.

If the user decides to run FLEXPASS to predict pavement performance for the initial design period, the data entry program, PREFLEX, is executed to create the input files for the FLEXPASS program. The input data are stored in a file called, FLEX_ _.DAT, where the two blank spaces denote the scenario, and traffic direction respectively. The first blank space, for the scenario, can be either 1 or 2 depending on whether the input data are for the current or alternate scenario respectively. The second blank space is for the traffic direction, and is 1 if the input data are for the analysis section in the traffic direction first considered by the user, and 2 if the data are for the opposite direction of travel. The format of the input data for FLEXPASS is explained in Appendix E.

Output from each run of the FLEXPASS program are written in the following files:

1. FLEX_ _.OUT - contains an echo of the input data and the performance predictions for fatigue cracking, rutting, and serviceability loss.
2. STRS_ _.OUT - an optional output file that is created if the user requests for a listing of the stresses at each element of

the finite element mesh and the displacements at each nodal point.

3. FLEXPASS._ _ - an output file of the performance predictions for fatigue cracking, rutting, and serviceability loss that is used by the OVERLAY program to determine the time of the initial overlay.

The 2 blank spaces in the output file names denote the scenario and traffic direction as explained previously. The format of the output files FLEX_ _.OUT and STRS_ _.OUT is explained in Appendix E.

In addition to the above output files, a file called, FLEXPREO, is created that contains input data common to both the FLEXPASS and OVERLAY programs. This file is used by PREOVER in creating the input file, FLOVE5.INP, for program OVERLAY. The format of this input file is explained in Appendix F.

The thickness design of overlays is accomplished using the Overlay Design Equations developed in a previous FHWA study (5). These equations were developed assuming that overlay life is governed by reflection cracking. The overlay design procedure was modified in this study to predict crack growth with time or cumulative 18-kip load applications.

In the implementation of the overlay design procedure, the user has the option of specifying a minimum and a maximum overlay thickness. The program then designs as many overlays as necessary to last the analysis period for the given range of permissible overlay thicknesses. The timing of the initial overlay is governed by the earliest occurrence of one or more failure levels specified for PSI, rutting, and fatigue cracking. For subsequent overlays, the time it takes for a crack to propagate through the previous overlay is also considered, in addition to the preceding distress modes, in establishing the schedule of subsequent overlays.

The following output files are created by the overlay program:

1. FLOVE5.OUT - contains the PSI history for the entire analysis period that is needed by the cost analysis program, FLAGCAP.
2. FLOVECHO.INP - contains an echo of the input data for program OVERLAY.
3. FLOVLAY5.OUT - is a summary file of the performance predictions for the entire analysis period, and includes predictions on when overlays are necessary, the predicted overlay thicknesses, and the estimated quantities of level up.

After execution of the performance evaluation and overlay design routines, the predicted PSI histories for the different scenarios and traffic directions are used in the cost evaluation program to estimate user costs, and pavement costs throughout the analysis period. In this program, user costs attributed to vehicle depreciation, oil consumption, tire wear, vehicle maintenance, and user travel time are adjusted for the effects of PSI using relationships developed from data compiled by Zaniewski (6). Future costs are converted to equivalent present worth costs using the discount rate specified by the user. For each scenario, traffic direction, and vehicle category considered, the cost evaluation program provides estimates of user costs for each year of the analysis period. These include the user cost components mentioned previously plus fuel consumption cost. In addition, for each scenario and traffic direction, the program estimates the costs associated with routine maintenance, level-ups, and overlays. Maintenance costs are calculated based on the user-specified unit cost for routine maintenance during the initial year of the analysis period and the prescribed annual increment in maintenance cost. The level-up cost is calculated using the estimated volume of level-up required at the time of an overlay. This is calculated in the overlay design program using the predicted value for rut depth at the time of the overlay and assuming that the transverse pavement profile is shaped like a parabola and that the rut depth is based on a 4-foot straight edge. For cases where the user has specified a depth of milling, the cost of milling is also calculated. In this instance, the level-up cost may be zero if the depth of milling specified by the user is such that the rut depth at the time of the overlay is eliminated. Finally, overlay cost is calculated from the required thickness of the overlay and its unit in-place cost.

A summary is provided at the end that shows the cost impact of forecasted changes in heavy vehicle characteristics and truck use. For each scenario, the total pavement cost and total user cost are summarized, thus showing clearly the trade-offs that forecasted changes in truck characteristics and truck use may bring about. For example, the results may indicate that increased agency expenditures for maintenance and rehabilitation may be more than offset by the potential benefits to the user of reduced vehicle operating costs. This type of information would be extremely useful to the Department in formulating rational and defensible guidelines covering truck use of the State's highways.

SUMMARY

This Chapter has presented an overview of Florida COMPAS by explaining the basic functions of the different programs comprising the system and how these programs are linked together into a logical framework. As should be by now evident, the system is robust in terms of its capabilities for analyzing the effects of a wide-range of vehicle-related, and materials-related variables on pavement performance and life-cycle costs. The remainder of this report will provide instructions on the use of this comprehensive pavement analysis package, developed to permit the Florida DOT to be responsive to changes in truck and tire technology for the years to come.

CHAPTER 2. USING FLORIDA COMPAS

Florida COMPAS is a microcomputer-based pavement analysis package that will run on any IBM compatible XT, AT, 80386, or 80486 microcomputer operating under DOS. Familiarity with DOS is required to use the analysis package. Hardware requirements of the computer package include the following:

1. At least 640K of RAM of which 570K must be available before program execution;
2. A numeric co-processor;
3. A hard disk with at least 10 megabytes of available storage space;
4. An EGA or VGA monitor with corresponding graphics card; and
5. A 3 1/2, 1.44 Mb floppy drive or 5 1/4, 1.2 Mb floppy drive.

In order to install the package in your computer's hard disk, a batch file has been prepared that will create a subdirectory called, COMPAS, which will contain all the necessary files to run the package using your microcomputer. To install Florida COMPAS, just follow the instructions below:

1. Place the Florida COMPAS diskette into your microcomputer's floppy drive, such as the "A" drive, or the "B" drive.
2. Switch to that drive by typing in the letter of the drive, followed by a colon, e.g., A: or B:. Then press the CARRIAGE RETURN (<CR>) or ENTER key. (Note: From this point onwards, the notation <CR> will be used to indicate that the user must press the CARRIAGE RETURN or ENTER key to execute a command.)
3. At the "A" prompt or "B" prompt, type COMPINST <CR>, to execute the batch file that will install Florida COMPAS in your microcomputer's hard disk.

In addition to installing the package into your hard disk, you must include in your CONFIG.SYS file the statement, FILES = 25. Edit your CONFIG.SYS file and insert this statement in the file if it is not already there. Otherwise, make sure that the specification for the FILES statement is at least 25.

If you had to insert, or modify the FILES statement in CONFIG.SYS, you would need to re-boot your computer by pressing the keys, ALT, CTRL, and DEL simultaneously to effect the change that you made, prior to executing Florida COMPAS. Once the system has been re-booted, go to the COMPAS subdirectory by typing: CD\COMPAS <CR>, at the DOS prompt. Then, type, FCOMPAS <CR>, to start using Florida COMPAS.

During the execution of this package, the user will be presented with a variety of input data screens corresponding to the different analytical models in Florida COMPAS. These input data screens are presented in the subsequent sections, with comments provided, when necessary, to explain what some of the input parameters mean. In many cases, the input parameters are self explanatory. In addition, the appendices present the required input parameters; specify the various input formats used; and present recommended values or defaults to many of the required input data.

Before presenting the different input data screens, the following general comments are first noted:

1. The user has to press the carriage return key to enter a required input item. The only exception to this rule occurs when the value typed by the user has filled up the space for the required input. In this instance, the cursor automatically goes to the next input field, without the user having to press the carriage return key.
2. Prior to leaving an input data screen, the user can press the

escape (ESC) key to make changes to the input data entered on the screen. When the user hits the ESC key, the cursor goes to the first input field on the screen. The user can then go to a field where a change has to be made by pressing the carriage return key as many times as necessary until the cursor is on the required input field. To proceed to the next input data screen, the user presses the carriage return key until the cursor is on the last input field of the current screen. At this point, pressing the carriage return key one more time will bring up the next input data screen.

3. If a particular input item has a default value, the default is displayed as soon as the cursor goes to the field of the input item. The user can use this default for the required input item or type in a different entry.

4. The bottom of an input data screen is used to display messages to the user. Consequently, it is recommended that the user always check the bottom of the screen for program messages.

5. The program will beep if an invalid input is entered, such as when a character variable is used in a numeric field.

6. Florida COMPAS provides the user with the option of going to DOS. This allows for editing of input files created by the various data entry programs in Florida COMPAS. The appendices in this report explain the formats of the different input files created by the computer package. In addition, output files generated by any of the analysis programs can be printed out using the PRINT command in DOS. The syntax of this command is, PRINT fn.ext <CR>, where "fn" is the name of the file to be printed and "ext" is the file

name extension. The user can go back to Florida COMPAS from DOS by typing FCOMPAS <CR>.

The sections that follows present the different input data screens.

INPUT DATA SCREENS ASSOCIATED WITH PROGRAM MENUS

SCREEN MAINMENU.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                         MAIN MENU

        * A) Automatic Execution of Florida COMPAS *

            * B) Run COMPAS Programs Individually *

                      * C) Exit to DOS *

Use the ^ and v keys to highlight the desired option and press <ENTER>,
                 or enter the letter of desired option
```

COMMENT(S):

The user can select any option in this menu either by pressing the letter associated with the given option, or by using the up or down arrow keys to highlight the desired option, and then pressing the ENTER key to execute it. The 3 options are explained as follows:

1. Option A - if this option is selected, all of the programs in Florida COMPAS will be executed automatically for the user, following the framework illustrated in Figure 1.

2. Option B - if this option is selected, the user is presented with the PROGMENU.AID screen (presented subsequently), and he or she must then run each of the programs manually following the logic of the framework presented in Figure 1.

3. Option C - this option terminates Florida COMPAS.

SCREEN PROGMENU.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

INDIVIDUAL EXECUTION OF COMPAS PROGRAMS

*          A) Run FLAGCAP Data Entry            *
*             B) Run LOADSHIFT                  *
* C) Input Parameters to Model File Creation    *
*          D) Model File Generation             *
* E) Run Simulation/Load Equivalency Programs   *
*           F) Run ESAL18 Programs              *
*         G) Run FLEXPASS Input Program         *
*           H) Run FLEXPASS Program             *
*         I) Run OVERLAY Input Program          *
*           J) RUN OVERLAY Program              *
*           K) RUN FLAGCAP Program              *
*           L) Go Back to MAIN MENU             *

Use the ^ and v keys to highlight the desired option and press <ENTER>,
             or enter the letter of the desired option
```

COMMENT(S):

The user can select any option in this menu by pressing either the letter associated with the given option, or by using the up or down arrow keys to highlight the desired option, and then pressing the ENTER key to execute it. Options A to K were explained in the previous chapter. This screen is displayed if the user has selected Option B of the MAINMENU.AID screen presented previously. The user can go back to this main menu through Option L of the current menu. It is important that the user execute the individual programs following the logic of the framework presented in Figure 1. Once the execution of a selected option has been completed, the above screen is again displayed with the highlight bar on the option previously selected by the user. In this way, the user will know which option was executed last.

INPUT DATA SCREENS ASSOCIATED WITH FLAGCINP

SCREEN FL01.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

-District ---------------------------------------------------->XX
-County ---------------------------------->XXXXXXXXXXXXXXXXXXXX
-State Project Number ------------------------------>XXXXX-XXXX

-Work Program Item Number ----------------------------->XXXXXXX
-Federal Aid Project Number --------------->XXXXXXXXXXXXXXXXXXXX
-Beginning Milepost ------------------------------------>XXXXXXX
-Ending milepost ---------------------------------------->XXXXXXX

-Highway --------------------------------->XXXXXXXXXXXXXXXXXXXX
-Date ------------------------------------->XXXXXXXXXXXXXXXXXXXX
```

COMMENT(S):

The user enters the prescribed data identifying the project to be analyzed. The variables COUNTY, FEDERAL AID PROJECT NUMBER, HIGHWAY, and DATE are alphanumeric. The rest are numeric.

SCREEN FL02.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

-Number of Lanes in both directions ------------------------>XX
-Length (miles) ------------------------------------------->XXXXX
-Highway Type (1-freeway, 0-nonfreeway) --------------------->X
-Pavement Type (1-rigid, 0-flexible) ------------------------>X
-Width of Paved Portion of Highway (feet) ------------------>XXX
-Width of Travel Lanes (feet) ------------------------------>XXX
-Cost of Overlay per Ton of Asphaltic Concrete ($) ------>XXXXXX
-Number of Tons of compacted asphaltic concrete
 per compacted cubic yard -------------------------------->XXXX
-Cost of Routine Maintenance, first year after overlay
 or beginning of analysis period, per lane mile ($) ------>XXXXX
-Annual Increment in routine Maintenance Costs per
 lane mile ($) ------------------------------------------->XXX

-Depth of Milling (in.) ----------------------------------->XXX

-Cost of Milling per Square Yard ($) -------------------->XXXX
```

COMMENT(S):

Values for the prescribed input items are entered by the user. Although there is a field for pavement type, this field is always set to 0 (for flexible pavement). The current version of COMPAS is set up to handle only flexible pavements. This field, however, may be used in the event that rigid pavement performance and cost models are incorporated into a future version of Florida COMPAS.

The width of the paved portion of highway is the total width for both traffic directions and includes the shoulders if these are paved. At the very minimum, the width of the paved portion of highway is equal to the width of the travel lanes.

The user can also specify a depth of surface to be milled prior to the placement of an overlay. This depth of milling should be less than the thickness of the existing surface layer. If a depth of milling is specified, the default unit cost of milling is estimated from the following equation obtained from the Florida DOT:

$$UC_{mill} = 0.45 + 0.15t_{mill}$$

where,

UC_{mill} = unit of cost of milling, $/yd²

t_{mill} = prescribed depth of milling, inches.

SCREEN FLO3.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

-Analysis Period in years --------------------------------->XX
-Annual Growth Rate of ESAL's (%) ----------------------->XXXXX
-Discount Rate (%) ---------------------------------------->XX

-Number of Vehicle Categories in Current and
 Alternate Scenarios (maximum of 15) ---------------------->XX

-Current Scenario - GVW Limit (kips) --------------------->XXX
-Current Scenario - Single Axle Limit (kips) --------------->XX
-Current Scenario - Tandem Axle Limit (kips) --------------->XX
-Current Scenario - Triple Axle Limit (kips) --------------->XX

-Alternate Scenario - GVW Limit (kips) ------------------->XXX
-Alternate Scenario - Single Axle Limit (kips) ------------->XX
-Alternate Scenario - Tandem Axle Limit (kips) ------------->XX
-Alternate Scenario - Triple Axle Limit (kips) ------------->XX

-Problem Description -->XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

COMMENT(S):

The current version of COMPAS can handle up to 15 vehicle categories, of which the first 12 are already reserved for the vehicle types shown in Table 4. The numbering scheme for the first 12 vehicle categories follows the FHWA Classification Scheme "F" shown in Table 5. For Class Groups 2,8, and 9 which include more than one vehicle configuration, a given vehicle has been selected to represent the particular vehicle category or Class Group, as follows:

Class Group	Representative Vehicle
2	cars
8	2-S2
9	3-S2

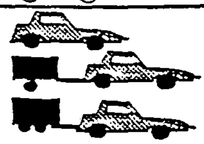
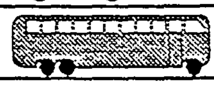
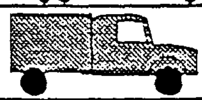
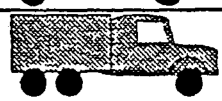
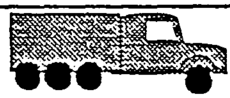
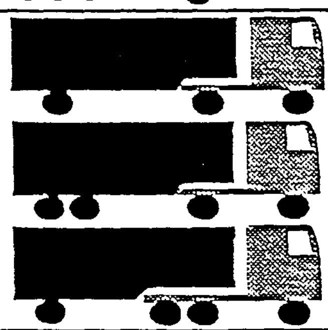
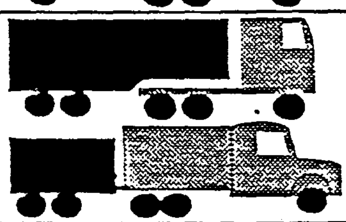
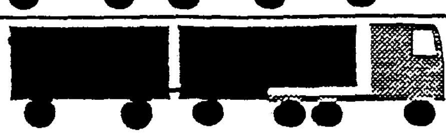
Table 4. Default Vehicle Categories Used in FLAGCINP.

Vehicle Category	Type of Vehicle for User Cost Calculations[a]	Vehicle Category Description	Number of			Vehicle Configuration[b]
			Single Axles	Tandem Axles	Triple Axles	
1	N/A	Motorcycle	N/A	N/A	N/A	N/A
2	1	Cars	2	0	0	1
3	1	Pick-Ups	2	0	0	1
4	2	Buses	1	1	0	1
5	2	2A	2	0	0	1
6	2	3A	1	1	0	1
7	2	4-Axle SU	1	0	1	1
8	3	2-S2	2	1	0	1
9	3	3-S2	1	2	0	2
10	3	3-S3	1	1	1	2
11	3	2-S1-2	5	0	0	3
12	3	3-S1-2	4	1	0	3

[a] 1 = passenger cars/pickups
2 = single unit trucks
3 = combination trucks

[b] 1 = single unit vehicle
2 = tractor-semitrailer combination
3 = tractor-semitrailer-full trailer combination
4 = tractor-semitrailer-full trailer-full trailer combination

Table 5. FHWA Classification Scheme "F".

CLASS. GROUP		DESCRIPTION	NO. OF AXLES
1		MOTORCYCLES	2
2		ALL CARS CARS W/ 1-AXLE TRLR CARS W/2-AXLE TRLR	2 3 4
3		PICK-UPS &VANS 1 & 2 AXLE TRLRS	2, 3, & 4
4		BUSES	2 & 3
5		2-AXLE, SINGLE UNIT	2
6		3-AXLE, SINGLE UNIT	3
7		4-AXLE, SINGLE UNIT	4
8		2-AXLE TRACTOR, 1-AXLE TRLR(2S1) 2-AXLE TRACTOR, 2-AXLE TRLR(2S2) 3-AXLE TRACTOR, 1-AXLE TRLR(3S1)	3 4 4
9		3-AXLE TRACTOR, 2-AXLE TRLR(3S2) 3-AXLE TRUCK, W/2-AXLE TRLR	5 5
10		TRACTOR W/ SINGLE TRLR	6 & 7
11		5-AXLE MULTI-TRLR	5
12		6-AXLE MULTI-TRLR	6
13	ANY 7 OR MORE AXLE		7 or more

The above selection has been made in consultation with Florida DOT personnel. Vehicle categories 13, 14, and 15 can be used by the user to define a vehicle configuration that is not described by any of the default vehicle categories shown in Table 4.

SCREEN FL04A.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

-Vehicle Category Number (1 to 15) ------------------------->XX
-Type of Vehicle for User Cost Calculations ------------------>X
-Vehicle Category Description ---------------------->XXXXXXXXXX

-Scenario (1-not in current scenario, 0-otherwise) ----------->X
-Shift Category ---------------------------------------------->X
-Payload Shift Switch (0-payload shifted internally within
                   program, 1-user input of payload) ----->X
-Percent Payload Shifted to new Vehicle Type (%) ---------->XXXX

-Number of Single Axles ------------------------------------->X
-Number of Tandem Axles ------------------------------------->X
-Number of Triple Axles ------------------------------------->X
```

COMMENT(S):

1. Vehicle categories 1 through 12 are reserved by the FLAGCINP program for the vehicle types shown in Table 4. Thus, if the user wants to specify a vehicle that is not among those listed in Table 4, he or she can use vehicle category numbers 13 to 15. The default vehicle categories shown in Table 4 should, however, be sufficient to characterize the traffic stream for most practical problems.

2. When specifying a vehicle for the analysis, the user must keep in mind the capabilities of the vehicle simulation program, TFPV, so as not to specify a vehicle that cannot be analyzed by the TFPV program. Specifically, the following should be considered:

   a. The vehicle configurations that can be simulated by the TFPV program are limited to the 4 configurations shown at the bottom of Table 4.

b. The drive axle assembly of a single unit truck or tractor, and the semitrailer axle assembly can have single, tandem, or triple axles.

c. The front and rear axle assemblies of full trailers can have single or tandem axles.

3. The field, vehicle category description, is an alphanumeric field for attaching a descriptor to a given vehicle category.

4. The field for "Scenario" allows the user to analyze the effect of a vehicle that is currently not in the traffic stream but which may be introduced sometime in the future. In many instances, a given vehicle category is both in the base and alternate scenarios. However, in the event that the user needs to analyze the effect of a "future" vehicle, he or she must enter a 1 in the "Scenario" field to indicate that the given vehicle is not in the current scenario. The user must then specify a vehicle category, in the "Shift Category" field, which will be the basis for projecting the GVW and axle weight distributions of the "future" vehicle being considered. The shift category must be a vehicle that is present in the current scenario, and is the vehicle category from which payload will be shifted over to the new vehicle, i.e., a portion of the payload carried by the shift category vehicle will be assigned to the new vehicle in the alternate scenario. The proportion of payload shifted to the new vehicle can be calculated internally within the program or the user can specify the desired shift. The Payload Shift Switch is used for this purpose. A zero indicates that the payload will be shifted internally within the load shift program. A 1 indicates user input of the payload shift. If this option is used, then the percent payload to be shifted to the new vehicle must be specified by the user.

5. Motorcycles are not considered in any of the analyses carried out within Florida COMPAS. A vehicle category number, i.e., vehicle 1, has been assigned to motorcycles only to comply with the FHWA Classification Scheme "F."

SCREEN WINDOW1.AID

```
┌──────────────────────────────────────────────────┐
│ -Vehicle Configuration ------------------------->X │
│ -Number of Drive Axles ------------------------->X │
│                                                    │
│ -Number of Semi-trailer Axles ----------------->X │
│  Full Trailer # 1:                                 │
│ -Number of Front Axles ------------------------>X │
│ -Number of Rear Axles ------------------------->X │
│  Full Trailer # 2:                                 │
│ -Number of Front Axles ------------------------>X │
│ -Number of Rear Axles ------------------------->X │
│                                                    │
│  Is the above information correct? (Y/N) ------>X │
└──────────────────────────────────────────────────┘
```

COMMENT(S):

This window pops out if the vehicle category number is not one of the default vehicles shown in Table 4. For the "Vehicle Configuration" enter a number from 1 to 4 where the levels for this variable are as defined in Table 4. The number of drive axles and semi-trailer axles can be 1, 2 or 3 corresponding, respectively, to single, tandem, or triple axle assemblies. The number of full trailer front and rear axles can be 1 or 2 corresponding, respectively, to single or tandem axle assemblies.

SCREEN FL04B.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

-Empty Weight (kips) ------------------------------------->XXXX
-GVW at which load shifting occurs (kips) ---------------->XXXX

-Average Travel Speed w/very good pavement condition (mph) >XXXX

-Cost of Fuel per Gallon ($) ----------------------------->XXXX
-Cost of Oil per Quart ($) ------------------------------->XXXX
-Cost of Maintenance and Repair per 1000 miles ($) ------>XXXXXX

-Depreciable Value of Vehicle ($) -------------------->XXXXXXX
-Value of Time per Vehicle ($/hr.) --------------------->XXXXX
```

COMMENT(S):

1. The empty weight is the gross vehicle weight without payload.

2. When the legal load limits specified are different between the base and alternate scenarios, the GVW at which load shifting occurs is the weight at which payloads start shifting over to higher or lower GVW categories depending upon whether legal load limits have increased or decreased from the base to the alternate scenario.

3. One of the factors affecting average travel speed is pavement condition. Vehicles tend to slow down on rougher pavements which would affect cost associated with user travel time as well as vehicle operating costs. The average travel speed in this screen is used to adjust the travel speed for the effect of pavement roughness. It is noted that the expected average speed with pavement in very good condition should be entered even though the speed at which vehicles are actually being driven over the project length is slower due to a rougher pavement surface existing over the project length. The average travel speed with pavement in very good condition is just a reference for adjusting the travel speed

to a value corresponding to the actual pavement roughness. The user is referred to Chapter 7 of the accompanying volume (1) to this User's Guide for details on the procedure used within FLAGCAP to adjust vehicle travel speed for the effect of pavement condition.

SCREEN FL05.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

-Enter the Number of Vehicles for each of the following Kip
 Ranges for Vehicle Category ->X:

  0.0 -   5.0 --->XXXXXX              70.1 -  75.0 --->XXXXXX
  5.1 -  10.0 --->XXXXXX              75.1 -  80.0 --->XXXXXX
 10.1 -  15.0 --->XXXXXX              80.1 -  85.0 --->XXXXXX
 15.1 -  20.0 --->XXXXXX              85.1 -  90.0 --->XXXXXX
 20.1 -  25.0 --->XXXXXX              90.1 -  95.0 --->XXXXXX
 25.1 -  30.0 --->XXXXXX              95.1 - 100.0 --->XXXXXX
 30.1 -  35.0 --->XXXXXX             100.1 - 105.0 --->XXXXXX
 35.1 -  40.0 --->XXXXXX             105.1 - 110.0 --->XXXXXX
 40.1 -  45.0 --->XXXXXX             110.1 - 115.0 --->XXXXXX
 45.1 -  50.0 --->XXXXXX             115.1 - 120.0 --->XXXXXX
 50.1 -  55.0 --->XXXXXX             120.1 - 125.0 --->XXXXXX
 55.1 -  60.0 --->XXXXXX             125.1 - 130.0 --->XXXXXX
 60.1 -  65.0 --->XXXXXX             130.1 - 135.0 --->XXXXXX
 65.1 -  70.0 --->XXXXXX             135.1 - 140.0 --->XXXXXX
                    Accept Defaults? (Y/N) ->X
```

COMMENT(S):

The user establishes the GVW distribution of the given vehicle category by entering the number of vehicles for each prescribed GVW interval or category. If there are no vehicles in a particular GVW category, enter a 0 for that category. The number of vehicles entered for any GVW category is the daily number of vehicles for both directions of the given project. Default GVW distributions have been established for vehicle categories 4 through 12 using data supplied by the Florida DOT.

SCREEN FLO6.AID

```
FLORIDA  GENERAL  COST  ANALYSIS  for  PAVEMENTS  (COMPAS)

CURRENT  SCENARIO                              Vehicle Category ->X

-Percent of Vehicles in Category with Bias Ply Tires ------>XXXX
-Number of Bias Ply Tires per Vehicle ---------------------->XX
-Hot Inflation Pressure for Bias Ply Tires (psi) ---------->XXXX
-Cost of Bias Ply Tires ($/tire) ----------------------->XXXXX
-Cost of Bias Retread ($/tire) ------------------------->XXXXX
-Number of Bias Retreads per tire ----------------------->XXX

-Percent of Vehicles in Category with Conventional
 Radial Tires ------------------------------------------>XXXX
-Number of Conventional Radial Tires per Vehicle ----------->XX
-Hot Inflation Pressure of Radial Tires (psi) ------------>XXXX
-Cost of Radial Tires ($/tire) ------------------------->XXXXX
-Cost of Radial Retread ($/tire) ----------------------->XXXXX
-Number of Radial Retreads per tire ---------------------->XXX
```

COMMENT(S):

The user enters information establishing the usage of the different tire types in the current scenario. For example, if 20 percent of the vehicles in the given category use bias-ply tires in all axles, the user enters 20 in the first input field. When the cursor goes to the next field, the window on the next page is displayed.

SCREEN WINDOW2.AID

```
┌──────────────────────────────────────────────────────────┐
| -Number of Tires per side on Drive Axle ------------->X  |
| -Number of Tires per side on Semi-trailer Axle ------>X  |
|                                                          |
|  Number of Tires per side on Full Trailer # 1:           |
| -Front Axle ----------------------------------------->X  |
| -Rear Axle ------------------------------------------>X  |
|                                                          |
|  Number of Tires per side on Full Trailer # 2:           |
| -Front Axle ----------------------------------------->X  |
| -Rear Axle ------------------------------------------>X  |
|                                                          |
|  Is the above information correct? (Y/N) ------------>X  |
└──────────────────────────────────────────────────────────┘
```

COMMENT(S):

This window is displayed to establish the number of bias-ply or conventional radial tires for the vehicle category being considered. The user enters a 1 or 2 depending on whether there are single or dual tires at each end of a given axle. This window is only displayed for the current scenario.

SCREEN FL07.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

CURRENT  SCENARIO                              Vehicle Category ->X

-Percent of Vehicles in Category with Wide-Base
 Single Tires ------------------------------------------->XXXX

-Number of Wide-Base Single Tires (per vehicle) ------------->XX

-Number of Conventional Radial Tires on Wide-Base
 Single Vehicle ------------------------------------------->XX

-Hot Inflation Pressure of Wide-Base Single Tires --------->XXXX

-Cost of Wide-Base Single Tires ($/tire) ---------------->XXXXX

-Cost of Wide-Base Single Retread ($/tire) -------------->XXXXX

-Number of Wide-Base Retreads per Tire ------------------->XXX
```

COMMENT(S):

The percent of vehicles with wide-base tires can include vehicles which use wide-base radials in all axles or vehicles which use a combination of conventional and wide-base radial tires. The type of tire in each axle assembly is defined on the next screen.

SCREEN WINDOW3.AID

```
 Number of Axles with Wide-base Radial Tires
-(1=All, 2=All but Steering Axle, 3=Combination) --->X

-Type of Tires in Steering Axle -------------------->X
-Type of Tires in Drive Axle ----------------------->X

-Type of Tires in Axle of Semi-trailer ------------->X

 Full Trailer # 1:
-Type of Tires in Front Axle ----------------------->X
-Type of Tires in Rear Axle ------------------------>X

 Full Trailer # 2:
-Type of Tires in Front Axle ----------------------->X
-Type of Tires in Rear Axle ------------------------>X

 Is the above information correct? (Y/N) ----------->X
```

COMMENT(S):

This screen is used to specify which axle assemblies of a given vehicle have conventional radial tires, and which axle assemblies have wide-base radial tires. If the user selected Option 3 for the first input item, then the tire type for each axle assembly must be specified. The codes to indicate the tire type for each axle assembly are displayed at the bottom of the screen.

SCREEN FL08.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

ALTERNATE SCENARIO                                   Vehicle Category ->X

-Percent of Vehicles in Category with Bias Ply Tires ------>XXXX
-Number of Bias Ply Tires per Vehicle ---------------------->XX
-Hot Inflation Pressure for Bias Ply Tires (psi) ---------->XXXX
-Cost of Bias Ply Tires ($/tire) ----------------------->XXXXX
-Cost of Bias Retread ($/tire) -------------------------->XXXXX
-Number of Bias Retreads per tire ------------------------>XXX

-Percent of Vehicles in Category with Conventional
 Radial Tires ------------------------------------------->XXXX
-Number of Conventional Radial Tires per Vehicle ----------->XX
-Hot Inflation Pressure of Radial Tires (psi) ------------>XXXX
-Cost of Radial Tires ($/tire) ------------------------->XXXXX
-Cost of Radial Retread ($/tire) ----------------------->XXXXX
-Number of Radial Retreads per tire ---------------------->XXX
```

COMMENT(S):

Information on tire type use, tire inflation pressure, tire cost, cost of retreads, and number of retreads per tire are also requested for the alternate scenario.

SCREEN FL09.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

ALTERNATE SCENARIO                                Vehicle Category ->X

-Percent of Vehicles in Category with Wide-Base
 Single Tires ----------------------------------------->XXXX

-Number of Wide-Base Single Tires (per vehicle) -------------->XX

-Number of Conventional Radial Tires on Wide-Base
 Single Vehicle --------------------------------------------->XX

-Hot Inflation Pressure of Wide-Base Single Tires --------->XXXX

-Cost of Wide-Base Single Tires ($/tire) ----------------->XXXXX

-Cost of Wide-Base Single Retread ($/tire) --------------->XXXXX

-Number of Wide-Base Retreads per Tire -------------------->XXX
```

COMMENT(S):

The user provides the requested information for the alternate scenario. Once data on this screen has been entered, FLAGCINP again displays, the FL04A.AID screen to request data for the next vehicle category. The screens following FL04A.AID are also displayed in sequence to request the user for the required data on the vehicle category. This sequence is repeated until data for all specified vehicle categories have been entered.

INPUT DATA SCREENS ASSOCIATED WITH SIMULAT

SCREEN LOADEQUI.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                 VEHICLE SIMULATION PROGRAM

       Procedure for Adjusting Static Load Equivalencies

         *    1) Based on Dynamic Load Coefficient      *

         * 2) Based on Expected Value of Sampled LEF's *

- Calculate LEF's for Steering Axle (Y/N)? ------------------>X
```

COMMENT(S):

Load equivalency factors are adjusted for dynamic load effects through one of two possible approaches built into the load equivalency program. In one approach, a dynamic load coefficient is used to adjust the load equivalency factor from the damage equations. In the other approach, the expected value of a distribution of sampled load equivalency factors is determined and used as an adjusted load equivalency factor. On this screen, the user selects the procedure to be used for adjusting static load equivalencies by using the up or down arrow key to highlight the desired procedure and then hitting the carriage return key. In addition, the user is given the option of including the steering axle loads of the different vehicles in the traffic stream in the calculation of cumulative 18-kip ESAL'S.

SCREEN PROFILE1.AID

```
FLORIDA - COMprenhensive Pavement Analysis System  (COMPAS)

               VEHICLE PROFILE DATA INPUT SCREEN

-Divided or Undivided Highway? ------------------------->
```

COMMENT(S):

If the project to be analyzed has more than one lane and the project is on a non-freeway, this screen is displayed for the user to specify if the project is on a divided or an undivided highway. For undivided highways, the life-cycle cost analysis is conducted based on the worst section of the given project. Overlay designs, for example, are based on the characteristics of this section, and whenever an overlay needs to be placed, all travel lanes of the given project are overlaid. If the project is on a divided highway, the user has the option of conducting the life-cycle cost analysis separately, one for each traffic direction of the given project, based on the worst section of a given traffic direction. The user can exercise this option on the following screen.

SCREEN PROFILE2.AID

```
FLORIDA - COMprenhensive Pavement Analysis System  (COMPAS)

            VEHICLE PROFILE DATA INPUT SCREEN

-Do Pavement Performance & Cost Analysis based on
 Worst Highway Section? -------------------------------->
```

COMMENT(S):

If the project to be analyzed is on a divided highway, such as a freeway for example, the user can elect to conduct, for each scenario, two life-cycle cost analyses, one for each direction of the given project. In this instance, he or she would type an "N" for NO in response to the above query. Otherwise, if the project is on a divided highway, and the user prefers to conduct, for each scenario, a single life-cycle cost analysis based on the worst section of the given project, a "Y" for YES would be the appropriate response.

SCREEN LANESEQ1.AID

```
-Section's Current PSI ---------------------------------->XXX
-Terminal Serviceability Index -------------------------->XXX
-Profile Data Available? --------------------------------->X
-Profile Data Filename ----------------------->XXXXXXXXXXXX
-Profile Length (ft.) ---------------------------------->XXXX
-Asphalt Concrete Thickness (in.) ------------------->XXXXX
-Subgrade Modulus (psi) -------------------------->XXXXXXXX
```

COMMENT(S):

If the user specified that the project to be analyzed has only one lane, the current PSI of the selected analysis section for the given lane is entered on this screen as well as the existing asphalt concrete thickness and subgrade modulus. The user can also specify the name of a file containing profile measurements made on the analysis section if such measurements are available. The surface profile is an input to the vehicle simulation program. If profile measurements are available, the user types in a "Y" at the "Profile Data Available?" field, and also enters the profile data filename and profile length. If no profile measurements are available, the user types in an "N." In this instance, default profile measurements corresponding to the current PSI of the analysis section will be used in the vehicle simulation.

SCREEN LANSMOR1.AID

```
-Current PSI of Worst Section ----------------------------->XXX
-Terminal Serviceability Index ---------------------------->XXX
-Profile Data Available for Worst Section? ---------------->X
-Profile Data Filename ----------------------->XXXXXXXXXXXX
-Profile Length (ft.) ------------------------------------>XXXX
-Asphalt Concrete Thickness (in.) -------------------->XXXXX
-Subgrade Modulus (psi) --------------------------->XXXXXXXX
```

COMMENT(S):

If there is more than one lane in the given project, but the project is on an undivided highway, this screen is displayed. In this instance, the life-cycle cost analysis is based on the worst section within the given project, and overlays are assumed to be placed on all travel lanes. This screen is also displayed if the project is on a divided highway but the user elected to conduct the analysis based on just the worst section within the given project. The types of information requested are the same as those for the LANESEQ1.AID screen.

SCREEN LANSMOR2.AID

```
-Failure Level for Fatigue Cracking (ft²/1000 ft²) -->XXXXXXX

-Failure Level for Rutting (in.) --------------------->XXXXX

-PSI After Overlay ----------------------------------->XXXXX

-Maximum Overlay Thickness (in.) --------------------->XXXXX
```

COMMENT(S):

This screen is displayed after the LANESEQ1.AID or LANSMOR1.AID screen. The user provides the failure levels for fatigue cracking and rutting, the PSI immediately after the overlay, and the maximum overlay thickness to be considered in the overlay design. The failure levels for fatigue cracking and rutting are used in determining when an overlay is required. Typical values are 500 ft^2/1000 ft^2 and 0.5" respectively, although these may depend on the functional classification of the given roadway.

SCREEN TWODCURR.AID

```
 Current Travel Direction:
-PSI for Worst Section ------------------------------->XXX
-Terminal Serviceability Index ----------------------->XXX
-Profile Data Available? ------------------------------>X
-Profile Datafile Name ---------------------->XXXXXXXXXXXX
-Profile Length (ft.) ------------------------------>XXXX
-Asphalt Concrete Thickness (in.) ------------------>XXXXX
-Subgrade Modulus (psi) ------------------------>XXXXXXXX
-Failure Level for Fatigue Cracking (ft²/1000 ft²)->XXXXXXX
-Failure Level for Rutting (in.) ------------------->XXXXX
-PSI After Overlay --------------------------------->XXXXX
-Maximum Overlay Thickness (in.) ------------------->XXXXX
```

COMMENT(S):

This screen is displayed in lieu of the LANESEQ1.AID or LANSMOR1.AID screen if the project is on a divided highway and the user elected to conduct separate life-cycle cost analysis for each traffic direction. The types of data requested are the same as those for the LANESEQ1.AID, LANSMOR1.AID, and LANSMOR2.AID screens.

SCREEN TWODOPPO.AID

```
 Opposite Travel Direction:
-PSI for Worst Section ------------------------------->XXX
-Terminal Serviceability Index ----------------------->XXX
-Profile Data Available? ------------------------------->X
-Profile Datafile Name ---------------------->XXXXXXXXXXXX
-Profile Length (ft.) ------------------------------->XXXX
-Asphalt Concrete Thickness (in.) ------------------>XXXXX
-Subgrade Modulus (psi) ------------------------->XXXXXXXX
-Failure Level for Fatigue Cracking (ft²/1000 ft²)->XXXXXXX
-Failure Level for Rutting (in.) ------------------->XXXXX
-PSI After Overlay --------------------------------->XXXXX
-Maximum Overlay Thickness (in.) ------------------->XXXXX
```

COMMENT(S):

This screen is displayed after the TWODCURR.AID screen. The types of data requested are the same as those for the previous screen except that data associated with the worst section for the opposite direction of travel must be entered.

SCREEN SIMUL1.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

VEHICLE SIMULATION PROGRAM

- For the following Vehicle Category ------------------------>X
                          and Scenario ---------------->XXXXXXXXX

- Simulation Speed (mph) ------------------------------->XXXXXX

- Use the ^ and v keys to highlight how vehicle selection
  should be performed, then press <ENTER>. Or enter the option
  number and press <ENTER>:

          * 1) Percentile of GVW Distribution *

          * 2) Selection of GVW Categories *

     * 3) Skip Simulation for this Vehicle Category *
```

COMMENT(S):

1. For the given vehicle category and scenario, the user selects Option 1 if he or she prefers to specify a percentile of the GVW distribution which will be used to establish a representative vehicle, for the given vehicle category, that will be simulated using the TFPV program.

2. The user can also select specific GVW categories, within the given vehicle category, for which vehicle simulation runs will be made. As an example, the user can select, using this option, the 3 GVW categories with the most number of vehicles. Vehicles under these GVW categories will then be simulated using the TFPV program.

3. The user can also exclude the given vehicle category from the simulation by selecting option 3.

4. For any given vehicle category, it is important to be consistent in the options selected for both scenarios. Otherwise, the results of the analysis may not be comparable.

5. The simulation speed is the actual average speed of vehicles on the given project. This may be different from the average travel speed specified in the FLO4B.AID screen.

SCREEN SIMUL2.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

Vehicle Category ------------------------------------------>X
Scenario ------------------------------------------>XXXXXXXXX




-Enter the Percentile of the GVW Distribution -------------->XXX
```

COMMENT(S):

This screen is displayed if the user selected Option 1 in the SIMUL1.AID screen. The user enters the percentile which would be used in establishing a representative vehicle for the given vehicle category. This representative vehicle will have axle loads associated with the given percentile of the GVW distribution.

SCREEN SIMUL3.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                                        Vehicle Category ------->X
-Select the desired GVW Categories:     Scenario ------->XXXXXXXXX

  0.0 -  5.0 --->XXXXXX X               70.1 -  75.0 --->XXXXXX X
  5.1 - 10.0 --->XXXXXX X               75.1 -  80.0 --->XXXXXX X
 10.1 - 15.0 --->XXXXXX X               80.1 -  85.0 --->XXXXXX X
 15.1 - 20.0 --->XXXXXX X               85.1 -  90.0 --->XXXXXX X
 20.1 - 25.0 --->XXXXXX X               90.1 -  95.0 --->XXXXXX X
 25.1 - 30.0 --->XXXXXX X               95.1 - 100.0 --->XXXXXX X
 30.1 - 35.0 --->XXXXXX X              100.1 - 105.0 --->XXXXXX X
 35.1 - 40.0 --->XXXXXX X              105.1 - 110.0 --->XXXXXX X
 40.1 - 45.0 --->XXXXXX X              110.1 - 115.0 --->XXXXXX X
 45.1 - 50.0 --->XXXXXX X              115.1 - 120.0 --->XXXXXX X
 50.1 - 55.0 --->XXXXXX X              120.1 - 125.0 --->XXXXXX X
 55.1 - 60.0 --->XXXXXX X              125.1 - 130.0 --->XXXXXX X
 60.1 - 65.0 --->XXXXXX X              130.1 - 135.0 --->XXXXXX X
 65.1 - 70.0 --->XXXXXX X              135.1 - 140.0 --->XXXXXX X
```

COMMENT(S):

If the user selected Option 2 in the SIMUL1.AID screen, this screen is displayed to allow the user to select GVW categories to be considered in the vehicle simulation. The user specifies that a given GVW category be included in the simulation by typing a "Y" beside the field of the GVW category. Otherwise, if he or she does not want a given GVW category to be considered in the simulation, the letter "N" should be entered instead.

SCREEN SIMUL4.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

SUSPENSION TYPE PERCENTAGE SPECIFICATION FOR VEHICLE CATEGORIES

Vehicle Category ------------------------------------------->X
Scenario --------------------------------------------->XXXXXXXXX

   Enter Non-steering Axles suspension percentages of given
   Vehicle Category/Scenario/GVW Percentile or GVW Category
   combination:

-Leaf Spring Suspension (%) ------------------------------->XXX

-Air Suspension (%) --------------------------------------->XXX

-Walking Beam Suspension (%) ------------------------------>XXX

-Other Suspension Type (%) -------------------------------->XXX

       Accept Syspension Percentage Defaults? (Y/N) ->X
```

COMMENT(S):

For a given scenario and vehicle category, the user enters the percentage of vehicles, the non-steering axles of which are of a given suspension type. Default values have been established to characterize the first three suspension systems in terms of the suspension spring rate, coulomb damping, and viscous damping properties. The category for "Other Suspension Type" allows the user to specify some other suspension system that is neither leaf spring, air, or walking beam. The walking beam suspension is only applicable for tandem or triple axles. Thus, this option can be used only if none of the non-steering axles are single axle assemblies.

Once data for this screen has been entered, the series of screens, SIMUL1.AID to SIMUL4.AID, are again displayed to prompt for data associated with some other scenario/vehicle category combination. This sequence is repeated until all data required by SIMULAT have been entered.

INPUT DATA SCREENS ASSOCIATED WITH TRUCKDAT

SCREEN DEFTRUCK.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

              TRUCK/TRACTOR GEOMETRY INPUT SCREEN

                    Scenario ----->XXXXXXXXXXX
Category -->X     Configuration --->X   Description ->XXXXXXXXXX
Tire Type ->XX    Suspension Type ->XXX Direction --->XXXXXXXXXX
                  GVW Category ---->XXXXX



      Accept all Defaults for the above truck? (Y/N) --->X
```

COMMENT(S):

For a given scenario, vehicle category, GVW category, tire type, suspension type, and traffic direction, the user is asked whether he or she would like to accept all the defaults for the simulation of the given vehicle. If the user types in a "Y" for YES, the appropriate defaults will be used and the user will then be asked the same question but for the next vehicle. This process is repeated until the user types in an "N" for NO. In this instance, he or she can override any defaults established for the vehicle simulation by entering his or her own data in the appropriate fields of the following screens. After all data have been specified for all the appropriate screens, the DEFTRUCK.AID screen will again be displayed and the user asked the above question for the next vehicle. This process is repeated until all required vehicle simulation files have been created.

SCREEN TRACTOR1.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

              TRUCK/TRACTOR GEOMETRY INPUT SCREEN

                   Scenario ----->XXXXXXXXXXX
Category -->X   Configuration --->X  Description ->XXXXXXXXXX
Tire Type ->X   Suspension Type ->X  Direction --->XXXXXXXXXX
                GVW Category ---->XXXXX

-Truck/Tractor Wheelbase (in) -------------------->XXXXXXXXXXX

-Distance from Center of Rear Axle to Semitrailer
 Hitch (in) -------------------------------------->XXXXXXXXXXX

-Tractor       Axle Separation (in) -------------->XXXXXXXXXXX

-Are Rear Truck Axles Parametrized Identically? ------------>X
```

COMMENT(S):

1. This screen is displayed for every combination of the variables scenario, vehicle category, GVW category, tire type, suspension type, and direction of travel. For each required simulation run, TRUCKDAT creates a file containing the input provided by the user on this screen, and the ones that follow.

2. The truck/tractor wheelbase is the distance, in inches, from the front steering axle to the center of the rear drive axle assembly, as illustrated in Figure C2 of Appendix C, which explains the input format to the TFPV program. Figure 2 shows typical values of this simulation parameter.

3. The distance from the center of the rear axle to the semitrailer hitch is only required if a semitrailer is connected to a tractor.

4. The axle separation is only required for tandem or triple axle assemblies.

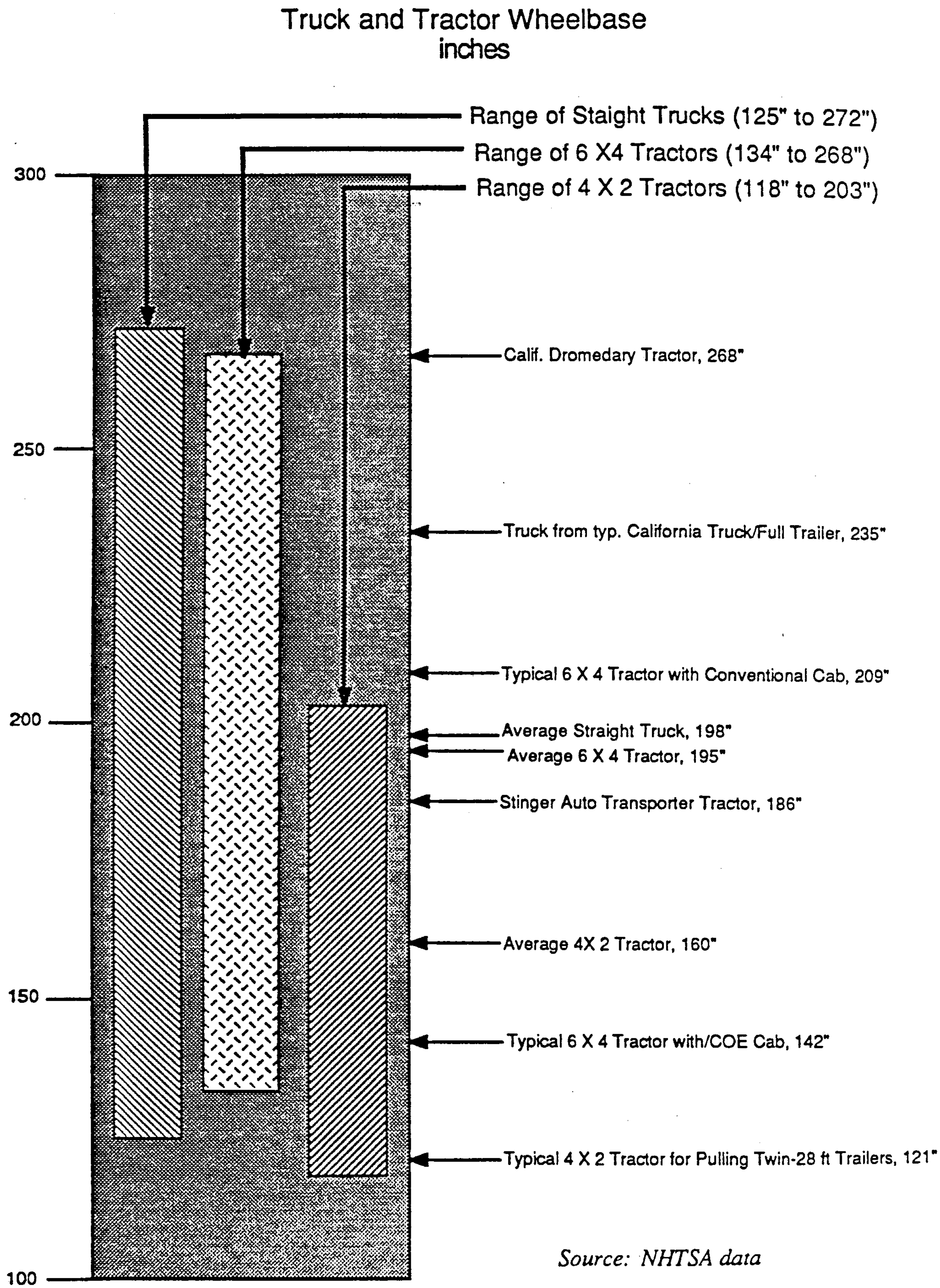


Figure 2. Truck and Trailer Wheelbase (7).

5. The last input item is always set to "Y" for truck and tractor rear axle assemblies for the vehicle simulation runs in Florida COMPAS.

SCREEN TRACTOR2.AID

```
                      Scenario ----->
   Category -->    Configuration --->    Description ->
   Tire Type ->    Suspension Type ->    Direction --->
                   GVW Category ---->
------------------------------------------------------------
        TRUCK/TRACTOR SUSPENSION CHARACTERISTICS INPUT SCREEN

        Enter the following information for tractor axle # ->X:
        Vehicle Axle Load (lbs) ------------------->XXXXXXXXXX

   -Suspension Spring Rate (lbs/in/side) ------------->XXXXXXXXXXX

   -Viscous Damping Rate (lbs/in/sec/side) ----------->XXXXXXXXXXX

   -Coulomb Damping Rate (lbs/side) ------------------>XXXXXXXXXXX

   -Unsprung Weight (lbs) ---------------------------->XXXXXXXXXXX

   -Tire Spring Rate (lbs/in/tire) ------------------->XXXXXXXXXXX
```

COMMENT(S):

1. Default values used for the first 4 suspension parameters are shown in Table 6. In addition, Figures 3 and 4 show the range in suspension spring rates and coulomb damping rates for a variety of suspension systems. It is noted that the values given in the figures are on a per axle basis and must be divided by 2 to get values on a per axle per side basis for input to the TFPV program. Figure 5 shows typical values of the unsprung axle weights.

2. The default value for tire spring rate is calculated from the following equation in TRUCKDAT:

$$K_t = 4282 + 35(P) - 1240(X_1) - 1519(X_2) + 756(X_3) \qquad (1)$$

N = 16 obs. RMSE = 158 $R^2 = 0.99$

Table 6. Default Values for Vehicle Simulation Parameters.

A. Wheelbase:	Default	Range
1. Straight Truck	198"	125" - 272"
2. 3-axle tractor (steering + tandem drive assembly)	195"	134" - 268"
3. 2-axle tractor (steering + single drive assembly)	160"	118" - 492"
4. Single-axle semitrailer	264"	180" - 203"
5. Tandem-axle semitrailer	450"	180" - 492"
6. Full trailers	228"	180" - 492"
B. Pitch Moments of Inertia	(in-lbs-sec^2)	
1. Straight Truck or Tractor	as computed from formula	100,000 - 1,000,000
2. Semi-trailer and full trailer	as computed from formula	400,000 - 5,000,000
C. Semi-Trailer Weight (lbs)		1.5 Ps - 70,000lbs where Ps = axle load on semitrailer assembly
D. Static Axle Loads (lbs)		
1. Steering		1250 - 16,000
2. Other Axles		1250 - 35,000
E. Semi-trailer hitch location	0"	-100" - 30"
F. Number of rear truck tires		1 - 2
G. Tandem axle separation	48"	46" - 54"
H. Suspension Parameters		
1. Leaf spring		
a. spring stiffness		
1. steering	1250	1,000 - 3,000 lbs/in/side
2. other single axle	5500	4,000 - 8,000 lbs/in/side
3. tandem and triple axles	8500	4,000 - 11,000 lbs/in/side
b. coulomb damping		
1. steering	500	400 - 650 lbs/side
2. other single axle	1050	600 - 1400 lbs/side

Table 6. Default Values for Vehicles Simulation Parameters. (Continued)

3. tandem and triple axles	1000	600 - 1400 lbs/side
c. viscous damping	(lbs/in/sec/ side)	
1. steering axle	30	-
2. other axles	0	-
2. Air bag (non-steering axles)		
a. spring stiffness	1750	500 - 4000 lbs/in/side
b. coulomb damping	450	250 - 800 lbs/side
c. viscous damping	20	-
3. Walking beam (non-steering axles)		
a. spring stiffness	9000	5000 - 11,000 lbs/in/side
b. coulomb damping	700	300 - 1100 lbs/side
c. viscous damping	0	-
I. Unsprung Weights (lbs)		
1. steering axle	1200	-
2. drive axles	2300	-
3. semitrailer and full trailer axles	1800	-
J. Number of rear truck or tractor drive axles		1-3
K. Number of semitrailer axles		1-3
L. Number of Full trailer axles		
1. Front		1-2
2. Rear		1-2

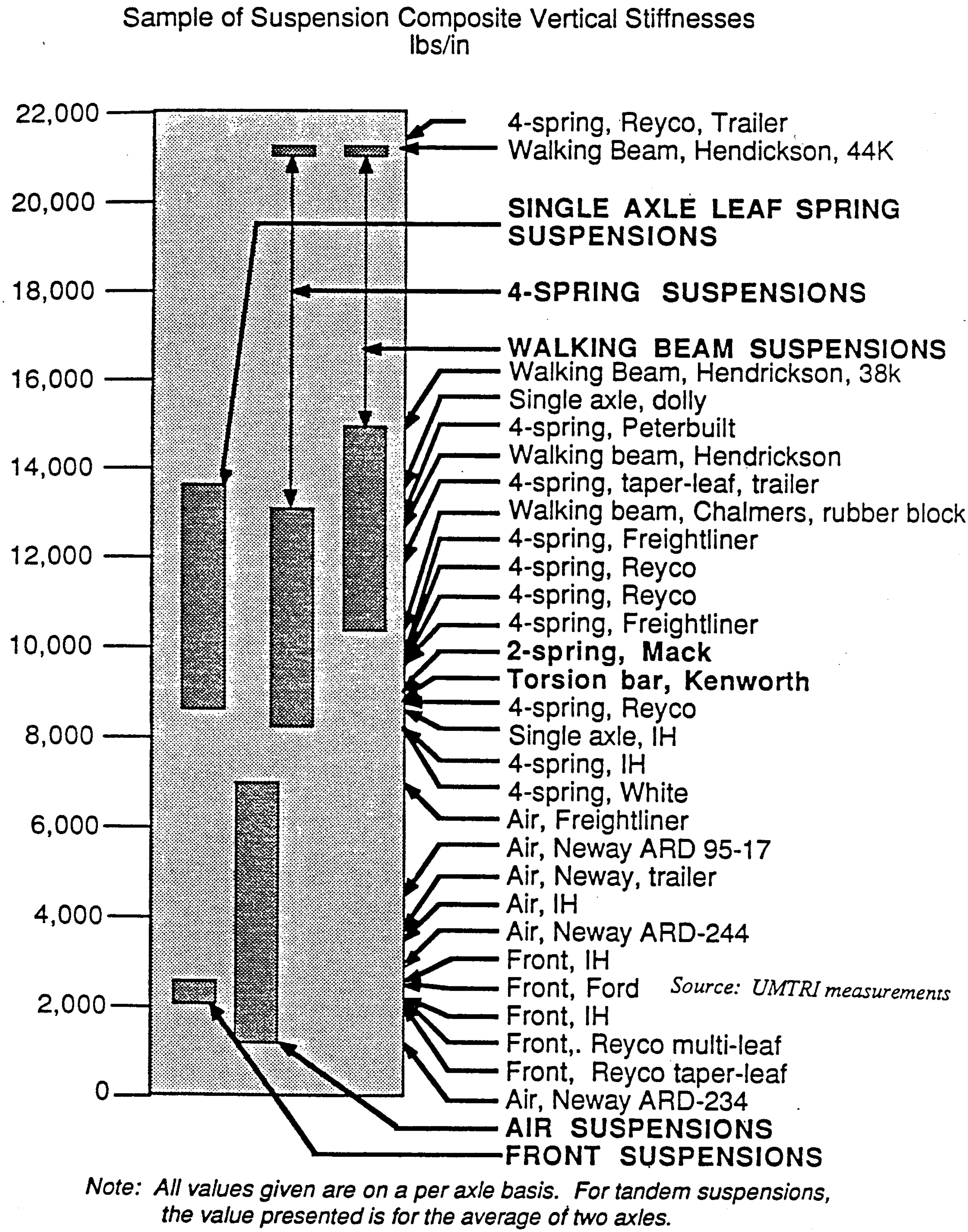
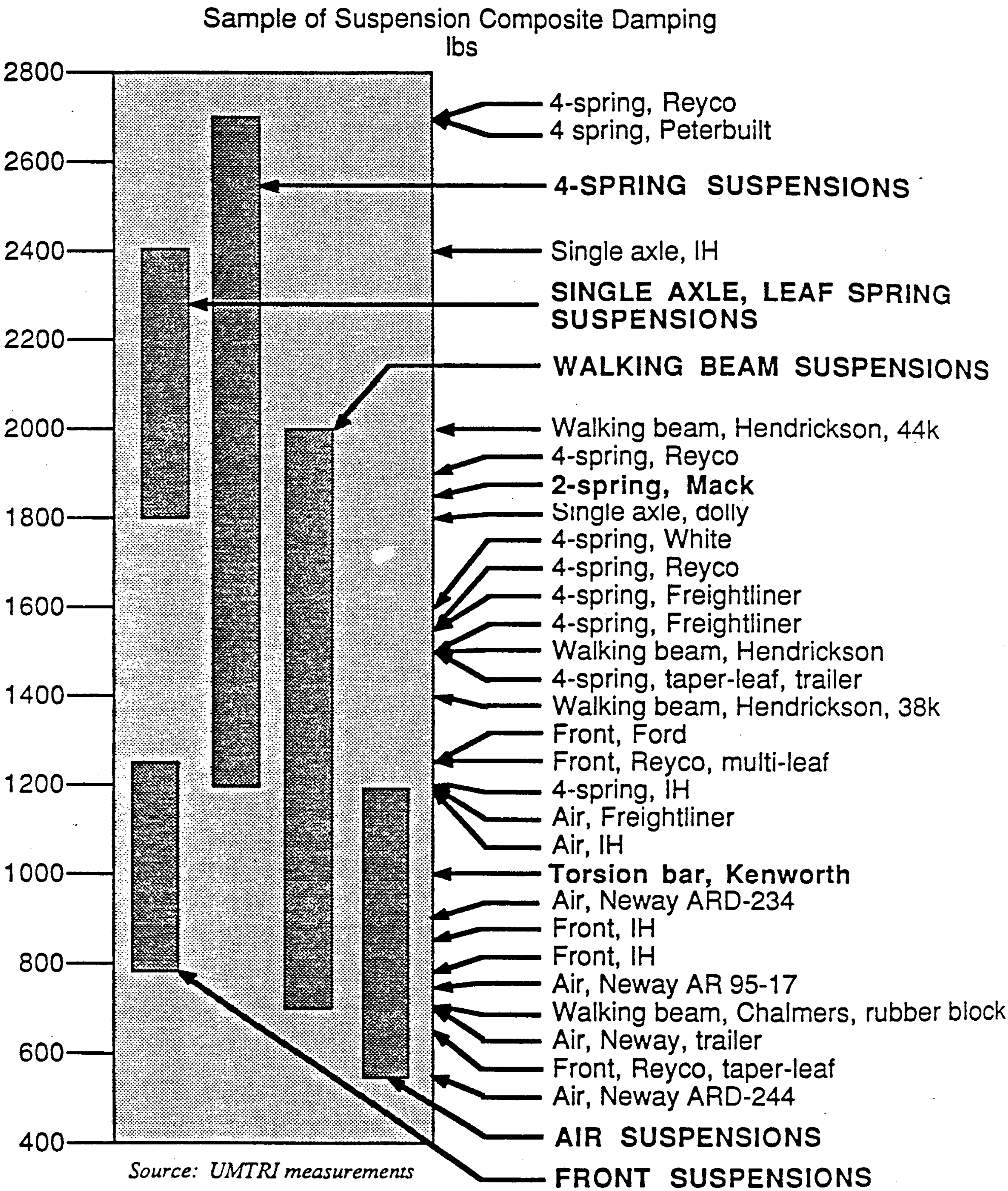


Figure 3. Suspension Composite Vertical Stiffnesses (7).



Note: All values given are on a per axle basis. For tandem suspensions, the value presented is for the average of two axles.

Figure 4 . Suspension Compension Composite Coulomb Damping (7).

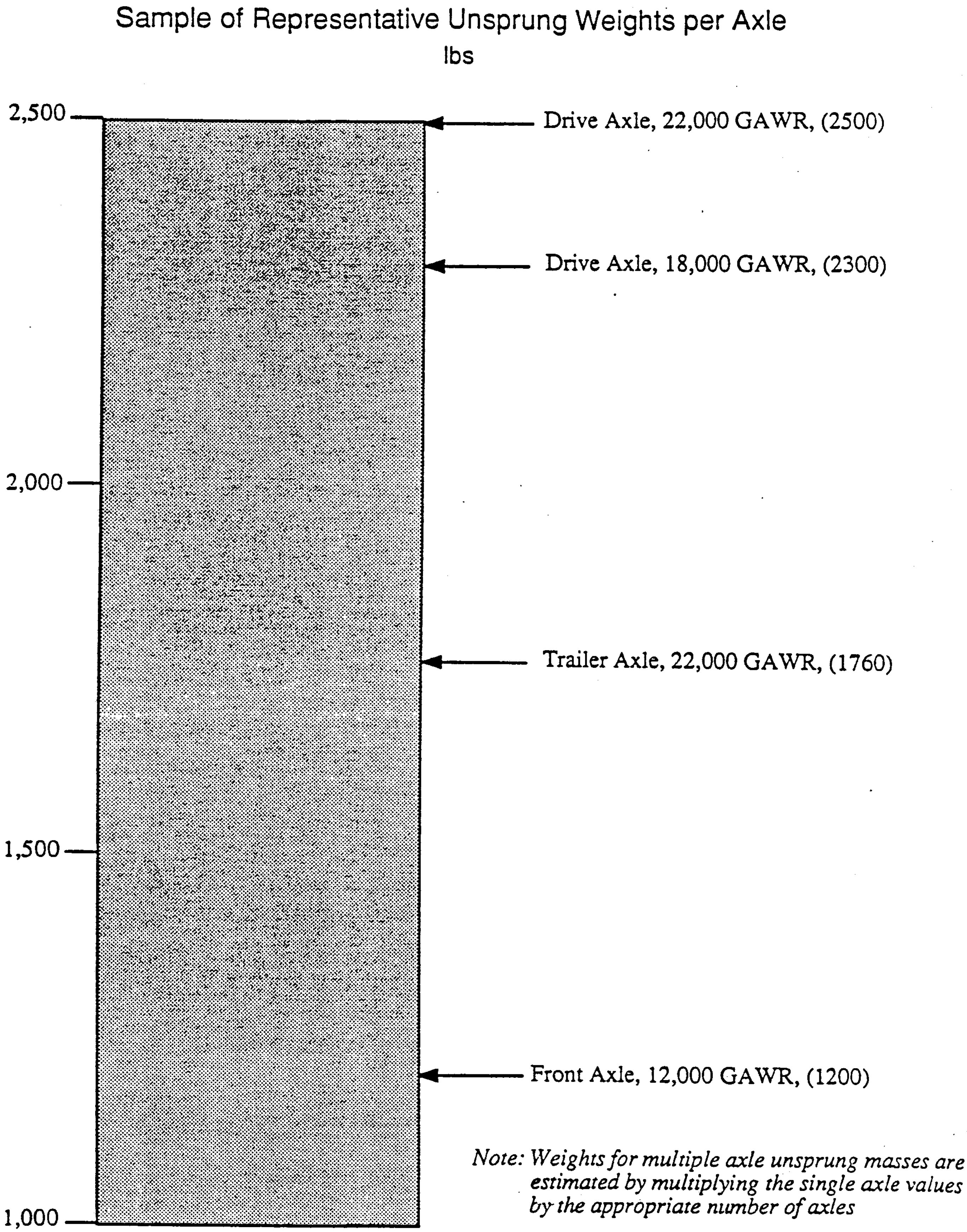


Figure 5. Representative Unsprung Weights Per Axle (Includes Axle, Tires, Brakes, Etc.) (7).

where,

K_t = tire spring rate, lbs/in.

P = tire inflation pressure, psi

X_1 = 1 if tire is conventional radial

= 0 otherwise

X_2 = 1 if tire is bias-ply

= 0 otherwise

X_3 = 1 if tire is wide base radial

= 0 otherwise

3. In addition to the tire spring rate, the user will be prompted for the truck pitch moment of inertia on this screen if the vehicle under consideration is a single unit truck. In this instance, a default value for the pitch moment of inertia is calculated from the following equation:

$$I_{yy} = \frac{W_t}{386} \left(\frac{L}{2}\right)^2 \tag{2}$$

where,

I_{yy} = pitch moment of inertia (in-lbs-sec^2)

W_t = weight of the truck or tractor (lbs.)

L = wheelbase (inches)

Figure 6 shows the typical range in pitch moments of inertia for unloaded trucks and tractors. Figure 7 shows typical values for unloaded truck and tractor weights.

Sample of Tractor and Straight Trucks
Yaw and Pitch Moments of Inertia
(in-Lbs-sec^2)

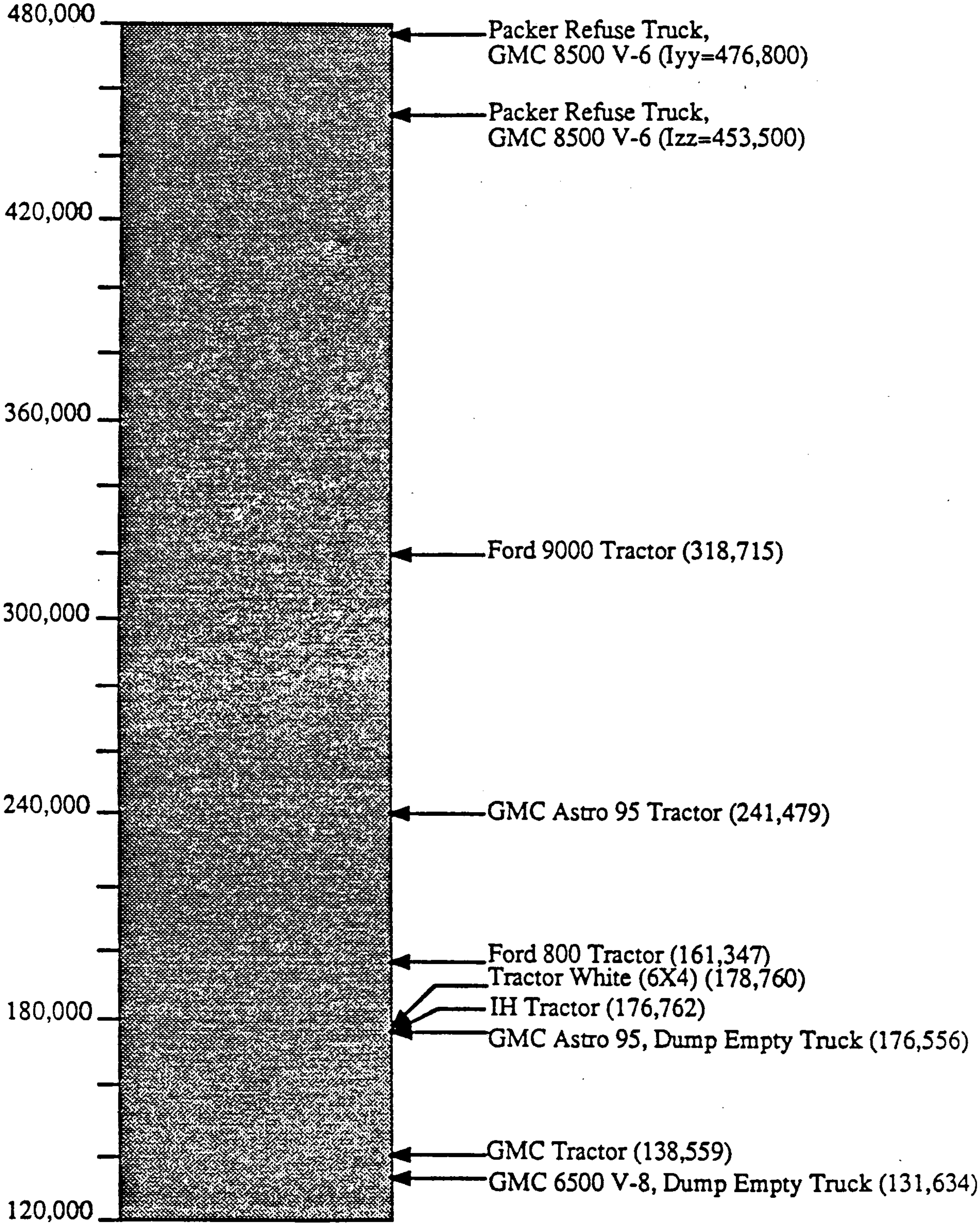


Figure 6. Tractor and Straight Trucks Yaw and Pitch Moments of Inertia About Axes Through Total c.g. (Unit Unladen) (7).

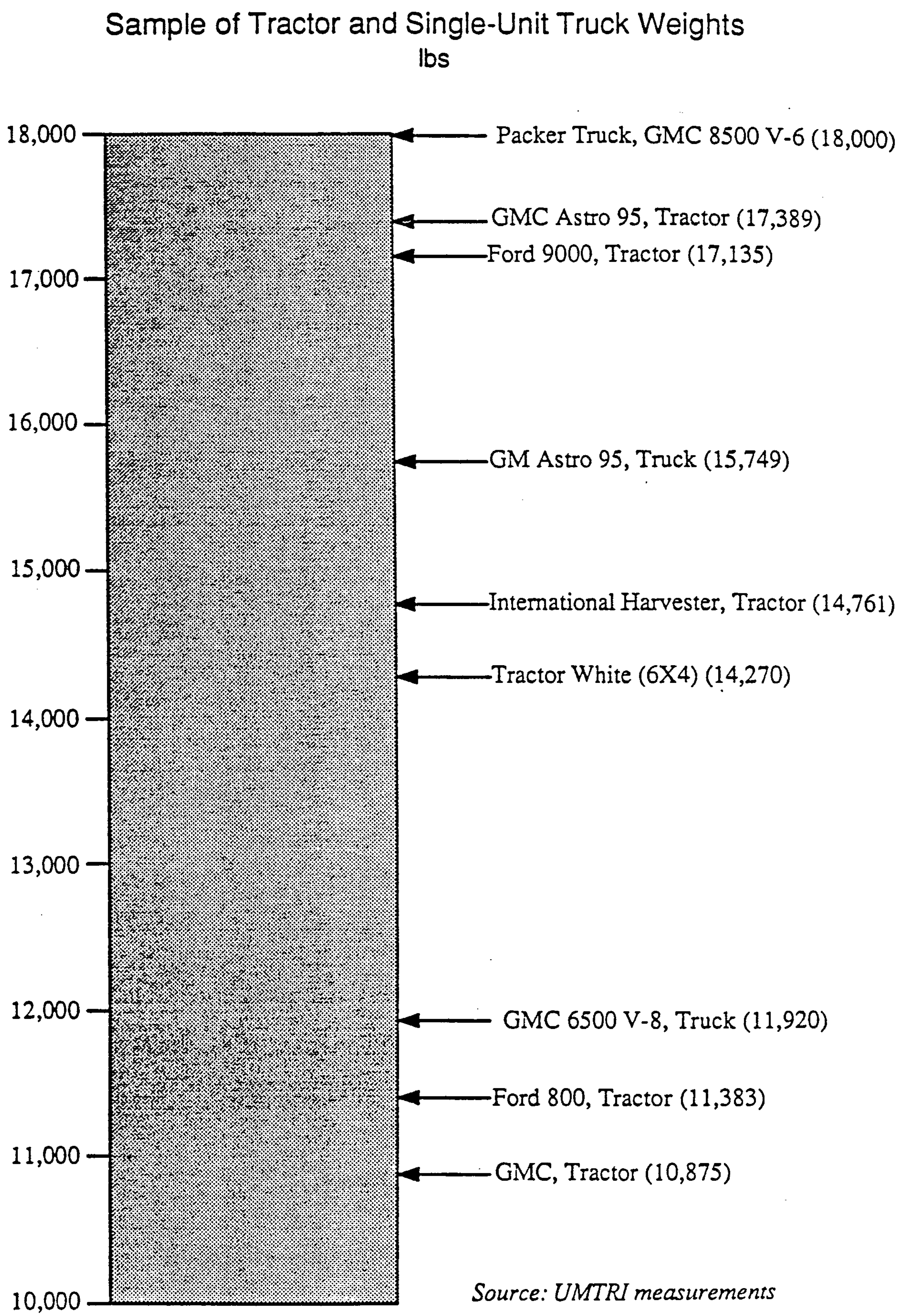


Figure 7. Tractor and Single-Unit Truck Weights (Total Unit, Unladen) (7).

SCREEN SEMI1.AID

```
                      Scenario ----->
Category -->      Configuration --->     Description ->
Tire Type ->      Suspension Type ->     Direction --->
                  GVW Category ---->
-----------------------------------------------------------
              SEMITRAILER GEOMETRY INPUT SCREEN

        Semitrailer Axle Load ---------------->XXXXXXXXXX


-Semitrailer Wheelbase (in) ---------------------->XXXXXXXXXXX

-Semitrailer Weight (lbs) ------------------------>XXXXXXXXXXX

-Semitrailer Height (in) ------------------------->XXXXXXXXXXX

-Semitrailer Length (in) ------------------------->XXXXXXXXXXX

-Semitrailer Axle Separation (in) ---------------->XXXXXXXXXXX

-Are Semitrailer Axles Parameterized Identically? ----------->X
```

COMMENT(S):

1. The semitrailer wheelbase is the distance, in inches, between the kingpin and the center of the semitrailer axle assembly as illustrated in Figure C2 of Appendix C. Typical values of this simulation parameter are shown in Table 6.

2. The semi-trailer weight is the sprung weight. Figures 8 and 9 show the range in semitrailer weights for empty and loaded semitrailers respectively.

3. The semitrailer height and length are used in TRUCKDAT to calculate a default value for the semitrailer pitch moment of inertia.

4. For the semitrailer axles, the last input item is always set to "Y" for the vehicle simulation runs in Florida COMPAS.

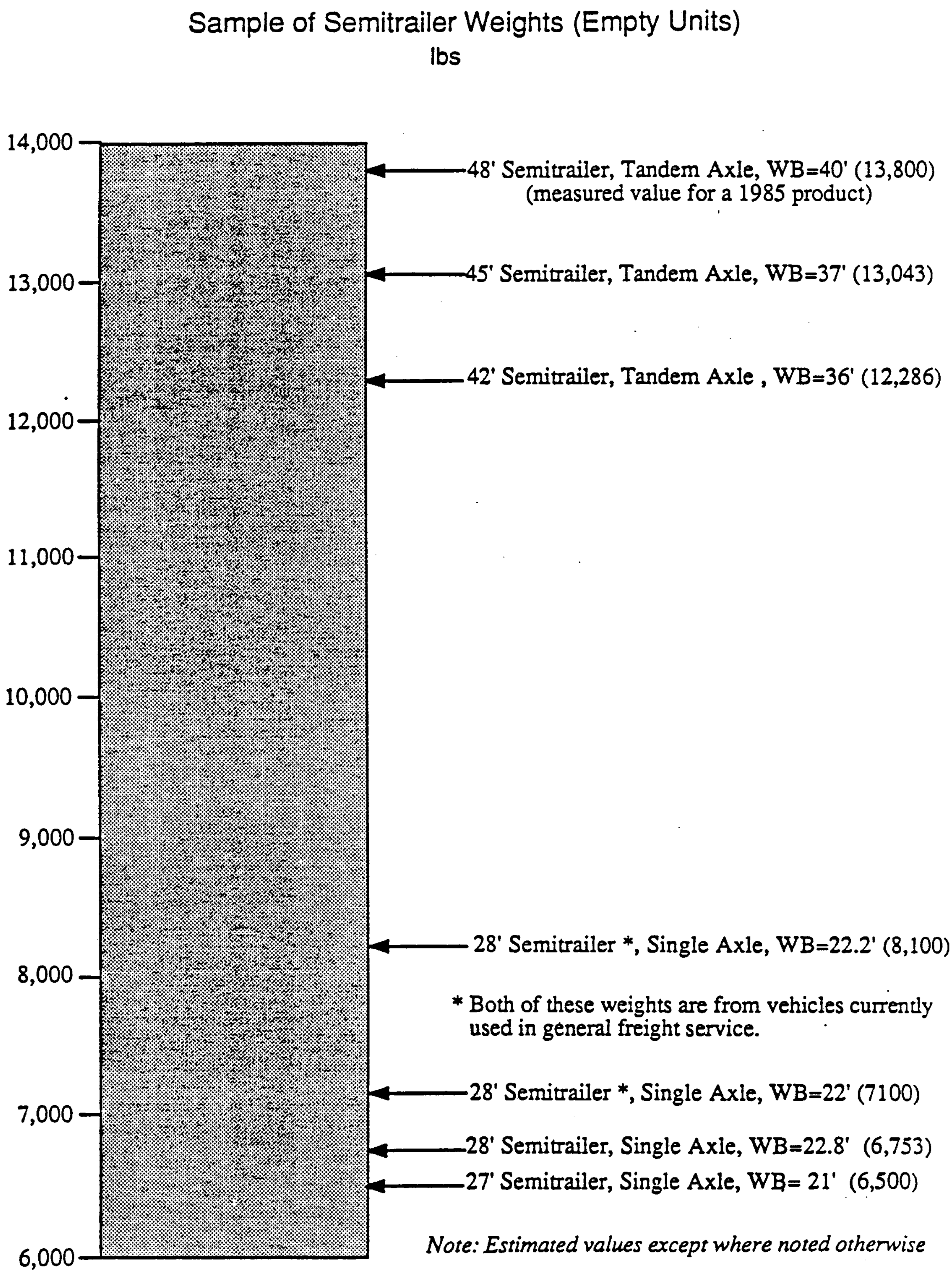


Figure 8. Semitrailer Weights (Empty Units) (7).

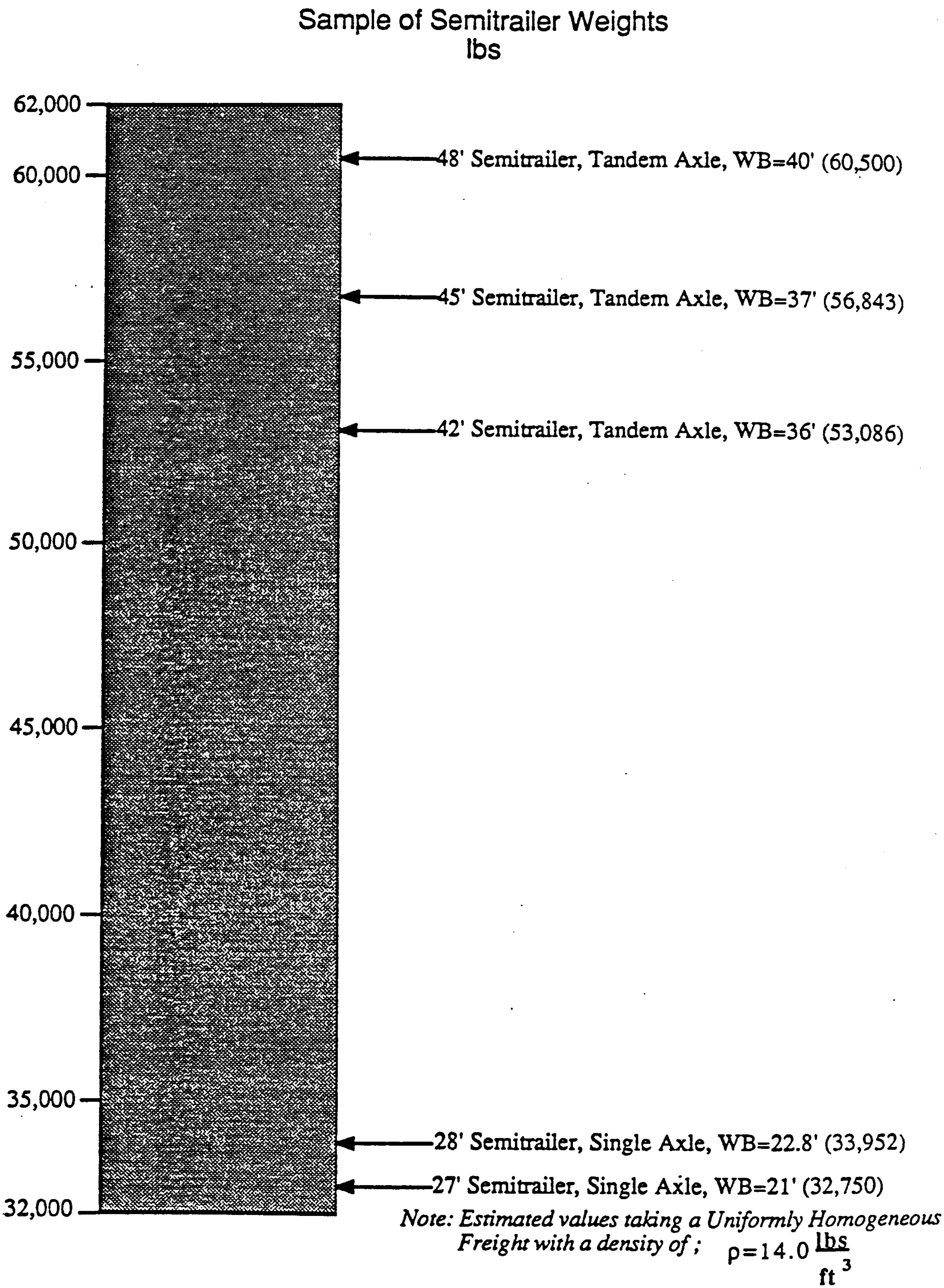


Figure 9 . Semitrailer Weights (Loaded Units) (7).

SCREEN SEMI2.AID

```
                     Scenario ----->
 Category -->     Configuration --->    Description ->
 Tire Type ->     Suspension Type ->    Direction --->
                  GVW Category ---->
------------------------------------------------------------
      SEMITRAILER SUSPENSION CHARACTERISTICS INPUT SCREEN

 -Suspension Spring Rate (lbs/in/side) ------------->XXXXXXXXXXX

 -Viscous Damping Rate (lbs/in/sec/side) ----------->XXXXXXXXXXX

 -Coulomb Damping Rate (lbs/side) ------------------>XXXXXXXXXXX

 -Unsprung Weight (lbs) ---------------------------->XXXXXXXXXXX

 -Tire Spring Rate (lbs/in/tire) ------------------->XXXXXXXXXXX
------------------------------------------------------------

 -Semitrailer Pitch Moment of Inertia (in/lbs/sec²) >XXXXXXXXXXX

 -Tractor Pitch Moment of Inertia (in/lbs/sec²) ---->XXXXXXXXXXX
```

COMMENT(S):

1. A default value for the semitrailer pitch moment of inertia is calculated from the following equation:

$$(I_{yy})_s = \left[\frac{W_s}{386}\right] \frac{(h^2 + \ell^2)}{12} \qquad (3)$$

where

$(I_{yy})_s$ = semitrailer pitch moment of inertia, in-lbs-sec^2

W_s = semitrailer weight, lbs

h = semitrailer height, inches

ℓ = semitrailer length, inches

Figures 10 and 11 show the range in semitrailer pitch moments of inertia for empty and loaded units respectively.

2. A default value for tire spring rate is calculated from Eq. (1) using the tire inflation pressure and tire type associated with the semitrailer.

3. For a tractor with a semitrailer connected to it, the tractor pitch moment of inertia is shown on this screen together with the semitrailer pitch moment of inertia. A default value for the tractor pitch moment of inertia is calculated using Eq. (2) with the tractor weight estimated from the known values of the static axle loads of the tractor-semitrailer combination, the semitrailer weight, and the unsprung axle weights of the tractor.

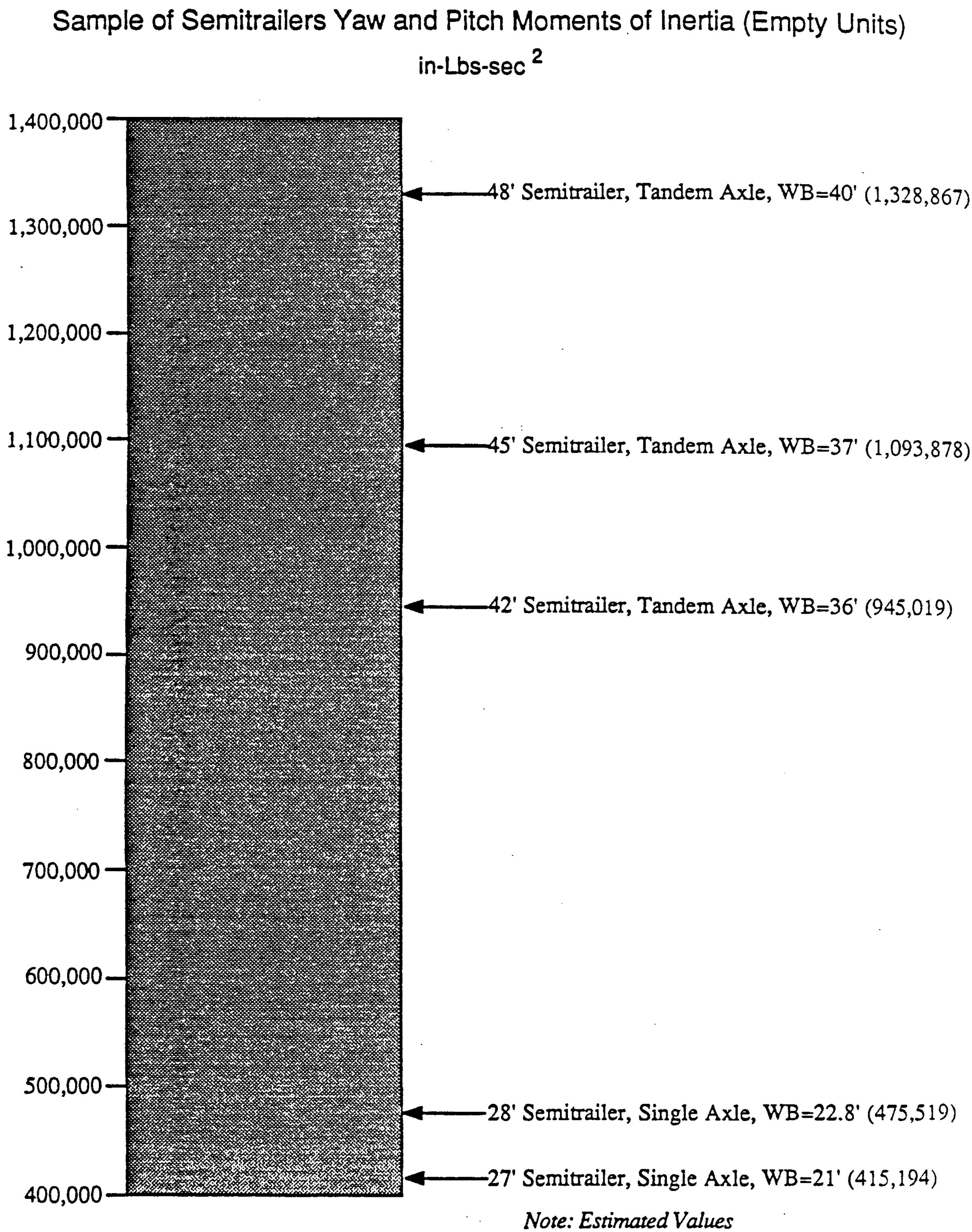


Figure 10. Semitrailers Yaw and Pitch Moments of Inertia (Empty Units) (7).

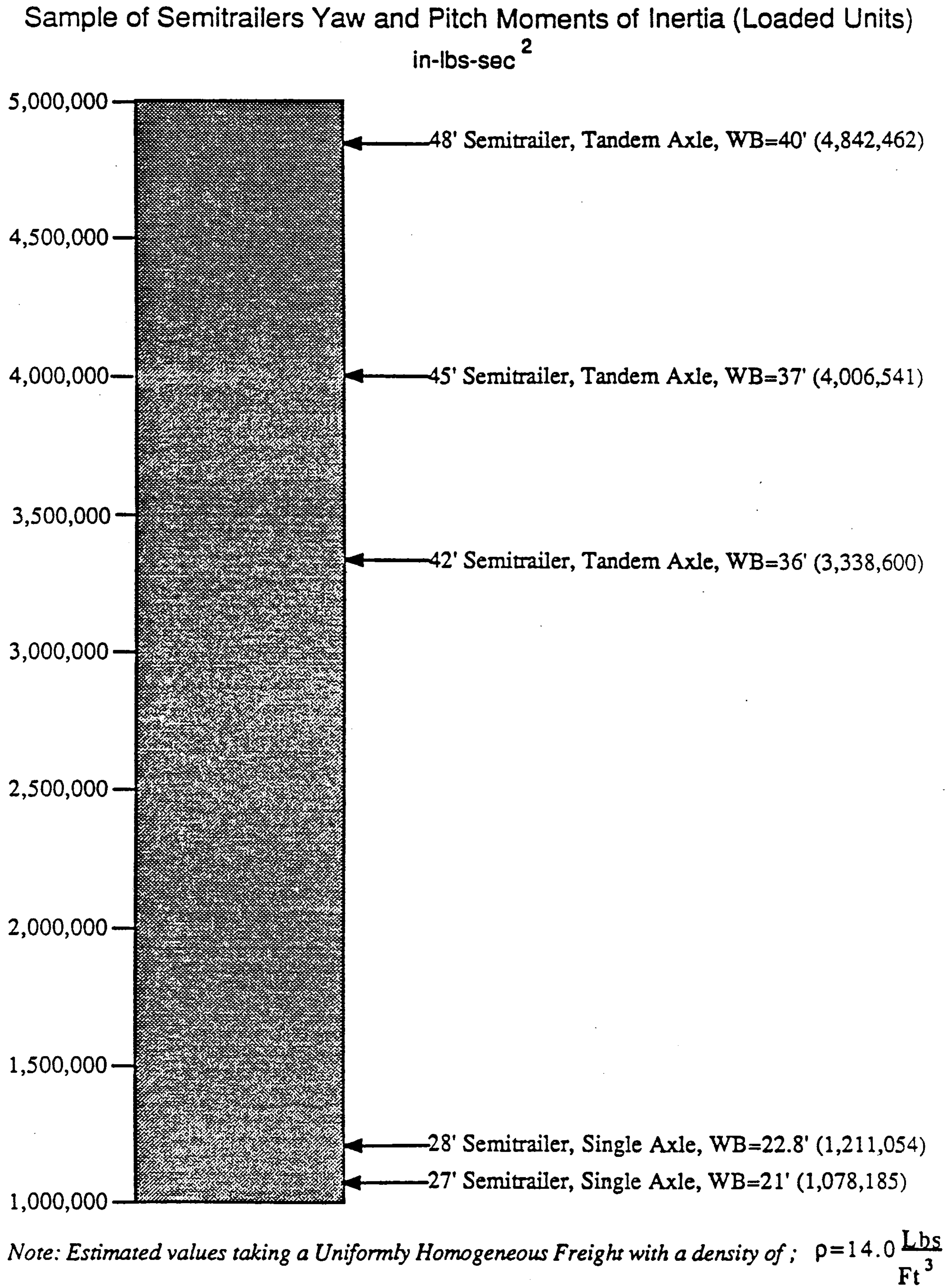


Figure 11. Semitrailers Yaw and Pitch Moments of Inertia (Loaded Units) (7).

SCREEN FULL1.AID

```
                    Scenario ----->
Category -->        Configuration --->    Description ->
Tire Type ->        Suspension Type ->    Direction --->
                    GVW Category ---->

              FULL TRAILER # X GEOMETRY INPUT SCREEN

        Front Axle Load (lds) ----------------->XXXXXXXXXX
        Rear Axle Load (lbs) ------------------>XXXXXXXXXX

  -Full Trailer Wheelbase (in) --------------------->XXXXXXXXXXX

  -Full Trailer Height (in) ------------------------>XXXXXXXXXXX

  -Full Trailer Length (in) ------------------------>XXXXXXXXXXX

  -Full Trailer Front Tandem Axle Separation (in) --->XXXXXXXXXXX

  -Full Trailer Rear Tandem Axle Separation (in) ---->XXXXXXXXXXX

  -Are all Full Trailer Axles Parameterized Identically? ------>X
```

COMMENT(S):

1. The full trailer wheelbase is the distance, in inches, from the center of the front axle assembly to the center of the rear axle assembly as illustrated in Figure C2 of Appendix C.

2. The full trailer height and length are used to estimate the pitch moment of inertia of the full trailer.

3. For full trailer axles, the last input item is always set to "N" for the vehicle simulation runs in Florida COMPAS.

SCREEN FULL2.AID

```
                  Scenario ----->
Category -->      Configuration --->    Description ->
Tire Type ->      Suspension Type ->    Direction --->
                  GVW Category ---->
--------------------------------------------------------------
       FULL TRAILER SUSPENSION CHARACTERISTICS INPUT SCREEN

  Enter the following information for:

       Full Trailer # ->X          Full Trailer Axle # ->X

-Suspension Spring Rate (lbs/in/side) ------------->XXXXXXXXXXX

-Viscous Damping Rate (lbs/in/sec/side) ----------->XXXXXXXXXXX

-Coulomb Damping Rate (lbs/side) ------------------>XXXXXXXXXXX

-Unsprung Weight (lbs) ---------------------------->XXXXXXXXXXX

-Tire Spring Rate (lbs/in/tire) ------------------->XXXXXXXXXXX

-Pitch Moment of Inertia (in/lbs/sec²) ------------>XXXXXXXXXXX
```

COMMENT(S):

1. The above data are required for each axle assembly of each full trailer of the vehicle combination.

2. A default value for tire spring rate is calculated from Eq. (1) using the tire inflation pressure and tire type associated with the full trailer.

3. A default value for the pitch moment of inertia of a full trailer is calculated using Eq. (3) with the given values for the full trailer height and length. The full trailer weight is estimated as the difference between the sum of the static axle loads and the unsprung weights of the full trailer axles.

INPUT DATA SCREENS ASSOCIATED WITH PREFLEX

SCREEN FLEX1.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

FLEXPASS INPUT PROGRAM

- Heading Information:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

- User Generated Finite Element Mesh (Y/N)? ---------------->X

- Number of Material Components ---------------------------->X

- Layer Number -------------------------------------------->X
- Density of Material (pcf) ---------------------->XXXXXXXXXX
- Poisson's Ratio -------------------------------->XXXXXXXXXX
- Coefficient of Earth Pressure at Rest ---------->XXXXXXXXXX
- Layer Thickness (in) --------------------------->XXXXXXXXXX
- Representative Year Round Pavement Temp. (°F) -->XXXXXXXXXX
- Resilient Modulus ------------------------------>XXXXXXXXXX
- XXXXXXX Content (%) ---------------------------->XXXXXXXXXX
```

COMMENT(S):

1. The FLEXPASS program can generate the finite element mesh automatically. If the user would like to specify his or her own finite element mesh, then a "Y" should be entered on the second input item of the screen above.

2. The number of material components is the number of layers for the analysis section in the given traffic direction. Up to 4 layers, including the subgrade, may be specified. The first layer must be the asphalt concrete layer. In addition, no bituminous bound base or subbase layer should be specified.

3. Typical values of density of asphalt concrete, granular base, and subgrade soils are 140, 130 and 120 pounds/cubic ft., respectively.

4. Typical values of the Poisson's ratio for different materials are shown in Table E1 of Appendix E which is the user's guide to the FLEXPASS program used in Florida COMPAS.

5. The coefficient of earth pressure at rest is calculated using the Poisson's ratio if the field for this input item is set to zero.

6. To represent a semi-infinite subgrade, enter a large value for the thickness of the layer, e.g., 360 inches.

7. The resilient modulus, in psi, for a particular layer should be representative of year-round pavement conditions at the site.

8. The last input item is the asphalt content for the asphalt surface layer, and the water content for the granular base and subgrade layers.

9. Once input data for all layers have been entered, the user is asked whether all of the specified data are correct. This gives the user the opportunity to change any of the previously entered data on the pavement layers. If the user responds with an "N" for NO, the cursor goes back to the "Number of layers" field, and he or she will again be prompted for the required layer data. If the user responds with a "Y" for YES, the next input data screen is displayed.

SCREEN FLEX2.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                 FLEXPASS INPUT PROGRAM
             Finite Element Mesh Description
                 Direction -->XXXXXXXXX

   - Number of Columns in the Mesh ---------------------------->XX
   - Number of Rows in the Mesh ------------------------------->XX

 Column    Dist.    Column    Dist.    Column    Dist.    Column    Dist.
 Bound. #  (in.)  | Bound. #  (in.)  | Bound. #  (in.)  | Bound. #  (in.)
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX  |   XX      XXXXX
```

COMMENT(S):

1. If the user wishes to specify his or her own finite element mesh, the screen above is displayed. The maximum allowable number of columns in the finite element mesh is 25. The maximum number of rows is 40.

2. The user needs to specify the horizontal distance, in inches, of each column boundary with respect to the origin. This is explained in more detail in Appendix E.

SCREEN FLEX3.AID

FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

FLEXPASS INPUT PROGRAM

Direction -->XXXXXXXXX

Row Bound. #	Layer	Elev. (in.)	Row Bound. #	Layer	Elev. (in.)	Row Bound. #	Layer	Elev. (in.)
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX
XX	X	XXXXXXX	XX	X	XXXXXXX	XX	X	XXXXXXX

COMMENT(S):

1. In this screen, the user is prompted for the elevation, in inches, of each row boundary above the bottom boundary whose elevation is assumed to be zero.

2. In addition to the elevation of a given row boundary, the user needs to specify the number of the layer below the row boundary.

3. The input for this screen are explained in more detail in Appendix E.

SCREEN FLEX4.AID

```
        FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                        FLEXPASS INPUT PROGRAM
                    Permanent Deformation Parameters


 Layer #.    Program       User Generated       User Generated   Material
             Generated    (Vary within layer)    (Constant)        Type

    1         *XXX*           *XXX*                *XXX*       XXXXXXXXXX

    2         *XXX*           *XXX*                *XXX*       XXXXXXXXXX

    3         *XXX*           *XXX*                *XXX*       XXXXXXXXXX

    4         *XXX* .         *XXX*                *XXX*       XXXXXXXXXX

                         Any Changes(Y/N)? ->X
```

COMMENT(S):

1. The user has 3 options for specifying the permanent deformation parameters for each layer:

   a. by using regression equations built into the FLEXPASS program.

   b. by specifying permanent deformation properties which vary with depth in the pavement layer.

   c. by specifying permanent deformation properties which are constant for the given layer.

   All 3 options are applicable if the user specifies his own finite element mesh. However, if the user chooses to have the mesh generated by the program, then only Options (a) and (c) are valid.

2. The material type is an alphanumeric variable which is use to describe a particular material. Under option (a) above, the following are the allowable values for material type:

a. AC for asphaltic concrete

b. BC for limerock base course

c. SG for subgrade soils

3. The required input data on permanent deformation properties are explained in more detail in Appendix E.

SCREEN FLEX5A.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

                FLEXPASS INPUT PROGRAM
        Permanent Deformation Parameter Properties
                Direction -->XXXXXXXXX

        Layer ->                              Sublayer ->

  EOR          RHO          BETA     |  EOR          RHO          BETA
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX | XXXXXXXXXX   XXXXXXXXXX   XXXXXXXXXX
```

COMMENT(S):

1. If the user selected the third option for specifying permanent deformation properties, this screen is displayed for the user to enter the required data on ϵ_0/ϵ_r(EOR), ρ(RHO), and ß(BETA), which are assumed to be constant within the given layer.

2. The sublayer field on this screen is not applicable if the third option is selected.

SCREEN FLEX5B.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

FLEXPASS INPUT PROGRAM
Permanent Deformation Parameter Properties
Direction -->XXXXXXXXX

Layer ->          Number of Sublayers ->          Sublayer ->

EOR         RHO         BETA       | EOR         RHO         BETA
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX | XXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXX
```

COMMENT(S):

If the user selected the second option for specifying permanent deformation properties, this screen is displayed for the user to enter the required data on ϵ_0/ϵ_r (EOR), ρ(RHO), and ß(BETA) for each sublayer of the given layer.

SCREEN FLEX6A.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

FLEXPASS INPUT PROGRAM
Asphalt Fatigue Concrete Constants

* 1. Rauhut's Model *

* 2. Lytton's Model *

* 3. User Input *
```

COMMENT(S):

1. The user has 3 options for specifying the fatigue properties, K_1 and K_2, of the existing asphalt layer:

   a. by using Rauhut's model

   b. by using Lytton's model

   c. by entering K_1 and K_2 directly

2. The required input data are explained in more detail in Appendix E.

SCREEN FLEX6B.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                 FLEXPASS INPUT PROGRAM
           Asphalt Fatigue Concrete Constants

                 * 1. Rauhut's Model *

                 * 2. Lytton's Model *

                   * 3. User Input *


       Viscosity Mode (1 or 2) --------------->XX
       Viscosity --------------------->XXXXXXXXXX
       Penetration @ 77 °F ----------->XXXXXXXXXX
       Percent Air Voids ------------->XXXXXXXXXX
       Max. Aggregate Radius (in.) --->XXXXXXXXXX
```

COMMENT(S):

If the user selected Lytton's model for generating the fatigue constants K_1 and K_2, the above data on mixture properties of the existing asphalt layer are required from the user.

SCREEN FLEX6C.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                 FLEXPASS INPUT PROGRAM
           Asphalt Fatigue Concrete Constants

                 * 1. Rauhut's Model *

                 * 2. Lytton's Model *

                   * 3. User Input *


     Fatigue Parameter K1 ---------->XXXXXXXXXX
     Fatigue Parameter K2 ---------->XXXXXXXXXX
```

COMMENT(S):

If the user selected the third option for specifying the fatigue properties, the user must enter the values of K_1 and K_2 on this card. The fatigue constants should be representative of the year round pavement temperature.

SCREEN FLEX7.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                    FLEXPASS INPUT PROGRAM
  Coefficient of Variation of Asphalt Concrete Fatigue Constants

 - Coefficient of Variation of K1 -------------------->XXXXXXXXXX
 - Coefficient of Variation of K2 -------------------->XXXXXXXXXX
 - Correlation Coefficient for K1 and K2 ------------->XXXXXXXXXX

                    Slope Variance Constants

 - Constant B of the Slope Variance ------------------>XXXXXXXXXX
 - Constant C of the Slope Variance ------------------>XXXXXXXXXX

                  Initial Serviceability Index

 - Initial Present Serviceability Index -------------->XXXXXXXXXX
```

COMMENT(S):

1. The coefficients of variation of fatigue constants, K_1 and K_2, and the correlation coefficient between K_1 and K_2 are used in FLEXPASS to predict the cracked area in $ft^2/1000\ ft^2$. Typical values of these variables are:

   a. coefficient of variation of K_1 = 0.20

   b. coefficient of variation of K_2 = 0.04

   c. correlation coefficient between K_1 and K_2 = -0.90

2. The slope variance constants relate the expected slope variance to the rut depth variance, as given by the following expression:

$$E(SV) = \frac{2B}{C^2}Var(RD) \tag{4}$$

where,

$E(SV)$ = expected slope variance

$Var(RD)$ = rut depth variance

B, C = slope variance constants

Typical values of B and C are 1.0 and 0.058 respectively.

3. The initial PSI is the existing PSI of the given analysis section.

SCREEN FLEX8A.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

FLEXPASS INPUT PROGRAM
Printout Control
Direction -->XXXXXXXXX

- Printout Option (0, 1,or 2) -------------------------------->X
```

COMMENT(S):

The user has 3 print out options in FLEXPASS. The first option (WRIOUT = 0) provides a summary printout of the input data and the performance predictions generated by the program. The second option (WRIOUT = 1) provides the user with all of the output information available in the first option plus a separate listing of the stresses at each finite element, and the displacements at the nodal points. For the microcomputer version of FLEXPASS used in Florida COMPAS, this listing has the filename "STRS_ _.OUT" where the 2 blank spaces refer to the scenario and traffic direction associated with the given run. The third option, WRIOUT = 2, enables the user to obtain a selective printout of the stresses and displacements.

The printout options available are also explained in Appendix E.

SCREEN FLEX8B.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                 FLEXPASS INPUT PROGRAM
                    Printout Control
                  Direction -->XXXXXXXXX

- Printout Option (0, 1,or 2) -------------------------------->X

- Stress Printout Style (H, V, or BLANK) --------------------->
```

COMMENT(S):

If the user selected the second printout option, WRIOUT = 1, he or she must specify the style of the printout of stresses and displacements (NNOPT). These pavement response variables can either be printed by row (NNOPT = H) or by column (NNOPT = V). If NNOPT is not specified, both options are used.

SCREEN FLEX81ST.AID

```
- Stress Printout Style (H, V, or BLANK) ---------------------->
```

COMMENT(S):

This screen is displayed for the user to enter the style of the printout of stresses and displacements if the printout option, WRIOUT=1, is selected.

SCREEN FLEX82ST.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                    FLEXPASS INPUT PROGRAM
                       Printout Control
                    Direction -->XXXXXXXXX

 - Printout Option (0, 1,or 2) --------------------------------->X
 - Number of Points for Printout of Stresses/Displacements ---->

Pt.  X(in.)  Y(in.)      Pt.  X(in.)  Y(in.)      Pt.  X(in.)  Y(in.)
```

COMMENT(S):

1. If the user selected the third printout option, WRIOUT = 2, he or she must specify the number of points for which stresses and displacements are to be printed. A maximum of 50 points can be specified.

2. The user must also enter the X-Y coordinates of each selected point. These coordinates are referenced from the top-left corner of the finite element mesh which coincides with the midpoint of the loaded area. The X-coordinate specifies the radial distance of the point selected from the left most column boundary, while the Y-coordinate specifies the depth of the point from the surface (row boundary = 1). For each selected point, FLEXPASS internally picks out the finite elements closest to the X-Y coordinates specified. Stresses and displacements for the elements selected are then printed out.

SCREEN FLEX83ST.AID

```
 - Number of Points for Printout of Stresses/Displacements ---->XX

Pt.  X(in.)  Y(in.)       Pt.  X(in.)  Y(in.)       Pt.  X(in.)  Y(in.)
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX      XX   XXXXXXX XXXXXXX
```

COMMENT(S):

The user enters, on this screen, the X-Y coordinates of points where stresses and displacements are to be printed out.

SCREEN FLEX9.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                FLEXPASS INPUT PROGRAM
                   Printout Control

               Direction -->XXXXXXXXX

     Pt.  X(in.)  Y(in.)        Pt.  X(in.)  Y(in.)
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
     XX  XXXXXXX XXXXXXX        XX  XXXXXXX XXXXXXX
```

COMMENT(S):

1. If the user specified, under printout option 2, more than 30 points for which stresses and displacements are to be printed out, this screen is displayed as a continuation of screen FLEX83ST.AID. The user enters on this screen, the X-Y coordinates of the remaining points where stresses and displacements are to be printed out.

2. The PREFLEX program prompts the user with the data displayed on the previous screens to create the required number of input files for all scenario/traffic direction combinations. The program creates 2 input files if there is only one analysis section for each scenario, or 4 input files, if each scenario has 2 analysis sections, one section for each traffic direction. The input files are called "FLEX_ _.DAT" where the blanks refer to the scenario and traffic direction respectively.

3. For all input files, the axle load used is the standard 18-kip single axle load with dual, bias-ply tires, inflated to a 75 psi tire inflation pressure. Nodal forces associated with the contact pressure distribution for this axle load are used in the

performance evaluation. The contact pressure distribution was obtained using the Texas A&M finite element tire model developed by Tielking (3).

INPUT DATA SCREENS ASSOCIATED WITH PREOVER

SCREEN OVER1A.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

INPUT SCREEN FOR OVERLAY PROGRAM

-Number of Layers Above Subgrade for Current Direction ------------->X

-AC Layer Elastic Modulus (psi) ->XXXXXXXX and Thickness (in.) ->XXXXX

-Base Elastic Modulus (psi) ----->XXXXXXXX and Thickness (in.) ->XXXXX

-Subbase Elastic Modulus (psi) -->XXXXXXXX and Thickness (in.) ->XXXXX

-Subgrade Elastic Modulus (psi) ---------------------------->XXXXXXXX

-Current PSI ----------------------------------------------------->XXX
```

COMMENT(S):

1. This screen is used to enter data on layer modulus, in psi, and layer thickness, in inches. The existing analysis section for a given direction of travel can have at most 4 layers, including the subgrade.

2. The modulus should be representative of year-round pavement conditions at the project site.

SCREEN OVER1B.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

INPUT SCREEN FOR OVERLAY PROGRAM

-Number of Layers Above Subgrade for Opposite Direction ------------>X

-AC Layer Elastic Modulus (psi) ->XXXXXXXX and Thickness (in.) ->XXXXX

-Base Elastic Modulus (psi) ----->XXXXXXXX and Thickness (in.) ->XXXXX

-Subbase Elastic Modulus (psi) -->XXXXXXXX and Thickness (in.) ->XXXXX

-Subgrade Elastic Modulus (psi) ---------------------------->XXXXXXXX

-Current PSI ---------------------------------------------------->XXX
```

COMMENT(S):

For a divided highway, the user can specify 2 analysis sections, one for each traffic direction. In this instance, the user will also be prompted for the layer moduli and thicknesses, and the current PSI of the analysis section in the opposite direction of travel, as shown on this screen.

SCREEN OVER2.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                  INPUT SCREEN FOR OVERLAY PROGRAM
                          Current Direction
 Enter the Following Data for the Existing AC Layer:

-TSI Failure Level ------------------------------------->XXX

-Cracking Failure Level -------------------------------->XXXX

-Rutting Failure Level --------------------------------->XXX

-Asphalt Cement (%) ---------------------------------->XXXXX

-Penetration at 77º F (in 0.1 mm) --------------------->XXXXX

-Viscosity at 140º F (in poises) ------------------->XXXXXXX

-Ring and Ball Softening Point (ºF) ------------------>XXXXXX
```

COMMENT(S):

1. The failure criteria for serviceability loss, fatigue cracking, and rutting are specified on this screen. The failure criteria for fatigue cracking should be specified in $ft^2/1000\ ft^2$ of surface area cracked. The failure criteria for rutting should be specified in inches.

2. The asphalt properties displayed on this screen are used in program OVERLAY to estimate the spacing of transverse cracks at the time of the first overlay. The input data should represent original properties of the asphalt used in the existing asphalt layer of the analysis section.

SCREEN OVER2B.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

                 INPUT SCREEN FOR OVERLAY PROGRAM
                        Opposite Direction
 Enter the Following Data for the Existing AC Layer:

-TSI Failure Level ---------------------------------------->XXX

-Cracking Failure Level ---------------------------------->XXXX

-Rutting Failure Level ------------------------------------>XXX

-Asphalt Cement (%) -------------------------------------->XXXXX

-Penetration at 77º F (in 0.1 mm) ------------------------>XXXXX

-Viscosity at 140º F (in poises) ---------------------->XXXXXXX

-Ring and Ball Softening Point (ºF) -------------------->XXXXXX
```

COMMENT(S):

If there are 2 traffic directions to be evaluated, this screen is displayed for the user to provide information on the failure criteria and asphalt properties for the opposite direction of travel.

SCREEN OVER3.AID

```
FLORIDA - COMprehensive Pavement Analysis System  (COMPAS)

              INPUT SCREEN FOR OVERLAY PROGRAM

-Mode (1 = 275º F, 2 = 140º F) ---------------------------->X
 Overlay Viscosity -------------------->XXXXXXXXXXXXXXXXXXX

-Penetration of the Overlay Binder (in 0.1 mm) ---------->XXXX

-Overlay Asphalt (%) ------------------------------->XXXXXX

-Overlay Air Voids (%) ----------------------------->XXXXXX

-Overlay Thickness for Analysis: Min. --->XXXX   Max. ---->XXXX

-Predicted PSI After Overlay ------------------------>XXXXX

-Damage Level ------------------------------------------->X
```

COMMENT(S):

1. The asphalt mixture properties on this screen are used in estimating the slope of the creep curve and the modulus of the overlay material following McCleod's nomograph. The input data on viscosity and penetration should represent original properties of the asphalt used in the overlay mix.

2. The user can specify a range of overlay thicknesses. The overlay design is then constrained by the range of overlay thicknesses established by the user.

3. The damage level is the criterion for designing overlays based on reflection cracking. Possible values of the damage level, IDMG, are:

   a. IDMG = 1 corresponds to a damage level where there are approximately 33 full-width transverse cracks per 500 feet of roadway, i.e., the crack spacing is approximately 15 feet.

b. IDMG = 2 corresponds to a damage level where there are approximately 40 full-width transverse cracks per 500 feet of roadway, i.e., the crack spacing is approximately 12.5 feet.

c. IDMG = 3 corresponds to a damage level where there are approximately 50 full-width transverse cracks per 500 feet of roadway, i.e., the crack spacing is 10 feet.

SCREEN OVER4.AID

```
FLORIDA - COMprehensive Pavement Analysis System (COMPAS)

INPUT SCREEN FOR OVERLAY PROGRAM
ENVIRONMENTAL DATA

-Year-Round Service Temperature (°F) ------------------->XXXXX

-Minimum Air Temperature (°F) -------------------------->XXXXX

-24-Hour Temperature Drop (°F) ------------------------->XXXXX

-Average Annual Amplitude of
 Solar Radiation (langleys/day) ------------------------>XXXXX
```

COMMENT(S):

1. The year-round service temperature is used, in conjunction with the given overlay mixture properties, to estimate the slope of the creep curve and the modulus of the overlay mix.

2. The minimum air temperature (°F), 24-hour temperature drop (°F), and the average annual amplitude of solar radiation, (langleys/day) are used, in conjunction with the given mixture properties of the existing asphalt layer, to estimate the crack spacing at the time of the first overlay.

3. The input data provided by the user, on the various input screens displayed by the PREOVER program, are written to a file called, FLOVE5.INP, which is the input file to the OVERLAY program. The format of this file is explained in Appendix F.

4. Default values for the required environmental data have been established for each Florida district using data from the National Weather Service. The defaults are shown in Table 7.

Table 7. Default Environmental Data

DISTRICT	YEAR-ROUND SERVICE TEMPERATURE, °F	MINIMUM AIR TEMPERATURE, °F	24-HOUR TEMPERATURE DROP, °F	AVERAGE ANNUAL AMPLITUDE OF SOLAR RATIATION (langleys/day)
1	73.	23.	21.	113.0
2	68.	7.	24.	142.5
3	68.	7.	21.	152.6
4	75.	27.	22.	113.0
5	71.	17.	22.	140.0
6	76.	36.	21.	104.2
7	72.	18.	22.	138.0

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APPENDIX A
INPUT GUIDE TO FLORIDA
GENERAL COST ANALYSIS for PAVEMENTS (FLAGCAP)

CARD 1, Overall Problem Assumptions and Description

Columns	Format	Description
1- 2	I2	* Number of Lanes in both directions
3- 7	F5.2	* Length (miles)
8	I1	* Highway Type (1-freeway, 0-non-freeway)
9	I1	* Pavement Type (1-rigid, 0-flexible)
10-12	I3	* Width, in feet, of Paved Portion of Highway
13-15	I3	* Width, in feet of travel lanes
16-21	F6.2	Cost of Overlay per Ton of Asphaltic Concrete ($) (default=30)
22-25	F4.2	Number of Tons of compacted asphaltic concrete per compacted cubic yard (default=1.96)
31-35	F5.0	Cost of Routine Maintenance, first year after overlay or beginning of analysis period, per lane mile ($) (default= 130 for flexible pavements, 260 for rigid pavements)
36-38	F3.0	Annual Increment in Routine Maintenance Costs per lane mile ($) (default=0)
39-41	F3.1	Depth of milling, inches (default = 0.0)
42-45	F4.2	Cost of milling, $/yd^2
46-47	I2	Analysis Period in years (default=20) (maximum 40)
48-52	F5.2	Annual Growth Rate of ESAL's in percent (default=3.35)
53-54	I2	Discount Rate in percent (default=7)
55-56	I2	* Number of Vehicle Categories in Current and Alternate Scenarios (maximum of 15)
57-59	I3	Current Scenario - GVW Limit in kips (default=80)

Note: * represents required data item

60-61	I2	Current Scenario - Tandem Axle Limit in kips (default=34)
62-63	I2	Current Scenario - Triple Axle Limit in kips (default=Tandem Limit)
64-65	I2	Current Scenario - Single Axle Limit in kips (default=20)
66-68	I3	Alternate Scenario - GVW Limit in kips (default=120)
69-70	I2	Alternate Scenario - Tandem Axle Limit in kips (default=44)
71-72	I2	Alternate Scenario - Triple Axle Limit in kips (default=Tandem Limit)
73-74	I2	Alternate Scenario - Single Axle Limit in kips (default=26)

Card 2, Overall Problem Assumptions and Description (Continued)

Columns	Format	Description
1-41	A40	Problem Description (maximum 40 spaces)

Note: * represents required data item

Cards A through E for each vehicle category (maximum of nine sets of cards)

Card A, Vehicle Description

Columns	Format	Description
1- 2	I2	* Vehicle Category Number (1 to 15)
3	I1	* Type of Vehicle for User Cost Calculations (1-pass car/pickups, 2-single unit trucks, 3-combination trucks)
4-13	A10	Vehicle Category Description (pass car, 2D, 3A, 3-S2, 2-S1-2, etc.)
14	I1	Scenario (1-not in current scenario, 0-otherwise) (default=0)
15-16	I2	* Shift Category (if not in current scenario, from what vehicle category will weight be shifted?) (required if not in current scenario)
17	I1	Payload Shift Switch (0 - payload shifted internally within program, 1 = user input of payload shift; default = 0)
18-21	F4.1	Percent payload shifted to new vehicle type (required if Payload Shift Switch = 1)
22	I1	* Number of Single Axles
23	I1	* Number of Tandem Axles
24	I1	* Number of Triple Axles
29-32	F4.0	Empty Weight, in kips (default = 4 for pass cars and pick-ups, = 11 for 2 axle SU trucks, = 14 for 3 axle SU trucks and buses, = 16 for 4 axle SU trucks = 20 for 4 axle tractor-semitrailers (e.g., 2-S2), = 27 for 5 axle tractor-semitrailers (e.g., 3-S2), = 30 for 6 axle tractor-semitrailers (e.g., 3-S3), = 37 for 5 axle multi-trailer (e.g., 2-S1-2), = 39 for 6 axle multi-trailer (e.g., 3-S1-2))
33-36	F4.0	GVW at which load shifting occurs, in kips (default=empty weight)

Note: * represents required data item

41-44	F4.0	Average Travel Speed (mph) with very good pavement condition (default=60)
45-48	F4.2	Cost of Fuel per Gallon ($) (default = 1.30 for pass car & 2 axle SU trucks, = 1.67 for all others)
49-52	F4.2	Cost of Oil per Quart ($) (default = 1.95 for pass car, = 2.00 for all others)
53-58	F6.2	Cost of Maintenance and Repair per 1000 miles ($) (default = 69.94 for pass car, = 153.25 for 2 axle SU trucks, = 216.72 for 3 axle SU trucks, = 224.46 for all others)
59-65	F7.0	Depreciable Value of Vehicle ($) (default = 10,057 for pass car, = 13,010 for 2 axle SU truck, = 68,025 for 3 axle and 4 axle SU trucks, = 73,051 for 4 axle combination truck (e.g., 2-S2), = 77,445 for 5 axle and 6 axle tractor-semitrailers, = 87,445 for tractor-semitrailer-full trailer combinations)
66-70	F5.2	Value of Time per Vehicle ($/hr.) (default = 11.15 for pass car, = 20.39 for all others)

Note: * represents required data item

Card B, Number of Vehicles by GVW

Columns	Format	Description
1-6	F6.0	* Number of Vehicles in 0-5 Kip Range
7-12	F6.0	* Number of Vehicles in 5.1-10 Kip Range
13-17	F5.0	* Number of Vehicles in 10.1-15 Kip Range
18-22	F5.0	* Number of Vehicles in 15.1-20 Kip Range
23-27	F5.0	* Number of Vehicles in 20.1-25 Kip Range
28-32	F5.0	* Number of Vehicles in 25.1-30 Kip Range
33-37	F5.0	* Number of Vehicles in 30.1-35 Kip Range
38-42	F5.0	* Number of Vehicles in 35.1-40 Kip Range
43-47	F5.0	* Number of Vehicles in 40.1-45 Kip Range
48-52	F5.0	* Number of Vehicles in 45.1-50 Kip Range
53-57	F5.0	* Number of Vehicles in 50.1-55 Kip Range
58-62	F5.0	* Number of Vehicles in 55.1-60 Kip Range
63-67	F5.0	* Number of Vehicles in 60.1-65 Kip Range
68-72	F5.0	* Number of Vehicles in 65.1-70 Kip Range
73-77	F5.0	* Number of Vehicles in 70.1-75 Kip Range

Note: * represents required data item

Card C, Number of Vehicles by GVW (Continued)

Columns	Format	Description
1-5	F5.0	* Number of Vehicles in 75.1-80 Kip Range
6-10	F5.0	* Number of Vehicles in 81.1-85 Kip Range
11-15	F5.0	* Number of Vehicles in 85.1-90 Kip Range
16-20	F5.0	* Number of Vehicles in 90.1-95 Kip Range
21-25	F5.0	* Number of Vehicles in 95.1-100 Kip Range
26-30	F5.0	* Number of Vehicles in 100.1-105 Kip Range
31-35	F5.0	* Number of Vehicles in 105.1-110 Kip Range
36-40	F5.0	* Number of Vehicles in 110.1-115 Kip Range
41-45	F5.0	* Number of Vehicles in 115.1-120 Kip Range
46-50	F5.0	* Number of Vehicles in 120.1-125 Kip Range
51-55	F5.0	* Number of Vehicles in 125.1-130 Kip Range
56-60	F5.0	* Number of Vehicles in 130.1-135 Kip Range
61-65	F5.0	* Number of Vehicles in 135.1-140 Kip Range

Note: * represents required data item

Card D, Current Scenario for Vehicle Category

Columns	Format	Description
1-4	F4.0	Percent of Vehicles in Category with Bias Ply tires (default = 10 for pass car, = 60 for 2D, = 50 for 3A, buses, and 4 axle SU trucks, = 28 for all others)
5-6	I2	Number of Bias Ply Tires per Vehicle
7-10	F4.0	Hot Inflation Pressure of Bias tires (default = 35 for pass car, = 60 for 2D, = 70 for 3A and buses = 90 for all others)
11-15	F5.0	Cost of Bias Tires, $ per tire (default = 67 for pass car, = 137 for 2 axle SU trucks, = 268 for all others)
16-20	F5.0	Cost of Bias Retread, $ per tire (default = 30 for pass car, = 46 for 2 axle SU trucks, = 90 for all others)
21-23	F3.1	Number of Bias Retreads per tire (default = 0 for pass car, = 1.5 for 2 axle SU trucks, = 2.5 for all others)
24-27	F4.0	Percent of Vehicles in Category with Conventional Radial tires (default = 90 for pass car, = 40 for 2D, = 50 for 3A, buses, and 4 axle SU trucks, = 70 for all others)
28-29	I2	Number of Conventional Radial Tires per Vehicle
30-33	F4.0	Hot Inflation Pressure of Radial tires (default = 35 for pass car, = 75 for 2D, = 85 for 3A and buses = 105 for all others)

Note: * represents required data item

34-38	F5.0	Cost of Radial Tires, $ per tire (default = 100 for pass car, = 200 for 2 axle SU truck, = 355 for all others)
39-43	F5.0	Cost of Radial Retread, $ per tire (default = 50 for pass car, = 100 for 2 axle SU truck, = 150 for all others)
44-46	F3.1	Number of Radial Retreads per tire (default = 0 for pass car, = 1.5 for 2 axle SU truck, = 2.5 for all others)
47-50	F4.0	Percent of Vehicles in Category with Wide-Base Single tires (default = 2 for vehicle categories 7 to 15 = 0 for all others)
51-52	I2	Number of Wide-Base Single Tires per Vehicle
53-54	I2	Number of Conventional Radial Tires on Wide-Base Single Vehicle
55-58	F4.0	Hot Inflation Pressure of Wide-Base Single tires (default = 105)
59-63	F5.0	Cost of Wide-Base Single Tires, per tire (default = $612)
64-68	F5.0	Cost of Wide-Base Single Retread, per tire (default = $250)
69-71	F3.1	Number of Wide-Base Retreads per tire (default = 0)

Note: * represents required data item

Card E, Alternate Scenario for Vehicle Category (defaults used are values specified for the base scenario)

Columns	Format	Description
1-4	F4.0	Percent of Vehicles in Category with Bias Ply tires
5-6	I2	Number of Bias Ply Tires per Vehicle
7-10	F4.0	Hot Inflation Pressure of Bias tires
11-15	F5.0	Cost of Bias Tires, $ per tire
16-20	F5.0	Cost of Bias Retread, $ per tire
21-23	F3.1	Number of Bias Retreads per tire
24-27	F4.0	Percent of Vehicles in Category with Conventional Radial tires
28-29	I2	Number of Conventional Radial Tires per Vehicle
30-33	F4.0	Hot Inflation Pressure of Radial tires
34-38	F5.0	Cost of Radial Tires, $ per tire
39-43	F5.0	Cost of Radial Retread, $ per tire
44-46	F3.1	Number of Radial Retreads per tire
47-50	F4.0	Percent of Vehicles in Category with Wide-Base Single tires
51-52	I2	Number of Wide-Base Single Tires per Vehicle
53-54	I2	Number of Conventional Radial Tires on Wide-Base Single Vehicle
55-58	F4.0	Hot Inflation Pressure of Wide-Base Single tires
59-63	F5.0	Cost of Wide-Base Single Tires, per tire
64-68	F5.0	Cost of Wide-Base Single Retread, per tire
69-71	F3.1	Number of Wide-Base Retreads per tire

Note: * represents required data item

FLAGCAP OUTPUT

The output from FLAGCAP consist of the file "FLAGCAP.ECH" which gives an echo of the input data entered by the user, and a file containing the estimated vehicle operating costs and pavement costs for the prescribed analysis period. This latter file is created only when the user has chosen to have the program output saved in a disk file. After completion of the cost analysis, FLAGCAP will ask the user if the results are to be written to a disk file. Figure A1 shows a sample cost analysis output file. The name of this file is specified by the user.

For each scenario, traffic direction, and vehicle category considered, estimates of vehicle operating costs, expressed in terms of present worth, are written to the user specified output file. Components of vehicle operating costs include those attributed to vehicle depreciation, oil consumption, tire wear, vehicle maintenance and repair, fuel consumption, and user travel time. Present worth costs for these components are calculated for each year of the analysis period. In addition, pavement costs attributed to routine maintenance, required overlays, level-ups, and millings are calculated, and the results presented for both the base and alternate scenarios. Again, the costs are expressed in terms of present worth, and are calculated for each year of the analysis period.

PROBLEM: Project FL-12345
USER COST CALCULATIONS, CURRENT SCENARIO, VEHICLE CATEGORY - PASS CAR

YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
	DISCOUNTED COSTS (THOUS. $)						
1	17.31	1.05	1.64	25.08	23.67	63.17	131.92
2	16.73	1.02	1.59	24.29	22.85	61.03	127.51
3	16.21	1.00	1.56	23.95	22.01	59.06	123.80
4	15.68	.97	1.52	23.39	21.22	57.11	119.90
5	15.16	.95	1.48	22.77	20.48	55.20	116.04
6	14.66	.92	1.44	22.13	19.76	53.35	112.26
7	14.17	.89	1.39	21.48	19.07	51.56	108.56
8	13.69	.86	1.35	20.81	18.41	49.81	104.94
9	13.23	.83	1.31	20.16	17.78	48.13	101.44
10	12.79	.81	1.27	19.53	17.16	46.50	98.06
11	12.36	.78	1.23	18.92	16.57	44.93	94.79
12	11.94	.76	1.19	18.33	16.00	43.41	91.62
13	11.54	.73	1.15	17.73	15.45	41.94	88.53
14	11.15	.71	1.11	17.15	14.92	40.51	85.55
15	10.77	.69	1.08	16.62	14.40	39.14	82.69
16	10.41	.66	1.04	16.07	13.91	37.81	79.90
17	10.05	.64	1.01	15.55	13.43	36.53	77.21
18	9.72	.62	.97	15.06	12.97	35.30	74.63
19	9.39	.60	.94	14.57	12.52	34.10	72.12
20	9.07	.58	.91	14.09	12.09	32.94	69.68
TOTAL	256.01	16.08	25.16	387.68	344.66	931.55	1961.15

PROBLEM: Project FL-12345
USER COST CALCULATIONS, ALTERNATE SCENARIO, VEHICLE CATEGORY - PASS CAR

YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
	DISCOUNTED COSTS (THOUS. $)						
1	17.33	1.06	1.65	25.24	23.65	63.21	132.13
2	16.74	1.02	1.60	24.45	22.83	61.07	127.71
3	16.22	1.00	1.57	24.11	21.99	59.10	123.99
4	15.69	.98	1.53	23.54	21.20	57.14	120.09
5	15.18	.95	1.49	22.91	20.46	55.24	116.23
6	14.67	.92	1.44	22.23	19.75	53.38	112.39
7	14.18	.89	1.40	21.57	19.06	51.58	108.69
8	13.71	.87	1.36	20.93	18.40	49.85	105.10
9	13.25	.84	1.31	20.28	17.76	48.16	101.60
10	12.80	.81	1.27	19.65	17.15	46.53	98.21
11	12.37	.79	1.23	19.03	16.55	44.96	94.93
12	11.95	.76	1.19	18.41	15.99	43.43	91.73
13	11.54	.73	1.15	17.81	15.44	41.96	88.64
14	11.16	.71	1.12	17.25	14.90	40.54	85.68
15	10.78	.69	1.08	16.72	14.39	39.17	82.82
16	10.42	.67	1.05	16.17	13.89	37.84	80.03
17	10.06	.64	1.01	15.64	13.42	36.55	77.33
18	9.72	.62	.98	15.13	12.96	35.31	74.72
19	9.39	.60	.95	14.63	12.51	34.11	72.20
20	9.07	.58	.91	14.16	12.08	32.96	69.76
TOTAL	256.24	16.15	25.29	389.87	344.37	932.09	1964.00

Figure A1. Sample Cost Analysis Output File From FLAGCAP.

PROBLEM: Project FL-12345
USER COST CALCULATIONS, CURRENT SCENARIO, VEHICLE CATEGORY - 2D

			DISCOUNTED COSTS (THOUS. $)				
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	.60	.08	.04	2.20	2.67	6.50	12.09
2	.58	.08	.04	2.13	2.58	6.28	11.68
3	.56	.08	.04	2.09	2.49	6.08	11.34
4	.55	.07	.04	2.04	2.41	5.88	10.98
5	.53	.07	.04	1.99	2.32	5.68	10.62
6	.51	.07	.04	1.93	2.24	5.49	10.28
7	.49	.07	.03	1.87	2.17	5.30	9.94
8	.48	.07	.03	1.81	2.09	5.12	9.60
9	.46	.06	.03	1.75	2.02	4.95	9.28
10	.45	.06	.03	1.70	1.95	4.78	8.97
11	.43	.06	.03	1.64	1.88	4.62	8.67
12	.42	.06	.03	1.59	1.82	4.47	8.38
13	.40	.05	.03	1.54	1.76	4.31	8.10
14	.39	.05	.03	1.49	1.70	4.17	7.83
15	.38	.05	.03	1.44	1.64	4.03	7.56
16	.36	.05	.03	1.40	1.58	3.89	7.31
17	.35	.05	.02	1.35	1.53	3.76	7.06
18	.34	.05	.02	1.31	1.48	3.63	6.83
19	.33	.04	.02	1.26	1.43	3.51	6.60
20	.32	.04	.02	1.22	1.38	3.39	6.37
TOTAL	8.93	1.22	.62	33.75	39.14	95.83	179.50

PROBLEM: Project FL-12345
USER COST CALCULATIONS, ALTERNATE SCENARIO, VEHICLE CATEGORY - 2D

			DISCOUNTED COSTS (THOUS. $)				
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	.52	.08	.04	1.98	2.41	5.83	10.86
2	.51	.07	.04	1.92	2.33	5.63	10.50
3	.49	.07	.04	1.89	2.25	5.45	10.18
4	.48	.07	.03	1.84	2.17	5.27	9.86
5	.46	.07	.03	1.79	2.10	5.10	9.54
6	.45	.06	.03	1.74	2.02	4.92	9.23
7	.43	.06	.03	1.68	1.95	4.76	8.92
8	.42	.06	.03	1.63	1.89	4.60	8.63
9	.41	.06	.03	1.58	1.82	4.44	8.34
10	.39	.06	.03	1.53	1.76	4.29	8.06
11	.38	.05	.03	1.48	1.70	4.15	7.79
12	.37	.05	.03	1.43	1.64	4.01	7.53
13	.35	.05	.03	1.39	1.59	3.87	7.27
14	.34	.05	.02	1.34	1.53	3.74	7.03
15	.33	.05	.02	1.30	1.48	3.61	6.79
16	.32	.05	.02	1.26	1.43	3.49	6.57
17	.31	.04	.02	1.22	1.38	3.37	6.34
18	.30	.04	.02	1.18	1.33	3.26	6.13
19	.29	.04	.02	1.14	1.29	3.15	5.92
20	.28	.04	.02	1.10	1.24	3.04	5.72
TOTAL	7.84	1.11	.57	30.41	35.31	85.97	161.21

Figure A1. Sample Cost Analysis Output File From FLAGCAP (continued).

PROBLEM: Project FL-12345
USER COST CALCULATIONS, CURRENT SCENARIO, VEHICLE CATEGORY - 3A

	DISCOUNTED COSTS (THOUS. $)						
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	2.37	.15	.15	3.80	4.76	7.97	19.20
2	2.29	.14	.15	3.68	4.60	7.70	18.56
3	2.23	.14	.14	3.62	4.44	7.45	18.02
4	2.16	.13	.14	3.53	4.29	7.21	17.46
5	2.09	.13	.13	3.43	4.14	6.97	16.89
6	2.02	.13	.13	3.33	4.00	6.73	16.35
7	1.96	.12	.13	3.23	3.86	6.51	15.81
8	1.89	.12	.12	3.13	3.73	6.29	15.28
9	1.83	.11	.12	3.03	3.60	6.07	14.77
10	1.77	.11	.11	2.94	3.48	5.87	14.28
11	1.71	.11	.11	2.84	3.36	5.67	13.80
12	1.65	.10	.11	2.75	3.25	5.48	13.34
13	1.60	.10	.10	2.66	3.14	5.29	12.89
14	1.55	.10	.10	2.58	3.03	5.11	12.46
15	1.49	.09	.10	2.49	2.93	4.94	12.04
16	1.44	.09	.09	2.41	2.83	4.77	11.64
17	1.40	.09	.09	2.33	2.73	4.61	11.24
18	1.35	.08	.09	2.26	2.64	4.45	10.87
19	1.30	.08	.08	2.18	2.55	4.30	10.50
20	1.26	.08	.08	2.11	2.46	4.16	10.15
TOTAL	35.35	2.19	2.27	58.35	69.82	117.57	285.55

PROBLEM: Project FL-12345
USER COST CALCULATIONS, ALTERNATE SCENARIO, VEHICLE CATEGORY - 3A

	DISCOUNTED COSTS (THOUS. $)						
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	1.89	.13	.14	3.18	4.12	6.65	16.11
2	1.82	.13	.13	3.08	3.98	6.42	15.57
3	1.77	.12	.13	3.03	3.85	6.22	15.12
4	1.72	.12	.12	2.96	3.72	6.01	14.65
5	1.67	.11	.12	2.87	3.59	5.81	14.17
6	1.61	.11	.12	2.79	3.47	5.62	13.71
7	1.56	.11	.11	2.70	3.35	5.43	13.26
8	1.51	.10	.11	2.62	3.23	5.24	12.82
9	1.46	.10	.11	2.54	3.12	5.07	12.39
10	1.41	.10	.10	2.46	3.02	4.90	11.98
11	1.36	.09	.10	2.38	2.91	4.73	11.58
12	1.32	.09	.10	2.30	2.81	4.57	11.19
13	1.27	.09	.09	2.23	2.72	4.41	10.81
14	1.23	.08	.09	2.16	2.63	4.27	10.45
15	1.19	.08	.09	2.09	2.54	4.12	10.10
16	1.15	.08	.08	2.02	2.45	3.98	9.76
17	1.11	.08	.08	1.95	2.37	3.85	9.43
18	1.08	.07	.08	1.89	2.28	3.72	9.12
19	1.04	.07	.08	1.83	2.21	3.59	8.81
20	1.00	.07	.07	1.77	2.13	3.47	8.51
TOTAL	28.18	1.93	2.03	48.86	60.48	98.06	239.54

Figure A1. Sample Cost Analysis Output File From FLAGCAP (continued).

PROBLEM: Project FL-12345
USER COST CALCULATIONS, CURRENT SCENARIO, VEHICLE CATEGORY - 3-S2

			DISCOUNTED COSTS (THOUS. $)				
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	27.13	2.69	2.22	56.52	85.43	114.79	288.77
2	26.22	2.60	2.14	54.72	82.51	110.90	279.10
3	25.51	2.52	2.09	53.82	79.66	107.33	270.94
4	24.74	2.44	2.03	52.49	76.93	103.78	262.40
5	23.96	2.36	1.96	51.05	74.29	100.31	253.93
6	23.20	2.28	1.90	49.57	71.75	96.95	245.65
7	22.44	2.21	1.84	48.07	69.29	93.69	237.54
8	21.70	2.13	1.78	46.56	66.92	90.52	229.61
9	20.98	2.06	1.72	45.09	64.64	87.46	221.95
10	20.29	1.99	1.66	43.67	62.43	84.50	214.54
11	19.62	1.92	1.61	42.29	60.29	81.65	207.38
12	18.97	1.86	1.56	40.95	58.23	78.88	200.46
13	18.33	1.80	1.50	39.61	56.24	76.21	193.69
14	17.72	1.73	1.45	38.31	54.32	73.62	187.16
15	17.13	1.68	1.40	37.10	52.47	71.13	180.91
16	16.56	1.62	1.36	35.88	50.68	68.71	174.81
17	16.00	1.56	1.31	34.70	48.95	66.38	168.91
18	15.47	1.51	1.27	33.61	47.27	64.14	163.27
19	14.95	1.46	1.23	32.50	45.66	61.96	157.76
20	14.45	1.41	1.19	31.43	44.10	59.85	152.44
TOTAL	405.39	39.85	33.22	867.94	1252.05	1692.75	4291.19

PROBLEM: Project FL-12345
USER COST CALCULATIONS, ALTERNATE SCENARIO, VEHICLE CATEGORY - 3-S2

			DISCOUNTED COSTS (THOUS. $)				
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	21.41	2.35	1.96	47.16	75.02	95.33	243.23
2	20.69	2.27	1.90	45.66	72.46	92.10	235.08
3	20.13	2.20	1.85	44.90	69.95	89.14	228.17
4	19.52	2.12	1.79	43.79	67.55	86.19	220.97
5	18.91	2.05	1.74	42.58	65.24	83.31	213.83
6	18.29	1.99	1.68	41.29	63.01	80.51	206.77
7	17.70	1.92	1.63	40.04	60.85	77.80	199.94
8	17.12	1.86	1.58	38.83	58.77	75.18	193.34
9	16.56	1.79	1.52	37.61	56.76	72.64	186.88
10	16.01	1.73	1.47	36.42	54.82	70.18	180.64
11	15.48	1.67	1.42	35.27	52.95	67.81	174.61
12	14.96	1.62	1.38	34.11	51.14	65.51	168.72
13	14.46	1.56	1.33	32.99	49.40	63.28	163.02
14	13.98	1.51	1.29	31.95	47.71	61.14	157.58
15	13.52	1.46	1.24	30.94	46.08	59.08	152.32
16	13.07	1.41	1.20	29.92	44.50	57.07	147.18
17	12.63	1.36	1.16	28.94	42.98	55.13	142.21
18	12.20	1.32	1.12	27.99	41.52	53.26	137.41
19	11.79	1.27	1.09	27.07	40.10	51.45	132.77
20	11.40	1.23	1.05	26.18	38.73	49.70	128.29
TOTAL	319.85	34.69	29.42	723.64	1099.54	1405.81	3612.95

Figure A1. Sample Cost Analysis Output File From FLAGCAP (continued).

PROBLEM: Project FL-12345
USER COST CALCULATIONS, CURRENT SCENARIO, ALL VEHICLES

	DISCOUNTED COSTS (THOUS. $)						
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	47.40	3.98	4.05	87.59	116.53	192.43	451.98
2	45.82	3.84	3.92	84.81	112.54	185.92	436.85
3	44.51	3.74	3.83	83.49	108.60	179.92	424.09
4	43.12	3.62	3.72	81.45	104.84	173.97	410.74
5	41.74	3.51	3.61	79.23	101.23	168.16	397.49
6	40.39	3.40	3.50	76.96	97.75	162.53	384.53
7	39.06	3.28	3.39	74.65	94.39	157.06	371.84
8	37.76	3.18	3.28	72.30	91.16	151.75	359.43
9	36.51	3.07	3.18	70.03	88.04	146.61	347.44
10	35.29	2.97	3.07	67.83	85.02	141.66	335.85
11	34.12	2.87	2.97	65.70	82.11	136.87	324.64
12	32.98	2.77	2.88	63.63	79.30	132.24	313.81
13	31.87	2.68	2.78	61.54	76.59	127.75	303.22
14	30.80	2.59	2.69	59.53	73.97	123.41	292.99
15	29.78	2.51	2.60	57.65	71.44	119.24	283.21
16	28.77	2.42	2.52	55.76	68.99	115.19	273.66
17	27.80	2.34	2.43	53.93	66.64	111.28	264.42
18	26.88	2.26	2.35	52.23	64.35	107.52	255.60
19	25.97	2.19	2.27	50.52	62.15	103.87	246.97
20	25.10	2.11	2.20	48.86	60.03	100.34	238.64
TOTAL	705.68	59.33	61.27	1347.72	1705.68	2837.72	6717.40

PROBLEM: Project FL-12345
USER COST CALCULATIONS, ALTERNATE SCENARIO, ALL VEHICLES

	DISCOUNTED COSTS (THOUS. $)						
YEAR	VEH. DEP.	OIL	TIRES	MAINT.	FUEL	TIME	TOTAL
1	41.14	3.61	3.79	77.57	105.20	171.02	402.33
2	39.77	3.49	3.66	75.10	101.60	165.23	388.85
3	38.62	3.39	3.58	73.93	98.04	159.91	377.47
4	37.42	3.29	3.48	72.12	94.64	154.62	365.57
5	36.22	3.19	3.38	70.16	91.38	149.46	353.78
6	35.03	3.08	3.27	68.05	88.24	144.43	342.10
7	33.87	2.98	3.17	66.00	85.21	139.56	330.81
8	32.76	2.88	3.07	64.02	82.29	134.87	319.89
9	31.67	2.79	2.97	62.01	79.47	130.31	309.21
10	30.61	2.70	2.88	60.06	76.75	125.90	298.89
11	29.59	2.61	2.78	58.17	74.12	121.65	288.91
12	28.60	2.52	2.69	56.26	71.58	117.51	279.17
13	27.63	2.43	2.60	54.42	69.14	113.52	269.74
14	26.71	2.35	2.52	52.70	66.77	109.69	260.74
15	25.82	2.28	2.44	51.04	64.48	105.98	252.04
16	24.95	2.20	2.35	49.37	62.28	102.38	243.53
17	24.11	2.13	2.28	47.75	60.15	98.90	235.31
18	23.30	2.05	2.20	46.18	58.09	95.54	227.37
19	22.51	1.99	2.13	44.67	56.10	92.30	219.70
20	21.76	1.92	2.06	43.20	54.19	89.17	212.29
TOTAL	612.11	53.88	57.31	1192.78	1539.70	2521.94	5977.71

Figure A1. Sample Cost Analysis Output File From FLAGCAP (continued).

PROBLEM: Project FL-12345
PAVEMENT COST CALCULATIONS, CURRENT SCENARIO

YEAR	ROUTINE MAINT.	DISCOUNTED COSTS (THOUS. $) OVERLAY	LEVEL-UP	MILLING	TOTAL
1	.10	48.54	.00	3.27	51.91
2	.09	.00	.00	.00	.09
3	.09	.00	.00	.00	.09
4	.08	.00	.00	.00	.08
5	.08	.00	.00	.00	.08
6	.07	.00	.00	.00	.07
7	.07	.00	.00	.00	.07
8	.06	.00	.00	.00	.06
9	.06	.00	.00	.00	.06
10	.05	.00	.00	.00	.05
11	.05	.00	.00	.00	.05
12	.05	.00	.00	.00	.05
13	.04	.00	.00	.00	.04
14	.04	.00	.00	.00	.04
15	.04	.00	.00	.00	.04
16	.04	.00	.00	.00	.04
17	.03	.00	.00	.00	.03
18	.03	.00	.00	.00	.03
19	.03	.00	.00	.00	.03
20	.03	.00	.00	.00	.03
TOTAL	1.14	48.54	.00	3.27	52.94

PROBLEM: Project FL-12345
PAVEMENT COST CALCULATIONS, ALTERNATE SCENARIO

YEAR	ROUTINE MAINT.	DISCOUNTED COSTS (THOUS. $) OVERLAY	LEVEL-UP	MILLING	TOTAL
1	.10	53.89	.00	3.27	57.26
2	.09	.00	.00	.00	.09
3	.09	.00	.00	.00	.09
4	.08	.00	.00	.00	.08
5	.08	.00	.00	.00	.08
6	.07	.00	.00	.00	.07
7	.07	.00	.00	.00	.07
8	.06	.00	.00	.00	.06
9	.06	.00	.00	.00	.06
10	.05	.00	.00	.00	.05
11	.05	.00	.00	.00	.05
12	.05	.00	.00	.00	.05
13	.04	.00	.00	.00	.04
14	.04	.00	.00	.00	.04
15	.04	.00	.00	.00	.04
16	.04	.00	.00	.00	.04
17	.03	.00	.00	.00	.03
18	.03	.00	.00	.00	.03
19	.03	.00	.00	.00	.03
20	.03	.00	.00	.00	.03
TOTAL	1.14	53.89	.00	3.27	58.30

Figure A1. Sample Cost Analysis Output File From FLAGCAP (continued).

PROBLEM: Project FL-12345

SUMMARY OF COST CALCULATIONS

	TOTAL PAVEMENT AND USER COSTS (THOUS. $)		
	CURRENT SCENARIO	ALTERNATE SCENARIO	BENEFITS
TOTAL PAVEMENT COSTS	52.94	58.30	-5.36
TOTAL USER COSTS	6717.40	5977.71	739.70
TOTAL	6770.34	6036.01	734.34

Figure A1. Sample Cost Analysis Output File From FLAGCAP (continued).

APPENDIX B
LOAD-SHIFT OUTPUT FORMAT

Columns	Format	Description
1-3	I3	Scenario, 1=current scenario, 2=alternate scenario
4-6	I3	Vehicle Category Number (max of 15)
7-9	I3	Vehicle weight cat., 1= 0-5 kips, 2= 5-10 kips, etc., up to 28= 135-140 kips
10-19	F10.3	Number of vehicles
20-29	F10.3	Upper limit of vehicle weight cat., in kips
30-39	F10.3	Midpoint of vehicle weight cat., in kips
40-49	F10.3	Average payload of vehicle weight cat., in kips
50-59	F10.3	Weight on front axle, in kips
60-69	F10.3	Weight on each rear axle, in kips

Note: total number of lines of output = (# scenarios, 2) X (# veh types, up to 15) X (# GVW cat, 28) = up to 840 lines

APPENDIX C
INPUT GUIDE TO THE TIRE FORCE PREDICTION AND LOAD EQUIVALENCY PROGRAMS

This Appendix describes the format of the input data files of the Tire Force Prediction and load equivalency programs. The Tire Force Prediction Program (TFP) is an analytical model of a truck or truck-trailer combination used to predict the forces that occur between the tires of the vehicles and the road. The load equivalency program uses the predicted dynamic load profile from the TFP program to incorporate the effects of vehicle dynamic loading in the calculation of load equivalency factors for different loading conditions, asphalt concrete thicknesses, and subgrade moduli. Both of these programs are described in greater detail in the volume accompanying this User's Guide that discusses the development of the different analytical models in Florida COMPAS.

The TFP program, and the program for calculating load equivalency factors, referred to herein as LEF, share a common input file, the format of which is explained in this Appendix. The name of this common input file is TRKMOD.DAT. Not all of the variables in this input file are needed by both programs. Instead, each program reads only the data it needs to carry out its function. The input data required by each program are identified in this user's guide.

It is noted that the vehicle simulation files created by the TRUCKDAT data entry program have default filenames of the form "nnnnnnnn.DAT" where the first 8 characters are numbers which were explained in Chapter 1 of this User's Guide. Before execution of the TFPV and LEF6 programs a copy of the required vehicle simulation input file is first created with the filename TRKMOD.DAT.

INPUT PARAMETERS FOR TRKMOD.DAT

A. General

1. The following data, required by the LEF program, are written on the first card in the following FORTRAN format: 1X, I1, 2I2, F10.3, 2I2, 2(F6.2, 1X), 4I2, 2F4.1, F5.2, F8.0, 1X, F7.2, 1X, 3(F5.2, 1X).

Column(s)	Variable	Entry
2	ISCE	Scenario number which is 1 for current scenario, and 2 for alternate scenario.
3-4	VEHCAT	Vehicle category.
5-6	GVWCAT	Gross vehicle weight (GVW) category. If a percentile of the GVW distribution has been specified by the user, GVWCAT = 99.
7-16	VEHNO	Number of vehicles per day for the given scenario, vehicle category, and GVW category. This is the number of vehicles for both traffic directions.
17-18	TIRTYP	Tire type, which is 1 for conventional radial tires; 2 for bias-ply tires; and 3 for wide-base radial tires.
19-20	ISUS	Suspension category, which is 1 for leaf spring suspensions; 2 for air bag suspensions; 3 for walking beam suspensions; and 4 for "OTHER" user defined suspension system.
21-26	PCTTIR	Percent of vehicle in given vehicle category with given tire type, TIRTYP.
28-33	PCTSUS	Percent of vehicles in given vehicle category the non-steering axles of which are of the given suspension type, ISUS.
35-36	LANES	The number of lanes in both traffic directions.
38	KODE1	Code for divided (KODE1 = 1) or undivided (KODE1 = 2) highway.
40	KODE2	For a divided highway (KODE1 = 1), KODE2 specifies if the analysis is to be done based on just one selected section (KODE2 = 1), or for 2 selected sections (KODE2 = 2), one for each traffic direction. If LANES = 1 or if KODE1 = 2, then KODE2 = 0.

Column(s)	Variable	Entry
42	KODE3	If KODE1 = 1, and KODE2 = 2, KODE3 specifies if the traffic direction associated with the input data. KODE3 = 1 for data associated with the traffic direction first considered by the user. KODE3 = 2 for the opposite traffic direction.
43-46	PSII	Current Present Serviceability Index for given analysis section.
47-50	TSI	Terminal Serviceability Index for given analysis section.
51-55	TI	Asphalt concrete thickness, in inches, of given analysis section.
56-63	ES	Subgrade modulus, in psi, of given analysis section.
65-71	CRKF	Failure level for fatigue cracking, $ft^2/1{,}000ft^2$
73-77	RUTF	Failure level for rutting, inches
79-83	PSIOVL	PSI immediately after the overlay
85-89	HOVMAX	Maximum overlay thickness, inches

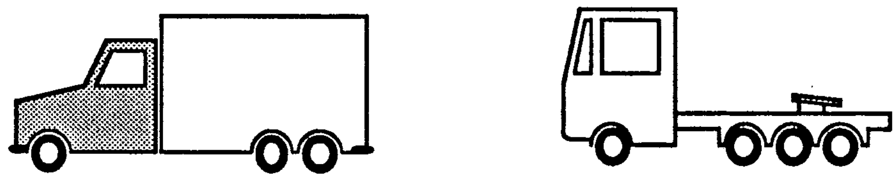
The above data are not required by the TFP program. This program just reads the first card as a "title" card using the FORTRAN format, (1X, A79).

2. Configuration (8X, I1)

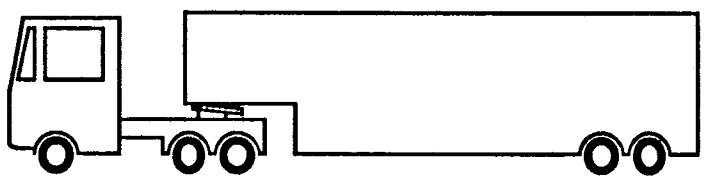
   The second line of entry is the configuration of the truck-trailer combination. A configuration of 1 is for a straight truck or a tractor by itself. A configuration of 2 is for a tractor-semitrailer combination. A configuration of 3 is for a tractor-semitrailer-full trailer combination. A configuration of 4 is for a tractor-semitrailer-full trailer-full trailer combination. Figure C1 illustrates the four possible configurations. This input is required by both the TFP and LEF programs.

3. Velocity (1X, F11.2)

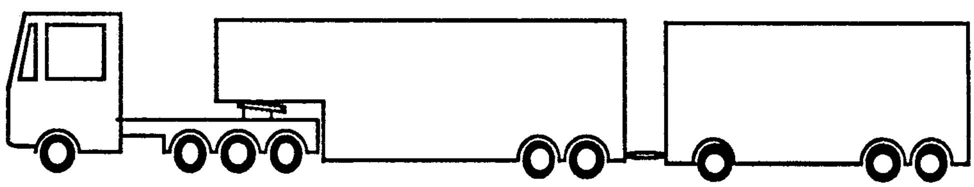
   The third line is the velocity of the vehicle in units of feet/sec. This input is only used by the TFP program.



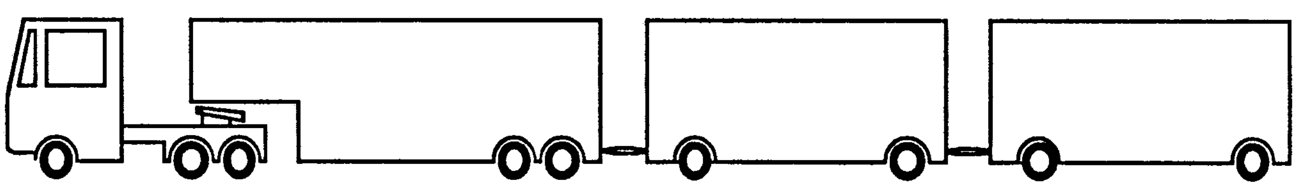
Configuration 1: Straight Truck or Tractor



Configuration 2: Tractor/Semitrailer



Configuration 3: Tractor/Semitrailer/Full Trailer



Configuration 4: Tractor/Semitrailer/Full Trailer/Full Trailer

Figure C1. Vehicle Configurations That Can Be Simulated Using the TFP Program.

4. Simulation distance (1X, F11.2)

   The fourth line is the simulation distance in feet. The length of the road profile should be considered when determining the simulation distance. The amount of road profile data should exceed the simulation distance by at least the length of the truck-trailer combination. This input is only required by the TFP program.

B. Truck or Tractor Geometry

1. Truck Wheelbase (1X, F11.2)

   This is the distance, in inches, from the front steering axle to the centerline of the rear suspension (see Figure C2). This input is only used by the TFP program.

2. Pitch Moment of Inertia of Truck (1X, F11.2)

   This is the pitch moment of inertia about the center of gravity of the unladen truck or tractor in in-lbs-sec^2. This input is only used by the TFP program.

3. Truck Payload Weight (1X, F11.2)

   This is the weight of the payload in lbs., of the truck or tractor. If the payload is already included in parameterizing the truck, i.e., static axle loads, truck pitch moment of inertia, then the payload is 0.0. This information is only used by the TFP program.

4. Truck Payload Pitch Moment of Inertia (1X, F11.2)

   This is the truck payload pitch moment of inertia (m.o.i.) in in-lbs-sec^2. If there is no payload, the m.o.i. is 0.0. If the payload is already included in parameterizing the truck, i.e., static axle loads, truck pitch moment of inertia, then the

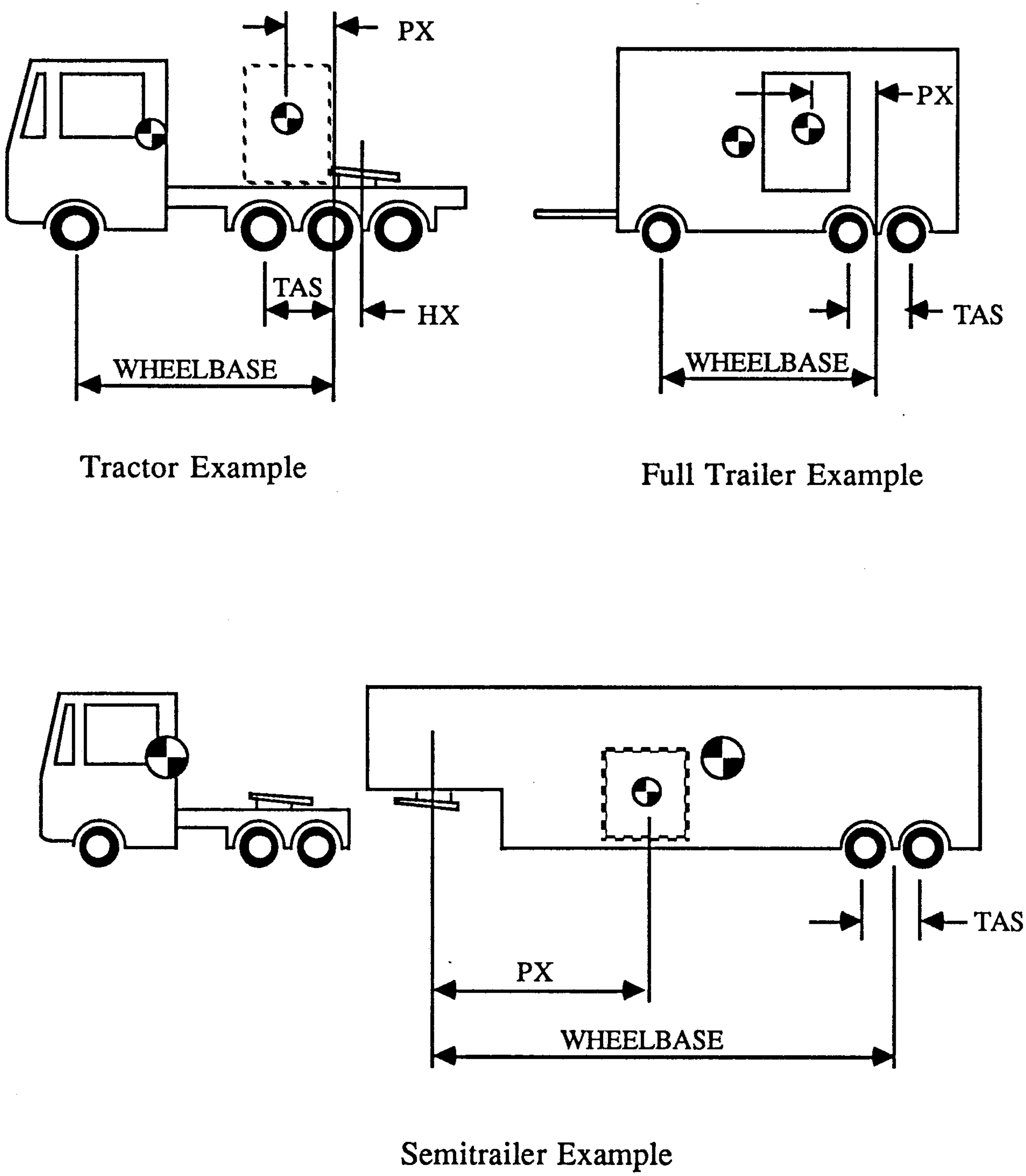


Figure C2. Input Data on Vehicle Dimensions Required by the TFP Program.

payload pitch moment of inertia is 0.0. This information is only required by the TFP program.

5. Truck Payload C. G. Location (1X, F11.2)

   This is the distance, in inches, from the center of the rear suspension to the center of gravity (c.g.) of the truck payload (See dimension "PX" in Figure C2). The distance is positive measured towards the front of the truck. If the payload is already included in parameterizing the truck, i.e., static axle loads, truck pitch moment of inertia, then the truck payload c.g. location is 0.0. This input is only used by the TFP program.

6. Semitrailer Hitch Location (1X, F11.2)

   If there is a semitrailer, the program prompts for the distance from the center of the tractor rear suspension to the hitch location on the tractor. The distance is positive measured towards the front of the tractor (See dimension "HX" in Figure C2). This input is only used by the TFP program.

7. Number of Rear Tractor Axles (8X, I1)

   The next line is the number of axles on the rear of the truck or tractor. It is 1 for a single axle; 2 for a tandem axle assembly; and 3 for a triple axle assembly. This input is required by both the TFP and LEF programs.

8. Number of Rear Truck Tires (8X, I1)

   The next line is the number of tires on each side of the rear axles of the truck or tractor. This is 1 for axles with single tires at each end, and 2 for axles with dual tires at each end. This input is used by both the TFP and LEF programs.

9. Axle Separation (1X, F11.2)

   If there is more than one rear axle, the user is prompted for the distance, in inches, between the axles. If there are three axles, the axle separation is the distance between two adjacent axles. (See dimension "TAS" in Figure C2). This input is required by both the TFP and LEF programs.

10. Are Rear Truck or Tractor Axles Parameterized Identically? (8X, A1)

    If there is more than one rear axle and they each have identical parameters, enter "Y". If there is more than one rear axle and they are parameterized differently, enter "N". This input is only required by the TFP program.

C. Truck or Tractor Suspension Characteristics

Each axle of the suspension is modelled as a system of springs, coulomb dampers, and viscous dampers connected to the unsprung mass of the axle, wheels, and wheel support hardware (See Figure C3).

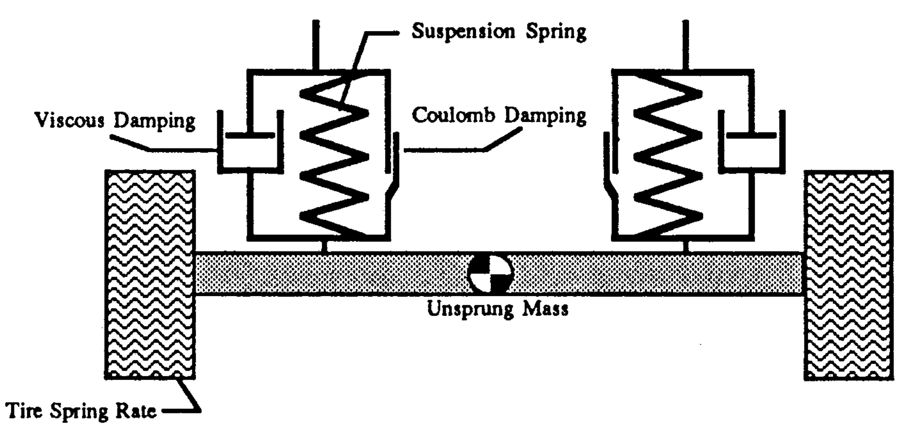


Figure C3. Model of Suspension System.

For each axle i of the truck or tractor (i = 1 to 4), the following parameters are required on separate cards:

1. Truck Axle #i Static Axle Load (1X, F11.2)

   This is the total static force between the tires of the axle and the ground. This input is required by both the TFP and LEF programs.

2. Truck Axle #i Suspension Spring Rate (1X, F11.2)

   This is the spring rate, in lbs/in, of the suspension spring on one side of the axle. This input is only used by the TFP program.

3. Truck Axle #i Viscous Damping Rate (1X, F11.2)

   This is the viscous damping rate, in lbs/(in/sec), of one side of the axle. The viscous damping is usually contributed by a shock absorber. This input is only used by the TFP program.

4. Truck Axle #i Coulomb Damping Rate (1X, F11.2)

   This is coulomb damping force, in lbs, on one side of the axle. The coulomb damping is usually due to friction in the leaf springs. This input is only used by the TFP program.

5. Truck Axle #i Unsprung Weight (1X, F11.2)

   This is the weight, in lbs, of the tires, wheels, axle, and wheel support hardware for the whole axle assembly. This input is only used by the TFP program.

6. Truck Axle #i Tire Spring Rate, Tire Type, and Tire Inflation Pressure (psi). (1X, F11.2, 3X, I1, 4X, F6.2)

   The following variables are required on this card:

Column(s)	Variable	Entry
1-12	KXXX	The vertical stiffness of the given tire, in lbs/in/tire, is entered on this card. This input is only used by the TFP program.
16	ITIRE	Type of tire on given axle. ITIRE is 1 for conventional radial tires; 2 for bias-ply tires; and 3 for wide base radial tires. This input is only required by the LEF program.
21-26	TIREP	Tire inflation pressure (psi) for given tire on given axle. This input is only required by the LEF program.

D. Semitrailer Geometry

The following input, written on separate cards, are required if a semi-trailer unit is present in the given vehicle.

1. Semitrailer Wheelbase (1X, F11.2)

   This is the distance, in inches, from the kingpin to the centerline of the rear suspension (see Figure C2). This input is only used by the TFP program.

2. Semitrailer Weight (1X, F11.2)

   This is the sprung weight of the semitrailer in pounds. This input is only used by the TFP program.

3. Semitrailer Pitch Moment of Inertia (1X, F11.2)

   This is the pitch moment of inertia about the center of gravity of the semitrailer in in-lbs-sec^2. This input is only used by the TFP program.

4. Semitrailer Payload Weight (1X, F11.2)

   This is the weight of the payload, in pounds, of the semitrailer. If the semitrailer payload is already included in the weight of the semitrailer, or if there is no payload, then the payload weight is 0.0. This input is only required by the TFP program.

5. Semitrailer Payload Pitch Moment of Inertia (1X, F11.2)

   This is the payload pitch moment of inertia (m.o.i.) in in-lbs-sec^2. If the semitrailer payload is already included in the parameterization of the trailer, or if there is no payload, then the m.o.i. is 0.0. This input is only used by the TFP program.

6. Semitrailer Payload C. G. Location (1X, F11.2)

   This is the distance, in inches, from the semitrailer hitch to the semitrailer payload center of gravity. If there is no payload, or if the semitrailer payload is already included in the weight of the semitrailer, enter 0.0. The distance is positive measured towards the rear of the semitrailer (See dimension "PX" on Figure C2). This input is only needed by the TFP program.

7. Semitrailer Number of Axles (8X, I1)

   The next line is the number of axles on the rear of the semitrailer. This can be 1, 2, or 3, depending upon whether the semitrailer has a single, tandem or triple axle assembly. This input is used by both the TFP and LEF programs.

8. Number of Tires on Each Side of Each Axle (8X, I1)

   The next entry is the number of tires on each side of each semitrailer axle. If the semitrailer has single tires, at each end of the axle, a 1 should be entered. If the semitrailer has dual tires at each end of the axle, enter 2. This input is used by both the TFP and LEF programs.

9. Semitrailer Axle Separation (1X, F11.2)

   If there is more than one semitrailer axle, the user is prompted for the distance in inches between the axles (See dimension "TAS"in Figure C2). This input is used by both the TFP and LEF programs.

10. Are Semitrailer Axles Parameterized Identically? (8X, A1)

    If there is more than one axle and they each have identical parameters, enter "Y". If there is more than one axle and they are parameterized differently, then enter "N". This input is used only by the TFP program.

E. Semitrailer Suspension Characteristics

For each axle i of the semitrailer, where i may vary from 1 to 3, the program prompts for the following suspension parameters:

1. Semitrailer Axle #i Static Axle Load (1X, F11.2)

   This is the total force in pounds, between the tires of the axle and the ground. This input is used by both the TFP and LEF programs.

2. Semitrailer Axle #i Suspension Spring Rate (1X, F11.2)

   This is the spring rate, in lbs/in, of the suspension spring on one side of the axle. This input is only used by the TFP program.

3. Semitrailer Axle #i Viscous Damping Rate (1X, F11.2)

   This is the viscous damping rate, in lbs/(in/sec), of one side of the axle. This input is only used by the TFP program.

4. Semitrailer Axle #i Coulomb Damping Rate (1X, F11.2)

   This is the coulomb damping force, in pounds, on one side of the axle. This is input is only used by the TFP program.

5. Semitrailer Axle #i Unsprung Weight (1X, F11.2)

This is the weight in pounds of the tires, wheels, axle, and wheel support hardware for the whole axle assembly. This input is only required by the TFP program.

6. Semitrailer Axle #i Tire Spring Rate, Tire Type, and Tire Inflation Pressure (1X, F11.2, 3X, I1, 4X, F6.2).

The following variables are required on this card:

Column(s)	Variable	Entry
1-12	KXXX	The vertical stiffness of the given tire, in lbs/in/tire, is entered on this card. This input is only used by the TFP program.
16	ITIRE	Type of tire on given axle. ITIRE is 1 for conventional radial tires; 2 for bias-ply tires; and 3 for wide base radial tires. This input is only required by the LEF program.
21-26	TIREP	Tire inflation pressure (psi) for given tire on given axle. This input is only required by the LEF program.

F. Full Trailer Geometry

1. Full Trailer Wheelbase (1X, F11.2)

This is the distance, in inches, from the centerline of the front suspension to the centerline of the rear suspension (see Figure C2). This input is only required by the TFP program.

2. Full Trailer Pitch Moment of Inertia (1X, F11.2)

This is the pitch moment of inertia about the center of gravity of the full trailer in in-lbs-sec^2. This input is only required by the TFP program.

3. Full Trailer Payload weight (1X, F11.2)

This is the weight of the payload of the trailer. If the trailer has no payload, the payload weight is 0.0. If the payload is already included in parameterizing the full trailer, i.e, static axle loads, trailer pitch moment of inertia, then the payload is also 0.0. This input is only required by the TFP program.

4. Full Trailer Payload Pitch Moment of Inertia (1X, F11.2)
   This is the payload pitch moment of inertia (m.o.i.) in in-lbs-sec^2. If there is no payload, the m.o.i. is 0.0. If the payload is already included in parameterizing the trailer, i.e., static axle loads, trailer pitch moment of inertia, then the payload pitch moment of inertia is also 0.0. This input is only used by the TFP program.
5. Full Trailer Payload C. G. Location (1X, F11.2)
   This is the distance, in inches, from the center of the rear suspension to the c.g. of the trailer payload. The distance is positive measured towards the front of the truck (see dimension "PX" in Figure C2). If there is no payload, or if the payload is already included in parameterizing the trailer, i.e., static axle loads, trailer pitch moment of inertia, then the trailer payload c.g. location is 0.0. This input is only required by the TFP program.
6. Number of Full Trailer Front Axles (8X, I1)
   The next line is the number of axles on the front of the full trailer. This should be 1 or 2, corresponding to single or tandem axle, respectively. This input is used by both TFP and LEF.
7. Number of Tires on Each Side of Each Front Axle of Full Trailer (8X, I1)

This entry is the number of tires on each side of the front axle(s) of the full trailer. If the front axle(s) has single tires at each end, a 1 should be entered. If the front axle(s) has dual tires, at each end, a 2 should be entered. This input is used by both TFP and LEF.

8. Full Trailer Front Tandem Axle Separation (1X, F11.2)
   If there is more than one front axle, the user is prompted for the distance, in inches, between the axles (See dimension "TAS" in Figure C2). This input is used by both the TFP and LEF programs.
9. Number of Full Trailer Rear Axles (8X, I1)
   The next line is the number of axles on the rear of the full trailer. This should be 1 or 2, corresponding to single or tandem axle, respectively. This input is used by both the TFP and LEF programs.
10. Number of Tires on each side of Each Rear Axle of Full Trailer (8X, I1)
   The next entry is the number of tires on each side of each rear full trailer axle. If the rear axle(s) has single tires at each end, a one should be entered. If the rear axle(s) has dual tires at each end, a two should be enter. This input is used by both the TFP and LEF programs.
11. Full Trailer Rear Tandem Axle Separation (1X, F11.2)
   If there is more than one rear axle, the user is prompted for the distance, in inches, between the axles (See dimension "TAS" in Figure C2). This input is used by both the TFP and LEF programs.

12. Are All Full Trailer Axles Parameterized Identically? (8X, A1)

    If all the axles on the trailer have identical parameters, enter "Y". If they are parameterized differently, then enter "N". This input is only used by the TFP program.

G. Full Trailer Suspension Characteristics

The following data are required for each full trailer axle i, where i may vary from 1 to 4.

1. Full Trailer Axle #i Static Axle Load (1X, F11.2)

    This is the total between the tires of the axle and the ground. This input is used by both the TFP and LEF programs.

2. Full Trailer Axle #i Suspension Spring Rate (1X, F11.2)

    This is the spring rate, in lbs/in, of the suspension spring on one side of the axle. This input is only used by the TFP program.

3. Full Trailer Axle #i Viscous Damping Rate (1X, F11.2)

    This is the viscous damping rate, in lbs/(in/sec), of one side of the axle. This input is only required by the TFP program.

4. Full Trailer Axle #i Coulomb Damping Rate (1X, F11.2)

    This is the coulomb damping force, in lbs, on one side of the axle. This input is only used by the TFP program.

5. Full Trailer Axle #i Unsprung Weight (1X, F11.2)

    This is the weight, in lbs, of the tires, wheels, axle, and wheel support hardware for the whole axle assembly. This input is only used by the TFP program.

6. Full Trailer Axle #i Tire Spring Rate, Tire Type, and Tire Inflation Pressure (1X, F11.2, 3X, I1, 4X, F6.2)

    The following variables are required on this card:

Column(s)	Variable	Entry
1-12	KXXX	The vertical stiffness of the given tire, in lbs/in/tire, is entered on this card. This input is only used by the TFP program.
16	ITIRE	Type of tire on given axle. ITIRE is 1 for conventional radial tires; 2 for bias-ply tires; and 3 for wide base radial tires. This input is only required by the LEF program.
21-26	TIREP	Tire inflation pressure (psi) for given tire on given axle. This input is only required by the LEF program.

THE ROAD PROFILE

In addition to TRKMOD.DAT, the TFP program requires information on the road profile. This information is read from a file called TERRAIN.DAT which contains the elevation data of the road surface where the vehicle to be simulated will be travelling. This file should contain two columns of road profile data. The data should represent the elevation of the road at constant intervals. The first column of data should contain the elevations, in thousandths of an inch (mils), of points on the road surface under one wheel path. The second column of data is the elevation profile for the other wheel path. The program uses the average of the two elevations at each distance in representing the road profile. In addition, the program uses a list-directed input format, so the data need only be written in two columns with the data in each record separated by at least one space or a comma.

The program automatically generates a runway of 100 data points in length leading up to the first elevation point. The runway is flat for the first 50 data points, and is a linear ramp for the next 50 data points up to the first measured data point.

The spacing between successive points in the road profile is read from a file called PROSPACE.DAT. This file consists of a single record containing the spacing between successive elevation points in inches. A typical spacing is 6.0 inches. The file PROSPACE.DAT is read by both the TFP and LEF programs. The file TERRAIN.DAT, however, is only read by the TFP program.

THE MODELEF.DAT FILE

In addition to the TRKMOD.DAT and the PROSPACE.DAT files, the LEF program requires information on how the static load equivalency factors will be adjusted to incorporate dynamic load effects, and whether load equivalencies will be computed for steering axles. This information is read from a file called MODELEF.DAT which consists of just one record containing the following variables:

1. MODE - an integer variable that tells the LEF program whether adjusted load equivalency factors will be determined based on the dynamic load coefficient (MODE = 0), or from the expected value of load equivalency factors calculated for different dynamic loads sampled from the predicted dynamic load distribution (MODE = 1). The procedures for adjusting load equivalency factors to incorporate dynamic load effects are explained in the accompanying volume to this User's Guide that discusses the development of the analytical models in Florida COMPAS.
2. INCSTR - an integer variable that tells the LEF program whether to exclude the steering axle in the calculation of load equivalency factors (INCSTR = 0), or to include the steering axles (INCSTR = 1). Under the former option, the contribution

of the steering axles to the daily 18-kip equivalent single axle loads is neglected.

The above variables are read in free-format by the LEF program. The file MODELEF.DAT is not used by the TFP program.

TFP PROGRAM OUTPUT

The output of the Tire Force Prediction Program is a list of the tire forces that are generated between each tire and the road as a function of distance. This distance output begins at a negative distance equal to the length of the runway. This is due to the runway preceding the first road elevation data point. Since this model does not consider vehicle roll, the forces generated on the right side of the vehicle are equivalent to the forces generated on the left side. Therefore, the data are output for only one side of the vehicle. Also, the force output is the force under one tire if the axle has single tires, or the total force under both tires, if the axle has dual tires. This results in only one tire force output per axle. The first column of each output file is the distance in feet. The rest of the columns in each data file are the tire forces that occur on each axle at that particular distance along the road.

The tire forces on the tractor axles are output in order from front to rear in the file "TRACTOR.DAT'. The tire forces on the semitrailer are output in order from front to rear in the file "TRAILER1.DAT'. The tire forces on the first full trailer are output in order from front to rear in the file "TRAILER2.DAT". The tire forces on the second full trailer are output in order from front to rear in the file "TRAILER3.DAT."

The output data for each axle is recorded with respect to its absolute distance along the road. For example, at 75 feet, the force that occurs due to the first axle passing that point is listed, followed by the force that occurs at some later time due to the second axle passing that point. Since all the axles are not at the same distance at the same time, one line of output data does not represent one instant in time.

LEF PROGRAM OUTPUT

The output from the LEF program is written in a file called "LEFOUT.$$$." The format of this file is as follows:

First Card:

Column(s)	Variable	Entry
3	ISCE	Scenario number which is 1 for current scenario, and 2 for alternate scenario.
4-5	VEHCAT	Vehicle category.
6-7	GVWCAT	Gross vehicle weight (GVW) category. If a percentile of the GVW distribution has been specified by the user, GVWCAT = 99.
8-17	VEHNO	Number of vehicles per day for the given scenario, vehicle category, and GVW category. This is the number of vehicles for both traffic directions.
19	TIRTYP	Tire type, which is 1 for conventional radial tires; 2 for bias-ply tires; and 3 for wide-base radial tires.
21	ISUS	Suspension category, which is 1 or leaf spring suspensions; 2 for air bag suspensions; 3 for walking beam suspensions; and 4 for "OTHER" user defined suspension system.
22-27	PCTTIR	Percent of vehicles in given vehicle category with given tire type, TIRTYP.
29-34	PCTSUS	Percent of vehicles in given vehicle category the non-steering axles of which are of the given suspension type, ISUS.

Column(s)	Variable	Entry
36-37	LANES	The number of lanes in both traffic directions.
39	KODE1	Code for divided (KODE1 = 1) or undivided (KODE1 = 2) highway
41	KODE2	For a divided highway (KODE1 = 1), KODE2 specifies if the analysis is to be done based on just one selected section (KODE 2 = 1), or for 2 selected sections (KODE2 = 2), one for each traffic direction. If LANES =1 or if KODE1 = 2, then KODE2 = 0.
43	KODE3	If KODE1 = 1, and KODE2 = 2, KODE3 specifies the traffic direction associated with the input data. KODE3 = 1 for data associated with the traffic direction first considered by the user. KODE3 = 2 for the other traffic direction.
44-45	IAXLE	The axle assembly associated with the calculated load equivalency factors. IAXLE starts from 1 for the steering axle and increases according to the order of the axle assemblies, i.e. from the steering axle to the rear most axle assembly of the given vehicle.
46-53	SAL (IAXLE)	Static load, in pounds, for the given axle assembly.
55	NA (IAXLE)	Number of axles on the given axle assembly, IAXLE; 1 for single axle; 2 for tandem axle assembly; and 3 for triple axle assembly.
57	NT (IAXLE)	Number of tires at each end of the axles of axle assembly, IAXLE; 1 for single tires at each end of an axle; 2 for dual tires at each end of an axle.
59	ITIRE (IAXLE)	Tire type for axle assembly, IAXLE; 1 for conventional radial tires; 2 for bias-ply tires; 3 for wide base radial tires.
60-65	TIREP (IAXLE)	Tire inflation pressure (psi) for tires in axle assembly, IAXLE.
66-73	ES	Subgrade modulus (psi) of given analysis section.

Second Card:

Column(s)	Variable	Entry
2- 6	T1	Asphalt concrete thickness (inches) of a given analysis section.
8- 19	LEFDAT (1, 1, 1)	Static load equivalency factor calculated based on PSI and the existing asphalt concrete thickness.
21- 32	LEFDAT (1, 2, 1)	Adjusted LEF calculated based on PSI and the existing asphalt concrete thickness.
34- 45	LEFDAT (1, 3, 1)	Ratio of adjusted to static LEF's calculated based on PSI and the existing asphalt concrete thickness.
47- 58	LEFDAT (2, 1, 1)	Static LEF calculated based on fatigue cracking and the existing asphalt concrete thickness.
60- 71	LEFDAT (2, 2, 1)	Adjusted LEF calculated based on fatigue cracking and the existing asphalt concrete thickness.
73- 84	LEFDAT (2, 3, 1)	Ratio of adjusted to static LEF's calculated based on fatigue cracking and existing asphalt concrete thickness
86- 97	LEFDAT (3, 1, 1)	Static LEF calculated based on rutting and the existing asphalt concrete thickness.
99-110	LEFDAT (3, 2, 1)	Adjusted LEF calculated based on rutting and the existing asphalt concrete thickness.
112-123	LEFDAT (3, 3, 1)	Ratio of adjusted to static LEF's calculated based on rutting and the existing asphalt concrete thickness.

Third Card:

Column(s)	Variable	Entry
2- 16	TMAX	Sum of existing asphalt concrete thickness and maximum overlay thickness, inches.
8- 19	LEFDAT (1, 1,2)	Static LEF calculated based on PSI and TMAX.
21- 32	LEFDAT (1, 2, 2)	Adjusted LEF calculated based on PSI and TMAX.
34- 45	LEFDAT (1, 3, 2)	Ratio of adjusted to static LEF's calculated based on PSI and TMAX.
47- 58	LEFDAT (2, 1, 2)	Static LEF calculated based on fatigue cracking and TMAX.
60- 71	LEFDAT (2, 2, 2)	Adjusted LEF calculated based on fatigue cracking and TMAX.
73- 84	LEFDAT (2, 3, 2)	Ratio of adjusted to static LEF's calculated based on fatigue cracking and TMAX.
86- 97	LEFDAT (3, 1, 2)	Static LEF calculated based on rutting and TMAX.
99-110	LEFDAT (3, 2, 2)	Adjusted LEF calculated based on rutting and TMAX.
112-123	LEFDAT (3, 3, 2)	Ratio of adjusted to static LEF's calculated based on rutting and TMAX.

The above data are written in file "LEFOUT.$$$" using the FORTRAN format: (1X, 3I2, F10.3, 2I2, 2(F6.2, 1X), 5I2, F8.0, 3I2, F6.2, F8.0/1X, F5.2, 1X, 9(E12.5, 1X)/1X, F5.2, 1X, 9(E12.5, 1X)). This file is read by the program that calculates the daily 18-kip ESAL's during the first year of the analysis period. The following important points are made regarding this file:

1. LEFOUT.$$$ is not created if no vehicle simulation runs were made. In this instance, the calculation of the daily 18-kip ESAL's during the first year of the analysis period is done using static load equivalency factors calculated by the ESAL18 program.

2. Each time the LEF program is executed, a check is made for the existence of the "LEFOUT.$$$" file. If the file exists, it is updated with new load equivalency factors and other data associated with the particular LEF program run. If the file does not exist, it is created and the data described above are written to the file prior to the termination of the program run.
3. Load equivalency factors are calculated for the 3 distress modes, i.e., serviceability loss, fatigue cracking, and rutting, and for 2 asphalt concrete thicknesses, T1 and TMAX. The calculated LEF's are used by the ESAL18 program in computing initial year traffic rates, in terms of 18-kip ESAL's/day. These in turn are used within the OVERLAY program to evaluate pavement performance at any time during the analysis period. Initial year traffic rates for 2 asphalt concrete thicknesses are evaluated to adjust for the effect of the increase in surface thickness on the predicted cumulative 18-kip ESAL's after an overlay.
4. Once all required TFP and LEF program runs have been made, the ESAL18 program uses the data stored in "LEFOUT.$$$" to calculate the daily 18-kip ESAL's for the first year of the analysis period based on each of the 3 distress modes. Prior to termination of program execution, the contents of the file are copied to a back-up file with the name, "LEFOUT.$$0", by the ESAL18 program. Once the back-up file has been created, the ESAL18 program deletes the file "LEFOUT.$$$" to prevent it from being inadvertently used in a different run of Florida COMPAS.

APPENDIX D
FORMAT OF ESAL18.$$$ INPUT FILE FOR CALCULATION OF TRAFFIC RATE FOR INITIAL YEAR OF ANALYSIS PERIOD

Card 1 (1X, I4, 9I5)

Column	Variable	Entry
5	Lanes	Number of lanes for both traffic directions

Card 2 (1X, I4, 9I5)

Column	Variable	Entry
5	KODE 1	Code for divided (KODE 1 = 1) or undivided (KODE 1 = 2) highway. This card is not required if LANES = 1 in Card 1.

Card 3 (1X, I4, 9I5)

Column	Variable	Entry
5	KODE 2	For a divided highway (KODE 1 = 1 in Card 2), the user specifies on this card if analysis is to be done based on just one selected section (KODE 2= 1) or for 2 selected sections (KODE 2 = 2), one for each traffic direction. This card is not required if LANES = 1 in Card 1 or if KODE 1 = 2 in Card 2.

Card 4 (1X, F9.2, 7F10.2)

Column	Variable	Entry
2-10	PSI	Current PSI for selected analysis section k.
11-20	TSI	Terminal serviceability index for selected analysis section k.
21-30	ES	Subgrade modulus for selected analysis section k.
31-40	T1	Surface layer thickness for selected analysis section k.
41-50	CRKF	Failure level for fatigue cracking for selected analysis section k.
51-60	RUTF	Failure level for rutting for selected analysis section k.

The above variables are specified for 1 or 2 analysis sections, as necessary. Specifically, 2 cards are required if LANES = 1 in Card 1, KODE1 = 1 in Card 2, and KODE2 = 2 in Card 3. Otherwise, only 1 card containing the above information for the lone selected analysis section is needed.

Card 5 (1X, F9.2, 7F10.2)

Column	Variable	Entry
2-10	HOVMAX	Maximum overlay thickness, inches.
11-20	PSIOVL	PSI immediately after the overlay.

Card 6 (1X, I4, 9I5)

Column	Variable	Entry
5	ISCE	Scenario number (1 for current scenario/2 for alternate scenario)
10	VEHCAT	Vehicle category (1-9)
15	CONFIG	Vehicle configuration (1-4)
19-20	NGVW	Number of gross vehicle weight (GVW) categories represented in the traffic stream for given vehicle category
25	ISIM1	Vehicle simulation flag: •ISIM1 = 0 if given vehicle class was skipped in the simulation •ISIM = 1 if a percentile of the GVW distribution was specified for the vehicle simulation •ISIM1 = 2 if specific GVW categories within the vehicle class were selected for the simulation

Card 7 (1X, I4, 9I5)

Column	Variable	Entry
5	AXCONF(1)	Axle configuration for steering axle
10	AXCONF(2)	Axle configuration for rear axle assembly of truck or tractor
15 • •	AXCONF(3) • •	Axle configuration for semi-trailer axle assembly, if vehicle includes a semi-trailer
• n	• AXCONF(i)	Axle configuration for axle assembly, i, of the given vehicle

The user enters on this card the configuration of each axle assembly of the vehicle, starting with the steering axle and proceeding to each of the rear axle assemblies. Variable AXCONF(i) may take on values of 1 for a single axle, 2 for a tandem axle, and 3 for a triple axle. Since the vehicle simulation program in COMPAS can model a vehicle combination consisting of up to 4 units (e.g., a tractor-semitrailer with two full trailers), configurations of up to 7 axle assemblies may have to be specified. The axle configuration entered by the user must be consistent with the capabilities of the simulation program. For example, a triple axle configuration may be specified for the drive axle of a truck or tractor or for a semi-trailer axle, but not for full trailer axles.

Card 8 (1X, F9.2, 7F10.2)

Column	Variable	Entry
2-10	PCTTIR(1)	Percent of vehicles within given category with conventional radial tires on all axles
11-20	PCTTIR(2)	Percent of vehicles within given category with bias-ply tires on all axles
21-30	PCTTIR(3)	Percent of vehicles within given category with wide-base tires

Card 9A (1X, I4, 9I5)

Column	Variable	Entry
5	NTIRE(1, j)	Tire configuration for axle 1, tire type j
10 • • •	NTIRE(2, j) • • •	Tire configuration for axle 2, tire type j
n	NTIRE(i, j)	Tire configuration for axle i, tire type j

Starting with vehicles for which all axles are equipped with conventional radial tires (j = 1), the tire configuration for each axle, starting with the steering, is specified by the user. The tire configuration is either 1 or 2, with 1 denoting an axle with a single tire at each end, and 2 denoting an axle with dual tires at each end. This card is followed by CARD 9B below.

Card 9B (1X, F9.2, 7F10.2)

Column	Variable	Entry
2-10	TIREP(j)	Tire inflation pressure, in psi, for tire type j

Cards 9A and 9B are entered in sequence for each tire type, starting with conventional radial tires (j = 1), followed by data for bias-ply tires (j = 2), and then by data for wide-base radial tires (j = 3). Cards 9A and 9B are, however, only required if PCTTIR for tire type j in Card 8 is greater than zero. In addition, for wide-base radial tires (j = 3), the following card must also be entered right after Card 9B.

CARD 9C (1X, I4, 9I5)

Column	Variable	Entry
5	TIRTYP(1)	Type of tire on steering axle
10 • • •	TIRTYP(2) • • •	Type of tire on second axle assembly of given vehicle
n	TIRTYP(i)	Type of tire on axle assembly i of given vehicle

TIRTYP(i) in Card 9C can be either 1 or 3 since only vehicles with combinations of conventional radial and wide-base tires in the different axles may be considered in the cost analysis program of Florida COMPAS.

CARD 10 (1X, F9.2, 7F10.2)

Column	Variable	Entry
2-10	PCTSUS(1)	Percent of vehicles within given category with leaf spring suspensions on all non-steering axles
11-20	PCTSUS(2)	Percent of vehicles within given category with air-bag suspensions on all non-steering axles
21-30	PCTSUS(3)	Percent of vehicles within given category with walking beam suspensions on all non-steering axles
31-40	PCTSUS(4)	Percent of vehicles within given category with "OTHER" user-specified suspension system for all non-steering axles

CARD 11 (1X, 4I2, F10.3, 3F8.3, 2F7.3)

Column	Variable	Entry
3	ISCE	Scenario number (1 or 2)
5	VEHCAT	Vehicle category (1-9)
6-7	GVWCAT	Gross vehicle weight category (1-28)
9	KODE4	An indicator variable which is zero if particular GVW category was not selected for the vehicle simulation, and is one otherwise
10-19	VEHNO	The number of vehicles within given GVW category
20-27	UPGVW	Upper limit of GVW category (kips)
28-35	GVWMID	Midpoint of GVW category (kips)
36-43	PAYLOD	Payload (kips)
44-50	FAXLE	Steering axle weight in kips
51-57	RAXLE	Weight on each rear axle in kips

With the exception of KODE4, the values of the above variables are obtained from the output of the LOAD SHIFT program. The number of cards entered in this group should match the value of NGVW given in Card 6 for a particular scenario and vehicle category combination.

Cards 6 through 11 are repeated for all scenario-vehicle category combinations.

APPENDIX E
USER'S GUIDE TO THE FLEXPASS PROGRAM (FLORIDA COMPAS VERSION)

INTRODUCTION

This appendix describes the input data to the FLEXPASS program as well as the program output. FLEXPASS is an acronym for FLEXible Pavement Analysis Structural System. It is a finite element program for the analysis of flexible pavement response to vehicle loadings and for the prediction of pavement performance. The program is based on modifications made to the ILLI-PAVE program provided by the Transportation Facilities Group of the Department of Civil Engineering, University of Illinois at Urbana - Champaign.

The FLEXPASS program was developed by R. L. Lytton and Kuo-Hung Tseng of the Texas Transportation Institute. Modifications made to the original ILLI-PAVE program included the following:

1. addition of interface slip elements to allow for the modeling of slip between pavement layers.
2. re-instatement of the capability to input vertical and horizontal tire contract stresses.
3. incorporation of the capability to handle single, tandem, and triple axles, on single or dual tires through the superposition principle.
4. provision of capability for seasonal materials characterization.
5. inclusion of prediction algorithms for fatigue cracking, rutting, and serviceability loss.
6. provision of default options for generating fatigue and permanent deformation properties of pavement layers.
7. provision of capability for automatic generation of the finite element mesh.

This user's guide describes the various input data required by the pavement analysis program. Input data are grouped in blocks called CARDS and are entered following fixed formats. The input data are read from UNIT 5 and output is written to UNIT 6. An explanation of the input data for the FLEXPASS program is given in the following.

DESCRIPTION OF INPUT DATA TO THE FLEXPASS PROGRAM

As stated previously, input to the FLEXPASS program are grouped into blocks called CARDS. Each block of input data must be separated by header lines. This is illustrated in Figure E1 which is a printout of a sample input file. The header lines in the figure are those which show the entry 'CARD #' where # refers to the group number of the input data following a particular header line. In Figure E1, the entry 'CARD #' is also placed in between series of equals (=) signs.

The user can use the header line for each group or block of input data to provide comments on certain data items and thus make the input file clearer. The header lines also provide a definite separation between groups of input data and thus can facilitate subsequent editing of input files. Each header line may comprise a maximum of 80 alphanumeric characters and must be placed before each block of input data as illustrated in Figure E1. There are 15 blocks of input data for the FLEXPASS program and certain input data blocks are subdivided further into various groups. The header lines are only required for the 15 major input data blocks. The various input data blocks or CARDS are described in the following.

CARD 1: (80A1) Identifying Information

Columns	Variable	Entry
1-80	TITLE	Heading information

This card allows the user to attach a title identifying a particular

```
 =============== CARD 1 =================
TRUCK 1, GROUP 2, TRIPLE  AXLES 19,000 PAVEMENT SECTION 4-8.0
 =============== CARD 2 =================
         1
 =============== CARD 3 =================
         0
 =============== CARD 4 =================
         3     4.490    90.000    48.000    12.000
 =============== CARD 5 =================
         1
 =============== CARD 6 =================
         3         2
         1    145.00       .30       .00      4.00         3
     70.00 500000.00       7.0       .00       .00       .00      5.50
     90.00 300000.00       5.0       .00       .00       .00      5.50
         2    130.00       .35       .00     08.00         4
       .00  15000.00   4000.00       .60      5.00       .01     10.00
       .00  15000.00   4000.00       .60      5.00       .01     10.00
         3    110.00       .35       .00    390.00         2
     32.80   6000.00      6.20  12340.00  -1110.00   -178.00     12.00
      2.00     32.80
     32.80   6000.00      6.20  12340.00  -1110.00   -178.00     12.00
      2.00     32.80
 =============== CARD 7 =================
Y        3
               0.0     16.40
              40.0      0.00
 =============== CARD 8 =================
        16        27
         1    0.00
         6    4.49
         9    10.0
        10    11.0
        11    13.0
        12    18.0
        13    25.0
        14    38.0
        15    58.0
        16    78.0
        17    98.0
         1         1     402.0
         3         1     401.0
         5         1     399.0
         7         2     398.0
         9         2     397.0
        10         2     396.0
        12         2     392.0
        14         3     390.0
        16         3     388.0
        18         3     384.0
        20         3     376.0
        21         3     370.0
        22         3     360.0
        23         3     340.0
        25         3     260.0
        27         3     100.0
        28         3       0.0
```

Figure E1. Sample input file for the FLEXPASS program

```
 =============== CARD 9 =================
          9
     1   50.  50.0
     2   50.  50.0
     4   55.  55.0
     6   60.  60.0
     8   70.  70.0
    10   75.  75.0
    12   85.  85.0
    15   90.  90.0
    20   95.  95.0
 =============== CARD 10 =================
ASPHALT             1
   3879.25  5.626E11    0.0728
   3879.25  5.626E11    0.0728
   3879.25  5.626E11    0.0728
   3879.25  5.626E11    0.0728
   3879.25  5.626E11    0.0728
   3879.25  5.626E11    0.0728
   2500.00  2.500E11    0.1303
   2500.00  2.500E11    0.1303
   2500.00  2.500E11    0.1303
   2500.00  2.500E11    0.1303
   2500.00  2.500E11    0.1303
   2500.00  2.500E11    0.1303
BC                  0
SG                  0
 =============== CARD 11 =================
          1
          2  2000.000    45.000     4.000      .375
 =============== CARD 12 =================
      .200      .040    -.900
 =============== CARD 13 =================
     1.000      .058
 =============== CARD 14 =================
     4.200
 =============== CARD 15 =================
          2
          3
      0.00      0.00
      0.00      3.99
      4.49      3.99
```

Figure E1. Sample input file for the FLEXPASS program (continued) run of the FLEXPASS program. This problem title may be 80 characters long.

CARD 2: (8I10) Finite Element Mesh Generation

Column	Variable	Entry
10	NGM	Flag indicating mesh generation = 0 mesh generated by the program = 1 mesh input by the user
20	ISCE	Scenario number (1 for current scenario; 2 for alternate scenario)
30	ITRAF	Traffic direction (1 if input data are for traffic direction first considered by the user; 2 if input data are for opposite direction of travel)

In the FLEXPASS program, the pavement is represented by an array of finite elements. Thus, the program has to know how the finite elements are arranged. To facilitate program use, a finite element mesh generator has been incorporated into FLEXPASS. Thus, the user has the option of generating his/her own mesh or of having the FLEXPASS program generate the mesh automatically. For most pavement design problems where full-friction between pavement layers can be assumed, the user can opt for automatic mesh generation. However, in special situations where the user may want to model slippage between pavement layers, he/she must generate the finite element mesh. In these cases, the user will be prompted for finite element mesh information in CARD 8. The user cannot invoke the automatic mesh generation feature for problems where slip between pavement layers is allowed to occur.

CARD 3: (I10,F10.0) Slip Condition and Friction Coefficient

Columns	Variable	Entry
10	SLICON	Flag indicating slip condition between layers = 0 without slip condition = 1 slip condition
11-20	FRICOE	Friction coefficient

The user specifies on this CARD whether slip is allowed to occur between pavement layers. If there is slippage, the user must specify a friction coefficient (FRICOE) indicating the degree of slip between layers. The friction coefficient will range from zero to some high value (usually 1,000). A zero implies full slip (frictionless condition) between layers, while a value of 1,000 implies full bonding. If SLICON = 0 or no slip occurs, the user need not enter any value for the variable FRICOE.

CARD 4: (I10,4F10.0) Load Geometry

Columns	Variable	Entry
1-10	LOAD	Number of axles
11-20	RZERO	Radius of the loaded area, inches
21-30	PSI	Tire inflation pressure, psi
31-40	DSLON	Spacing between axles, inches
41-50	DSLAT	Spacing between tires, inches

The user specifies the following data on this CARD: 1) axle configuration; 2) radius of the loaded area (inches); 3) inflation pressure (psi); 4) spacing between axles (inches); and 5) spacing between tires (inches). The axle configurations that can be handled by the program are limited to single, tandem, and triple axle assemblies with single or dual tires. The axle configuration is indicated by the variable LOAD which can take on values of 1, 2, or 3 for single, tandem, and triple axles respectively. For single axles, there is no need to specify DSLON, and for a single tire configuration, DSLAT need not be specified.

CARD 5-I: (I10) Applied Load Condition

Column	Variable	Entry
10	PORU	Flag indicating load condition = 1 uniform load = 2 point load

Either uniform or point loading condition is allowed in the program. Point loads may be used to model the non-uniformity of tire contact pressures.

CARD 5-II: (I10) Number of Point Loads

Columns	Variable	Entry
1-10	NBC	Number of point loads.

If PORU is set equal to 2 in CARD 5-I, then the user needs to specify the number of point loads on this card. Otherwise if PORU = 1, the user skips this card.

CARD 5-III: (I10,2F10.0) Nodal Point Loads

This card may be used for the input of horizontal and vertical forces, such as those obtained from the Texas A&M Tire Model developed by J. T. Tielking. If PORU = 1 (Card 5-I), skip this card.

Columns	Variable	Entry
1-10	NPN(N)	The nodal number at which the point load is applied
11-20	URS(N)	Horizontal force (lbs) at NPN(N)
21-30	UZS(N)	Vertical force (lbs) at NPN(N)

For a point loading condition, the user needs to specify the horizontal and vertical nodal forces. These forces act at the corners of the finite elements as illustrated in Figure E2.

CARD 6-I: (2I10) Number of Material Components and Seasons

Columns	Variable	Entry
1-10	NUMMAT	Number of material components
11-20	NSL	Number of seasons

For the version of FLEXPASS used in Florida COMPAS, the maximum number of material components or pavement layers, and the maximum number of seasons for materials characterization are limited to 4.

CARD 6-II: (I10,5F10.0) Layer Material Characteristics

Each layer must have a card 6-II followed by at least one card 6-III which is dependent on the model used to characterize a particular layer.

Note	Columns	Variable	Entry
1	1-10	MTYPE	Material type or layer number
2	11-20	DEN(MTYPE)	Density of material (pcf)
3	21-30	POSON(MTYPE)	Poisson's ratio
4	31-40	AKO(MTYPE)	Coefficient of earth pressure at rest
	41-50	THICK(MTYPE)	Thickness of the layer, inches
5	51-60	EMODE(MTYPE)	Flag indicating the model of material = 1.0 = 2.0 = 3.0 = 4.0

Notes:

1. The material types or layers are numbered sequentially beginning with 1 for the top layer.
2. Typical values of density for asphaltic concrete, granular base, and subgrade soils are 140, 130, and 120 pounds/cubic ft. (pcf), respectively.
3. Typical values of Poisson's ratio for various pavement materials

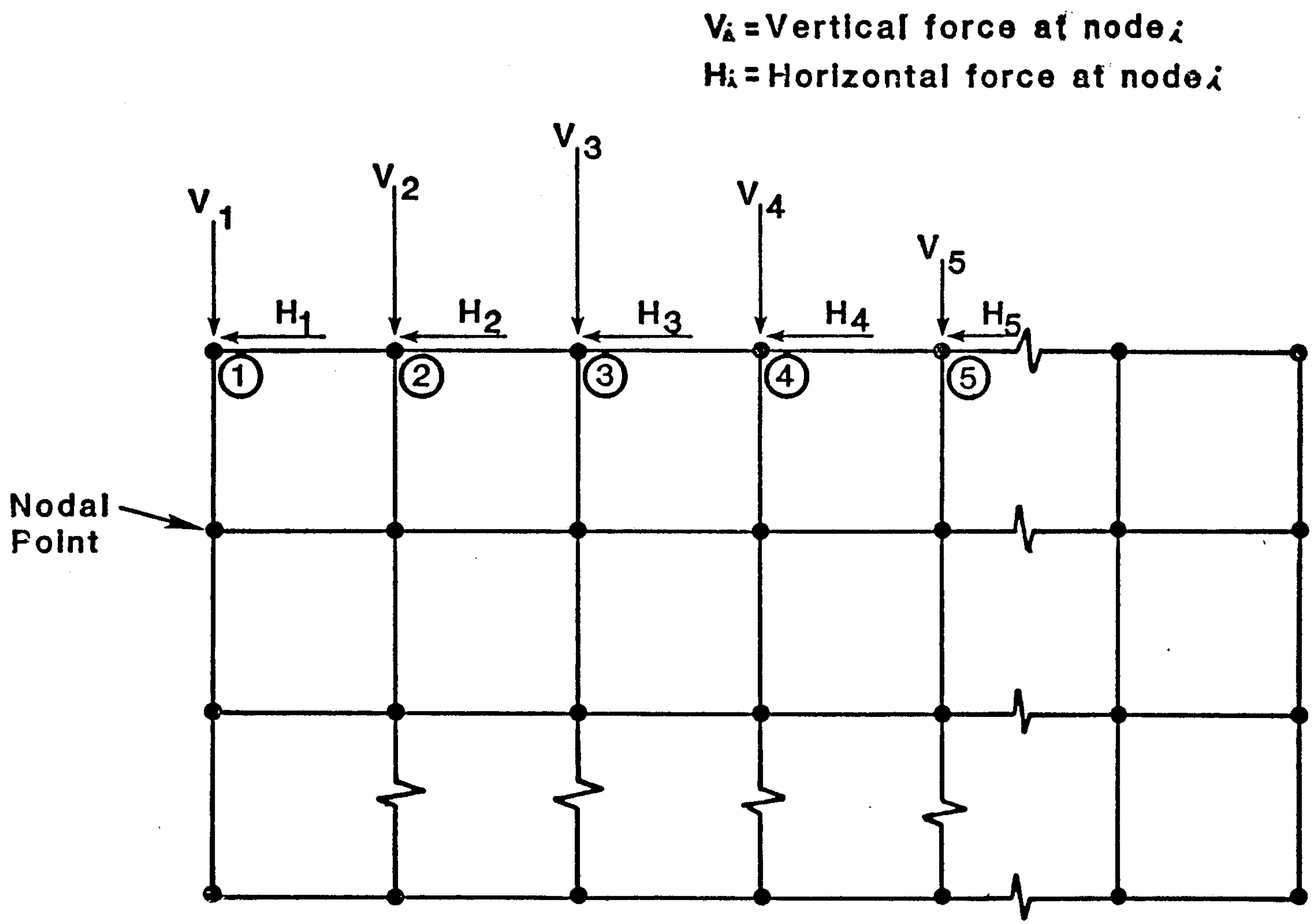


Figure E2. Illustration of Point Loads.

are shown in Table E1.

4. Coefficient of Earth pressure at rest in calculated as $\nu/(1-\nu)$ in which ν is the Poisson's ratio, if AKO(MTYPE) is left blank or set equal to zero.

5. There are four models to characterize the pavement layers in the program:

Model 1.0 - For materials with modulus (E_r) as a function of minor principal stress, σ_3. The equation is expressed as:

$$E_r = x_1(\sigma_3)^{x2} \qquad \text{if } \sigma_1/\sigma_3 < x_3 \;;\; \sigma_3 > x_4$$

otherwise E_r = resilient modulus at failure

x_1 = The material coefficient determined from repeated triaxial testing.

x_2 = The exponent for the confining stress; usually has a range from 0 to 10.

x_3 = The maximum allowable stress ratio. A value of 5.0 may be used.

x_4 = The minimum horizontal compressive stress that the material is permitted to reach. If x_4 is not known, use x_4 = 0.01.

Model 2,0 - For cohesive materials with the resilient modulus (E_r) as a function of deviator stress, σ_d (see Figure E3). The equations are:

$$E_r = x_2 + x_3\,[\sigma_d - x_1], \text{ if } x_1 > (\sigma_1 - \sigma_3)$$

and

$$E_r = x_2 + x_4\,[\sigma_d - x_1], \text{ if } x_1 < (\sigma_1 - \sigma_3)$$

in which

x_1 = Deviator stress (psi) at the breakpoint of the deviator stress-resilient modulus relationship.

Table E1. Typical Values of Poisson's Ratio for Pavement Materials

Material Type	Poisson's Ratio
Asphalt Concrete	0.35
Granular Base	0.40
Silty Subgrade	0.45
Clay Subgrade	0.50
Soil Cement	0.20

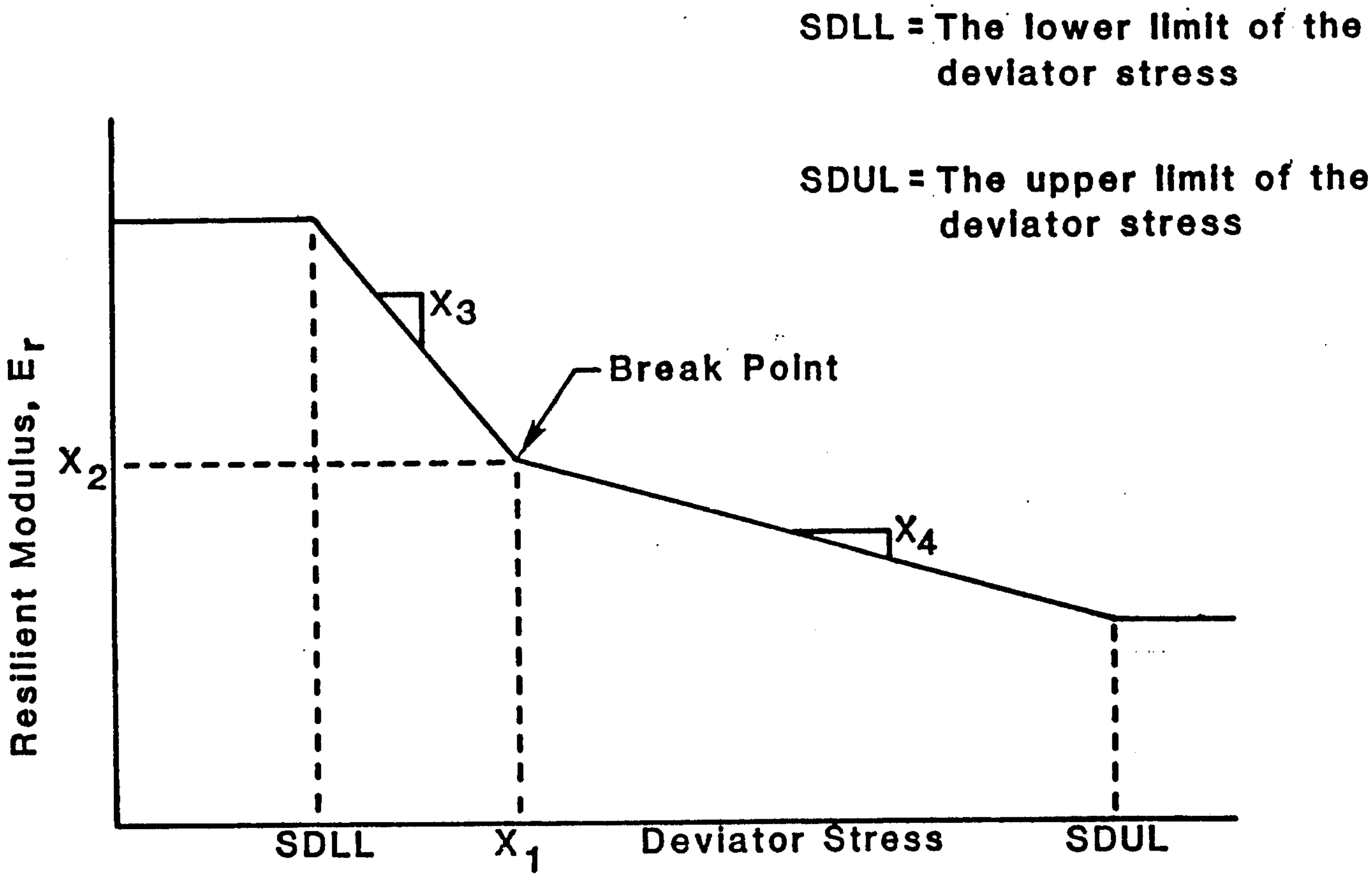


Figure E3. Variation of Resilient Modulus with Deviator Stress.

x_2 = Modulus value (psi) at the breakpoint of the deviator stress-resilient modulus relationship.

x_3 = Slope of the left portion of the deviator stress-resilient modulus relationship.

x_4 = Slope of the right portion of the deviator stress-resilient modulus relationship.

Typical values of material properties for material model 2 are shown in Table E2.

Model 3.0 - For materials with a constant modulus. This model is basically designed for asphalt concrete mixes. The temperature dependency of asphalt concrete mixes illustrated in Figure E4 may be modeled.

Model 4.0 - For materials with modulus as a function of bulk stress θ as shown in Figure E5. The equation is given as follows:

$$E_r = x_1 \ (\theta)^{x2}, \text{ if } \sigma_1/\sigma_3 < x_3 \text{ and } \sigma_3 > x_4;$$

otherwise, E_r = resilient modulus at failure.

x_1 = The material coefficient determined from repeated triaxial testing (see Table E3 for examples).

x_2 = The exponent for the bulk stress; usually has a range from 0 to 1.0.

x_3 = The maximum allowable stress ratio. A value of 5.0 may be used.

x_4 = The minimum horizontal compressive stress (psi) that the material is permitted to reach. If x_4 is not known, use x_4 = 0.01.

CARD 6-III: (7F10.1) Material Properties

A series of these cards should accompany CARD 6-II depending on the

Table E2. Material Properties for Fine-Grained Soils

	Subgrade			
	Stiff	Medium	Soft	Very Soft
Unconfined Compression Strength (psi)	32.8	22.85	12.90	6.21
Deviator Stress (psi)				
Upper Limit (SDUL)	32.8	22.85	12.90	6.21
Lower Limit (SDLL)	2.00	2.00	2.00	2.00
χ_3 (psi/psi)	-1110.0	-1110.0	-1110.0	-1110.0
χ_4 (psi/psi)	-178.0	-178.0	-178.0	-178.0
χ_1 (psi)	6.20	6.20	6.20	6.20
χ_2 (ksi)	12.34	7.68	3.02	1.00
Resilient modulus at failure (ksi)	7.605	4.716	1.827	1.00
Friction Angle (degrees)	0.00	0.00	0.00	0.00
Cohesion	16.4	11.425	6.45	3.105

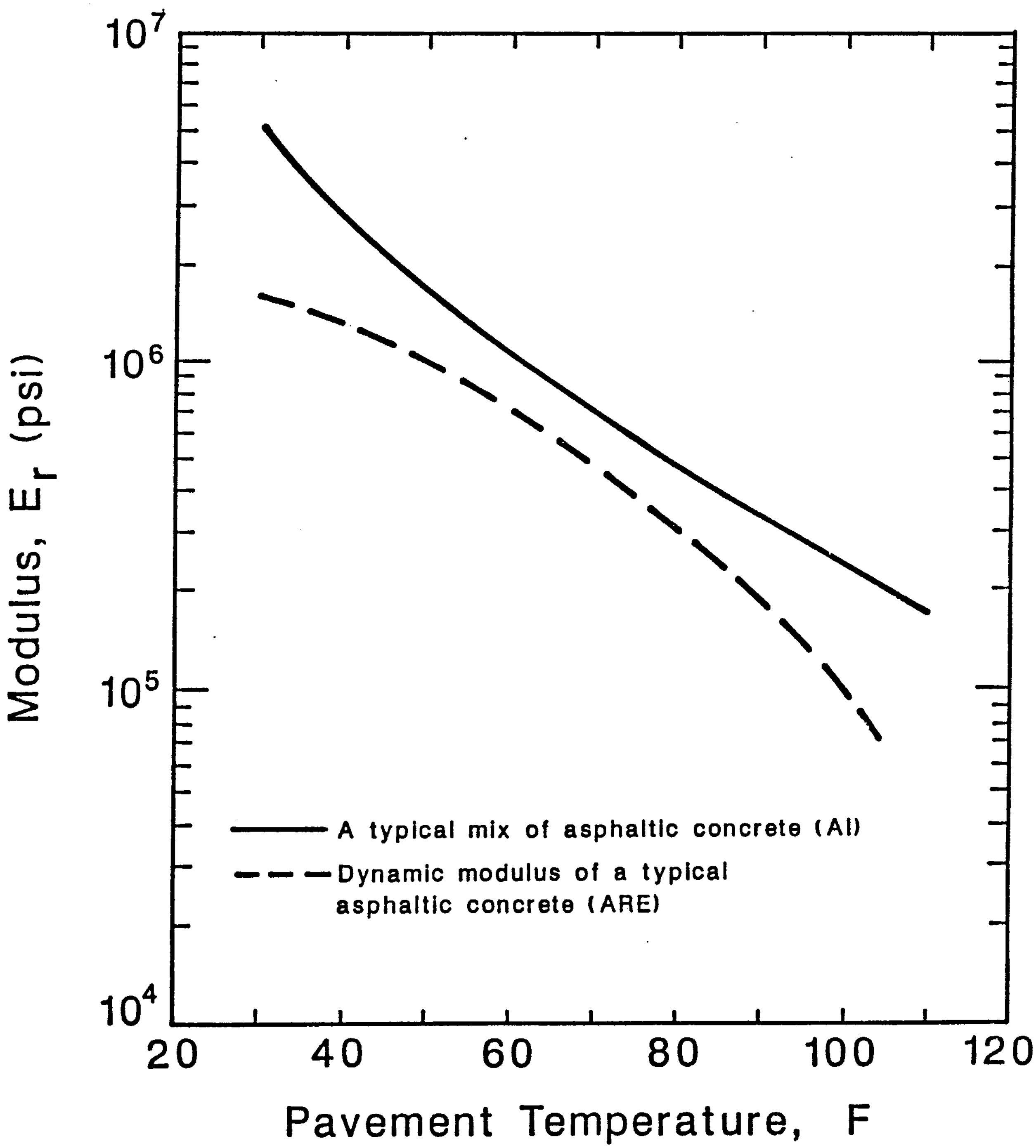


Figure E4. Relationships Between Asphalt Concrete Modulus and Pavement Temperature.

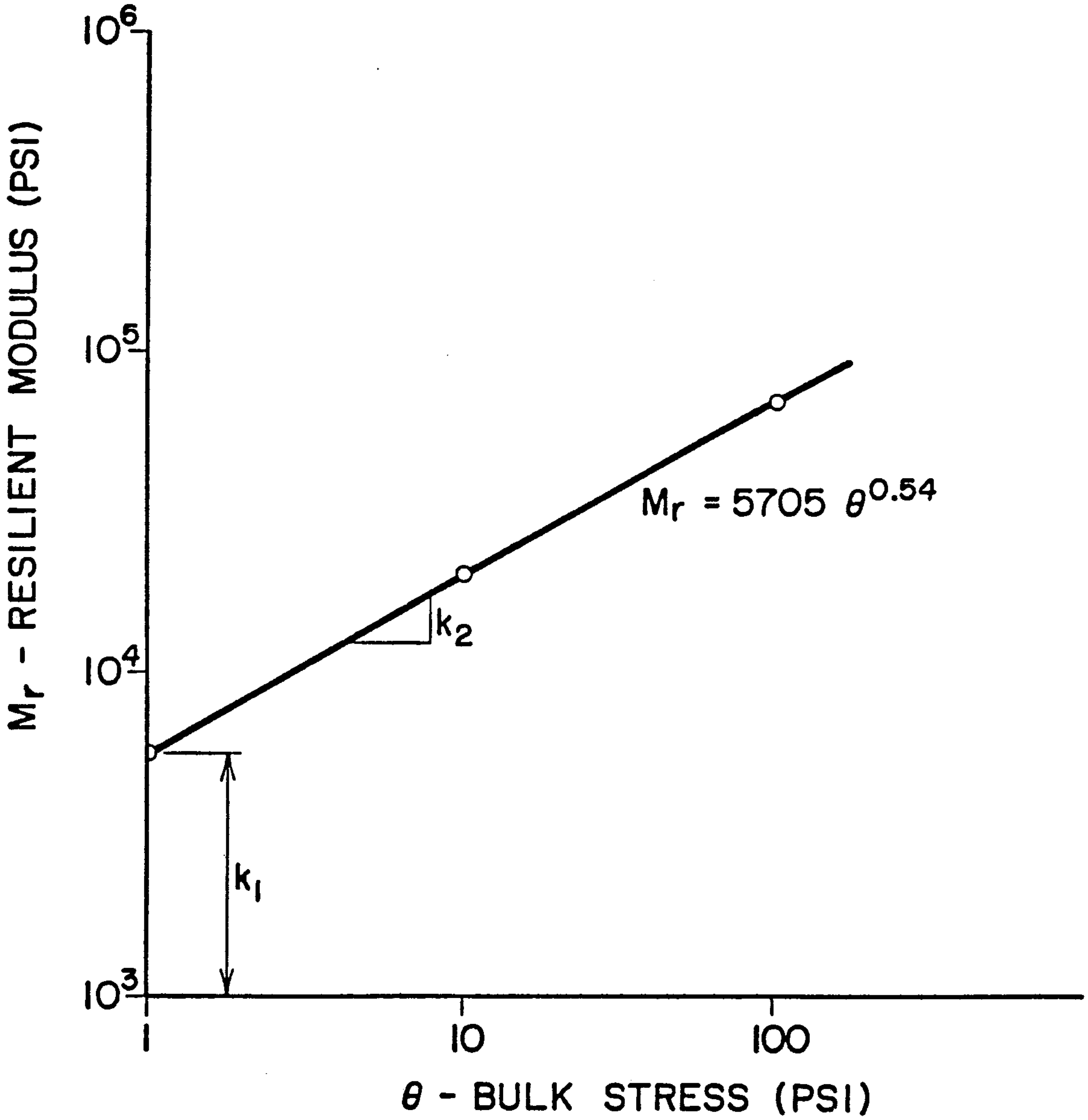


Figure E5. Variation of the Resilient Modulus of Granular Materials with Bulk Stress.

Table E3. Values of χ_1 and χ_2 for Various Granular Materials

Granular material type	χ_1		χ_2	
	Mean	Range	Mean	Range
Silty sands	1620	710 to 3830	0.62	0.36 to 0.80
Sand gravel	4480	860 to 12840	0.53	0.24 to 0.80
Sand-aggregate-blends	4350	1880 to 11070	0.59	0.23 to 0.82
Crushed stone	7210	1705 to 56670	0.45	-0.16 to 0.86
Limerock	14030	5700 to 83860	0.40	0.00 to 0.54
Slag	24250	9300 to 92360	0.37	0.00 to 0.52

Note: Typical values of cohesion and friction angle for granular materials are 0.0 and 40°, respectively.

number of seasons specified. This CARD group is used to specify layer material properties. Input data will depend on the model used for a particular layer. Table E4 summarizes the input data required for various material models.

Columns	Variables	Entry
1-10	E(I,1,K)	Unconfined compression strength or pavement temperature for I^{th} season and K^{th} layer
11-20	E(I,2,K)	Resilient modulus or resilient modulus after failure for I^{th} season and K^{th} layer
21-30	E(I,4,K)	x_1(depends on material model)
31-40	E(I,5,K)	x_2(depends on material model)
41-50	E(I,6,K)	x_3(depends on material model)
51-60	E(I,7,K)	x_4(depends on material model)
61-70	E(I,9,K)	Water content or asphalt content for I^{th} season and K^{th} layer

CARD 6-IV: (2F10.1) Deviator Stress Limits for Material Model 2.

Columns	Variables	Entry
1-10	SDLL(I,MTYPE)	Lower limit (psi) of the deviator stress-resilient modulus relationship for I^{th} season and for layer MTYPE
11-20	SDUL(I,MTYPE)	Upper limit (psi) of the deviator stress-resilient modulus relationship for I^{th} season and for layer MTYPE

Figure E3 illustrates the variables SDLL and SDUL which are required if material model 2.0 is selected for a particular layer. Table E2 provides typical values for these variables for fine-grained soils. This card is not required if material model is not equal to 2. Otherwise, this card should immediately follow CARD 6-III.

CARD 7-I: (A1,4X,I5) Mohr-Coulomb Failure Theory Correction

Note Columns Variable Entry

Table E4. Input Data Required for Various Material Models

Input Variable	Material Model 1.0	2.0	3.0	4.0
1. Pavement Temperature (°F)			X	
2. Unconfined compression strength (psi)		X		
3. Resilient modulus (psi)			X	
4. Resilient modulus after failure (psi)	X	X		X
5. Variable χ_1				
a. Coefficient of the relationship $E_r = \chi_1 \sigma_3^{\chi_2}$	X			
b. Deviator stress at breakpoint of resilient modulus-deviatoric stress relationship, psi		X		
c. Number of months in a given season			X	
d. Coefficient of the relationship $E_r = \chi_1 \theta^{\chi_2}$				X
6. Variable χ_2				
a. Exponent of the relationship: $E_r = \chi_1 \sigma_3^{\chi_2}$	X			
b. Resilient modulus at breakpoint of the resilient modulus-deviatoric relationship (psi)		X		
c. Exponent of the relationship: $E_r = \chi_1 \theta^{\chi_2}$				X
7. Variable χ_3				
a. Maximum allowable stress ratio: σ_1/σ_3	X			X
b. Slope of the left portion of the resilient modulus-deviatoric stress relationship		X		
8. Variable χ_4				
a. Minimum horizontal compressive stress	X			X
b. Slope of the right portion of the resilient modulus-deviatoric stress relationship		X		
9. Water Content, %	X	X		X
10. Asphalt Content, %			X	

1	1	NCORR	Option to make correction based on Mohr-coulomb failure theory = Y for yes = N for no
2	6-10	NUITER	Number of iterations

Notes:

1. The variable NCORR should be specified as either Y(yes) or N(no) to indicate if the element stresses are modified so that they do not exceed the strength of the material as defined by the Mohr-Coulomb failure envelope.
2. If NCORR is specified as "Y", a number between 3 and 4 is usually adequate to achieve convergence.

CARD 7-II: (8F10.1) Mohr-Coulomb Cohesive Shear Strength Values

If NCORR = N (Card 7-I), skip this card.

Columns	Variable	Entry
1-10	COHES(1)	Cohesion of the 1st layer
11-20	COHES(2)	Cohesion of the 2nd layer
...	...	...
...	COHES(I)	Cohesion of the I^{th} layer

CARD 7-III: (8F10.1) Mohr-Coulomb Friction Angles

If NCORR = N, skip this card.

Columns	Variable	Entry
1-10	FI(1)	Friction angle of the 1st layer
11-20	FI(2)	Friction angle of the 2nd layer
...	...	...
...	FI(I)	Friction angle of the I^{th} layer

Typical values of the cohesion and friction angles for fine-grained and granular materials are provided in Tables E2 and E3. When a given layer has a constant modulus (material model 3), the spaces in Cards 7-11 and 7-III for cohesion and friction angles should be left blank.

CARD 8-I: (2I10) Description of Finite Element Mesh

If NGM = 0, this card must be skipped.

Note	Columns	Variable	Entry
1	1-10	NUMCOL	Number of columns in the mesh
2	11-20	NUMROW	Number of rows in the mesh

Notes:

1. The maximum value of NUMCOL is limited to 25 as shown in Figure E6.
2. The maximum value of NUMROW is limited to 40 as shown in Figure E7.

CARD 8-II: (I10,F10.0) Numbers and Distances of Column Boundaries

If NGM = 0, this card is not required.

Columns	Variable	Entry
1-10	N	Column boundary number
11-20	RR	Distance (inches) to the column boundary with respect to the origin

The user needs to specify the horizontal distance, in inches, of each column boundary with respect to the origin. Figure E8 illustrates the required input data for this particular card. The variable N in Figure E8 represents the column boundary number while the variable RR represents the horizontal distance of a particular column boundary with respect to the origin. Input data need to be entered only at a change in the width of columns as shown in Figure E8. This facilitates user input of the required information.

CARD 8-III: (2I10,F10.0) Numbers and Distance of Row Boundaries

If NGM = 0, this card is not required.

Columns Variable Entry

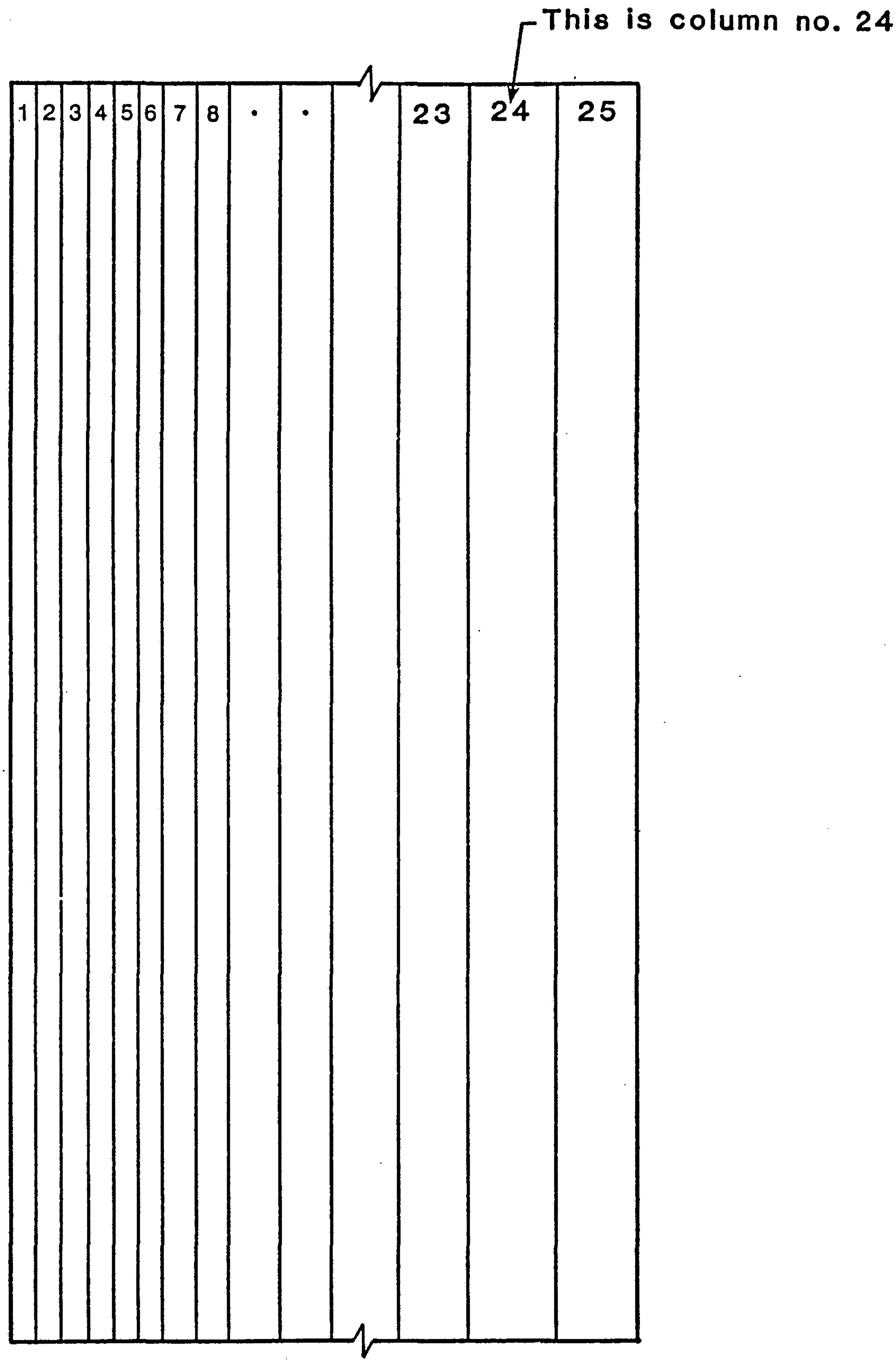


Figure E6. Illustration of Finite Element Mesh
Showing Columns.

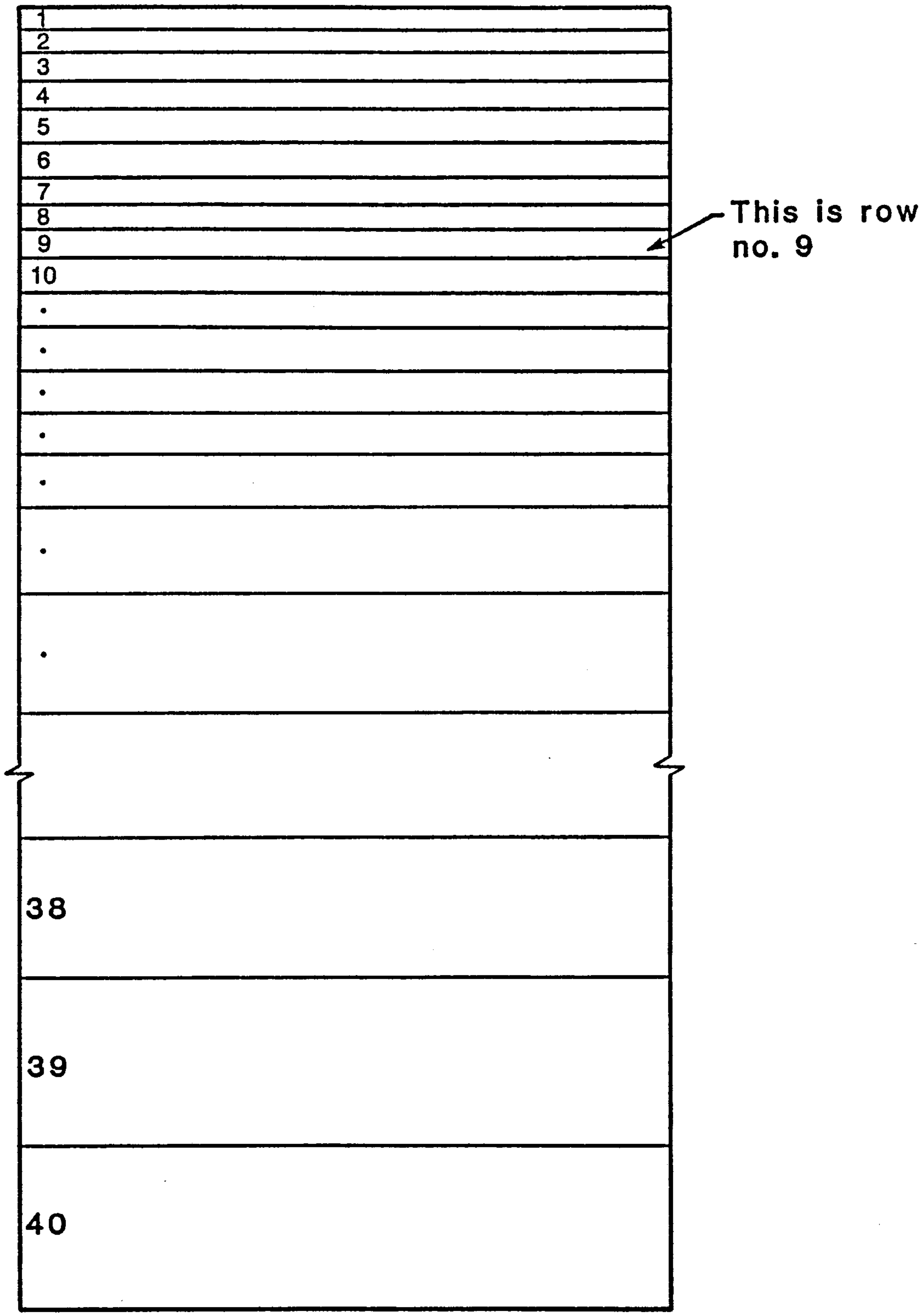
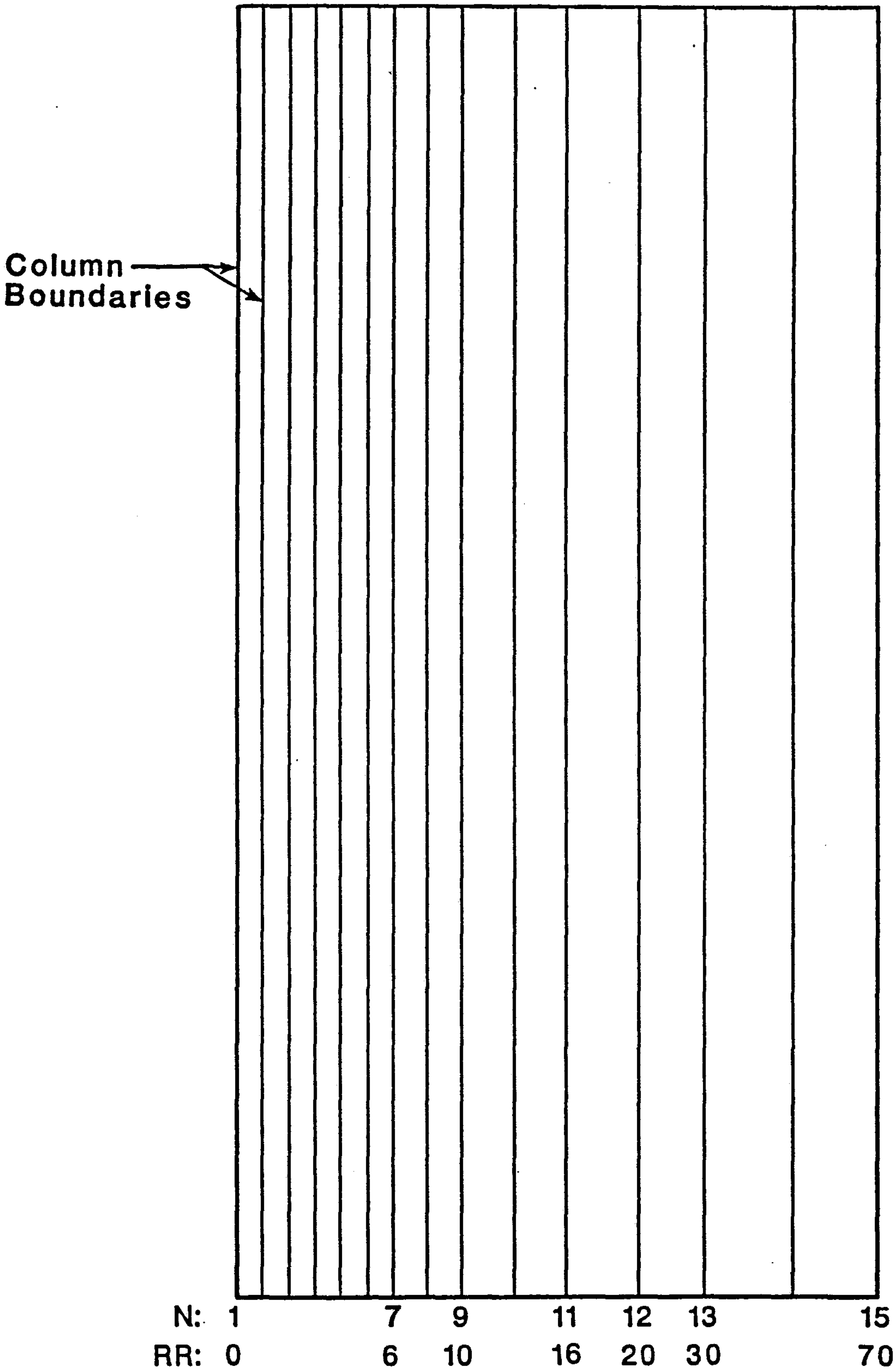


Figure E7. Illustration of Finite Element Mesh Showing Rows.



INPUT DATA:

N	RR (inches)
1	0.0
7	6.0
9	10.0
11	16.0
12	20.0
13	30.0
15	70.0

Figure E8. Numbers and Distances of Column Boundaries.

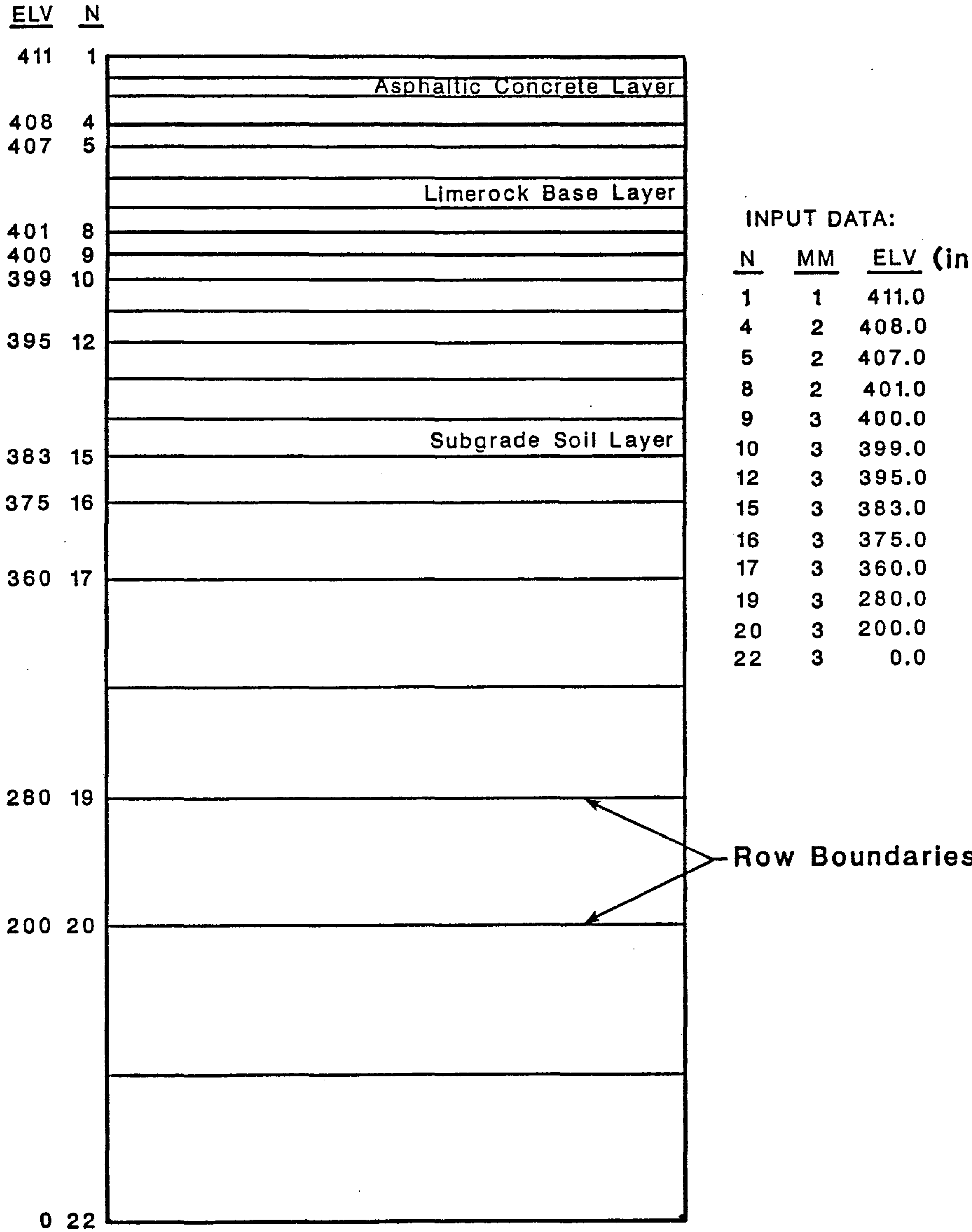
1-10	N	Row boundary number
11-20	MM	Material type number (from MTYPE, in card 6-II)
21-30	ELV	The elevation (inches) above the bottom boundary whose elevation is assumed to be zero.

In this card, the user is prompted for the elevation, in inches, of each row boundary above the bottom boundary whose elevation is assumed to be zero. Figure E9 illustrates the required input data for this card. The variable N in Figure E9 represents the row boundary number, while the variable ELV is the elevation, in inches, of a particular row boundary. MM is the material type number and is defined as the material below the row boundary number specified. Input data need to be entered only at a change in the length of the rows as illustrated in Figure E9.

In the case of a row boundary which coincides with an interface where there is slippage, the value MM should be specified as some number greater than the number of material components or layers in the pavement structure. This is the way an interface with a slip condition is identified in the FLEXPASS program. Figure E10 illustrates, on an enlarged scale, how the user should model a frictionless interface. As many be seen from the figure, a frictionless interface is modeled as a layer of infinitesimal thickness consisting of elements having 3 nodes each.

CARD 9-I: (I10) Number of Traffic Periods

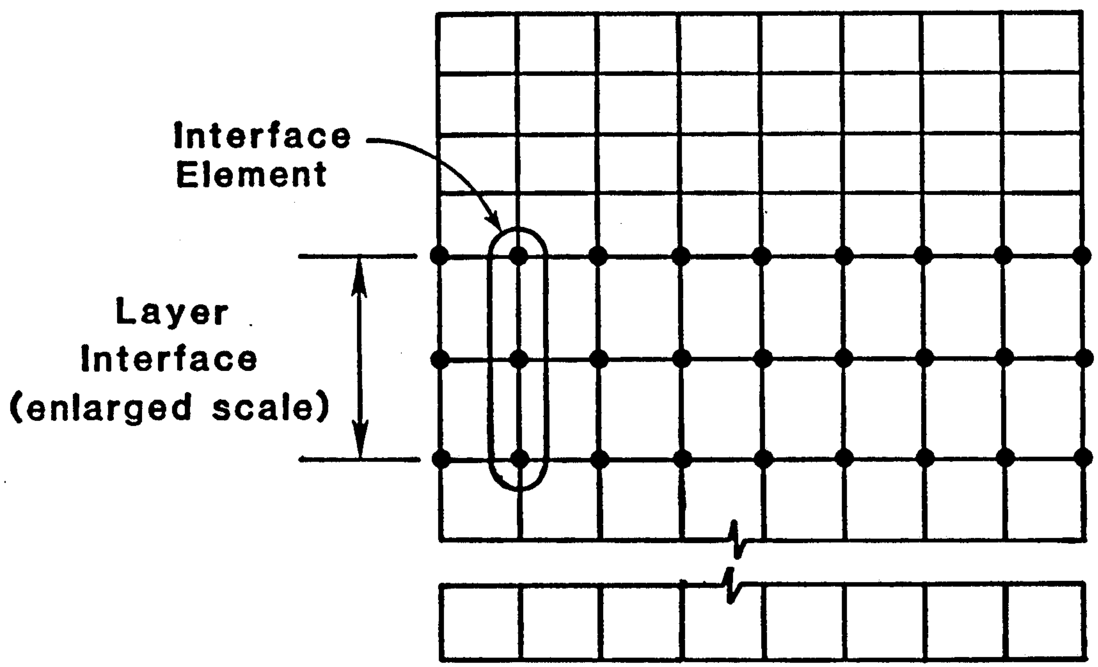
Columns	Variables	Entry
1-10	NYR	Number of traffic periods



INPUT DATA:

N	MM	ELV (inches)
1	1	411.0
4	2	408.0
5	2	407.0
8	2	401.0
9	3	400.0
10	3	399.0
12	3	395.0
15	3	383.0
16	3	375.0
17	3	360.0
19	3	280.0
20	3	200.0
22	3	0.0

Figure E9. Numbers and Distances of Row Boundaries.



Sample Imput Data

N	MM	ELV.
1	1	370.
2	1	369.
3	1	368.
4	1	367.
5	5*	366.**
6	5	366.
7	2	366.
.	.	.
.	.	.
.	.	.

* Number of material components assumed to be 4. Therefore a value of 5 for MM was used to identify an interface where there is slippage.

** Note that the row boundaries at an interface with a slip condition are all at the same elevation above the bottom boundary.

Figure E10.Illustration of Layer Interface with Slip Condition.

CARD 9-II:(I5,12F6.0) Traffic Data

Columns	Variable	Entry
1- 5	NEYRS(I)	The start of the I_{th} analysis period
6-77	TRFC(I,J)	Average daily traffic rate during the J^{th} season of the I^{th} analysis period

The program requires the number of traffic periods. In routine pavement design, the pavement engineer selects a period of time, commonly called the design period, defining the length of time that a particular pavement section should provide satisfactory service. Traffic periods are used in the program to divide the design period into time intervals of differing traffic levels. The user is prompted for the year each traffic period starts and for the average daily traffic rate during each season of the year within a given traffic period.

CARD 10-I: (A10,I10) Permanent Deformation Properties

One of these cards must be input for each material layer, and each of these cards must be followed by CARD 10-II when applicable.

Columns	Variable	Entry
1-10	TYPMR(I)	Type of material in the I^{th} layer (alphanumeric variable, left-justified) = AC; asphalt concrete = BC; base course = SG; subgrade
20	INDEX1(I)	Flag indicating the generation of permanent deformation parameters for I^{th} layer = 0, generated by the program = 1, input by the user; properties vary within layer = 2, input by the user; properties constant within a layer

Permanent deformation characteristics are specified in terms of three parameters in the program. These parameters are determined by fitting a curve to measured data of permanent strain for various loading cycles. These data are developed from either creep and recovery tests or repeated load triaxial laboratory tests. Typical permanent strain versus loading cycle curves are illustrated in Figure E11. The curves are defined by the equation:

$$\epsilon_a = \epsilon_0 \exp[-(\rho/N)^{\beta}]$$

where

ϵ_a = permanent strain

N = number of load cycles

ϵ_0, ρ, β = model parameters determined by regression.

The parameters ϵ_0, ρ, and β are used to define the permanent deformation properties of each pavement layer in the FLEXPASS program. However, to facilitate the application of the program, regression equations have been developed for predicting permanent deformation parameters for asphalt concrete (TYPMR = AC), limerock base (TYPMR = BC), and fine-grained subgrade soils (TYPMR = SG). Thus, for these materials, the user can opt to have the permanent deformation properties generated by the program (INDEX1(I) = 0). In this instance, the variable TYPMR must either be AC, BC, or SG. However, the user can still choose to enter his/her own data whenever these are available. In this instance, there are two ways by which the user can specify the permanent deformation parameters. If INDEX1(I) = 1, the parameters are assumed to vary within the I^{th} layer. If INDEX1(I) = 2, the parameters are assumed to be constant within a given layer and vary only with seasons. In both of these cases, CARD 10-II below will be required. It should be noted that if INDEX1(I) = 1 or 2, then the variable TYPMR specified by the user

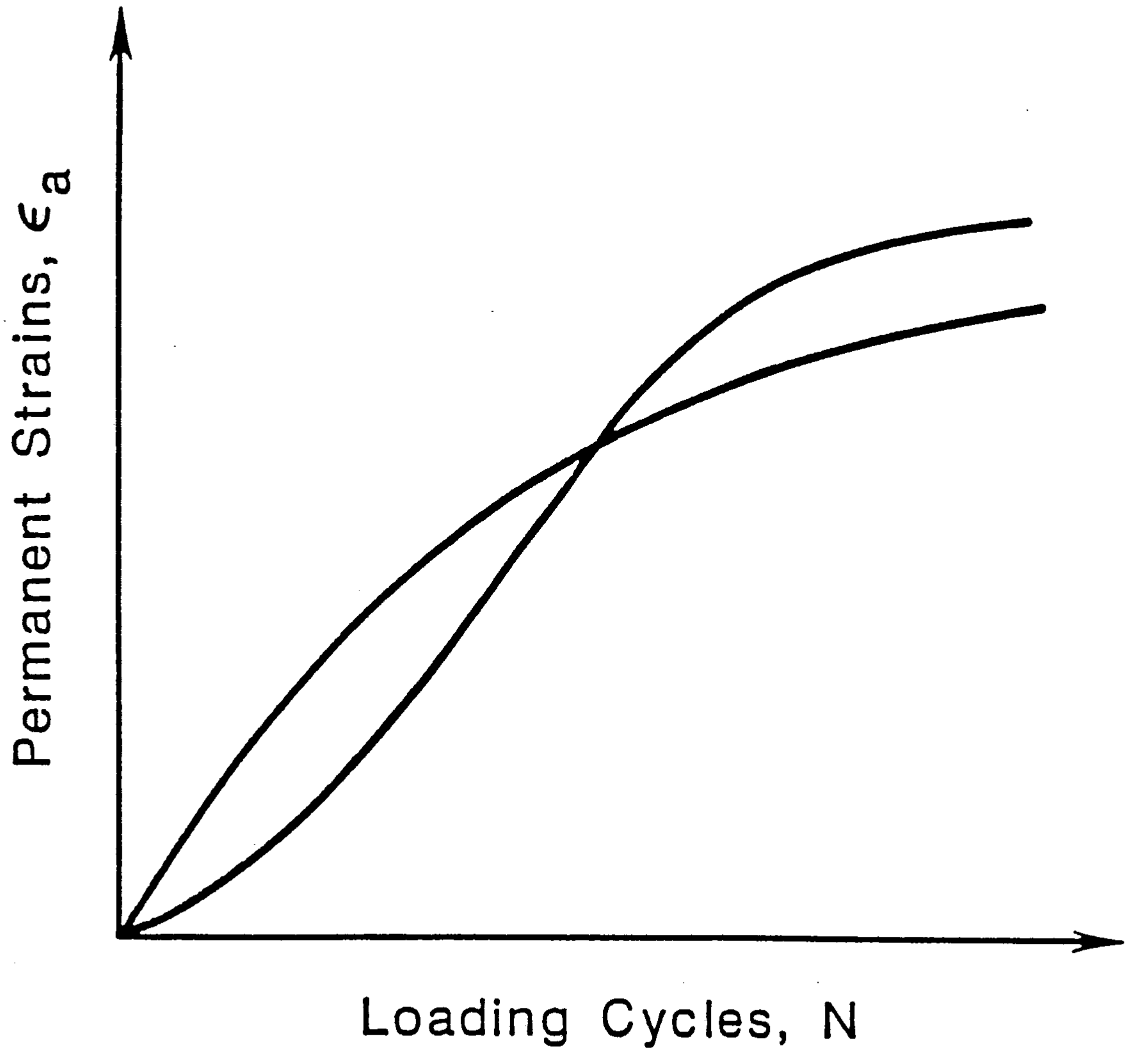


Figure E11. Variation of Permanent Strain with Loading Cycles.

can be any 10-character alphanumeric variable.

CARD 10-II: (3E10.4) User - Specified Permanent Deformation Properties

Columns	Variable	Entry
1-10	EOR(N,I,K)	ϵ_o/ϵ_r at N^{th} row of the I^{th} layer for K^{th} season
11-20	RHO(N,I,K)	ρ value at N^{th} row of the I^{th} layer for K^{th} season
21-30	BETA(N,I,K)	ß value at N^{th} row of the I^{th} layer for K^{th} season

If INDEX1(I)=1 for the I^{th} layer in CARD 10-I, then the user must specify the permanent deformation properties ϵ_o/ϵ_r, ρ, and ß for each row of layer I and for each specified season. Thus if layer I has 4 rows and 2 seasons have been specified, there will be a total of 4 x 2 or 8 lines of permanent deformation data for layer I. The program calculates internally the number of rows for each layer from the given finite element mesh. Thus, it is imperative that the number of records for permanent deformation parameters for a given layer I match the product of the number of rows and the number of seasons. Note that INDEX1(I) = 1 cannot be used in conjunction with the automatic mesh genation feature (NGM = 0) since it requires knowledge of the finite element mesh before the FLEXPASS program is executed.

If INDEX1(I)=2, only K lines of data are needed to specify the permanent deformation properties of layer I, one line for each of K seasons.

CARD 11-I: (I10) Asphalt Concrete Fatigue Constants

Column	Variable	Entry
10	INDEX2	Flag indicating the generation of fatigue properties K_1 and K_2 = 0; K_1 and K_2 based on Rauhut's model.

= 1; K_1 and K_2 based on Lytton's model.
= 2; K_1 and K_2 input by the user.

The FLEXPASS program uses the following model for predicting the occurrence of load-induced cracking:

$$N_f = k_1(1/\epsilon)^{k2}$$

N_f = number of load applications to failure,

ϵ = tensile strain at the bottom of the asphalt concrete,

K_1, K_2 = parameters of the fatigue model.

To facilitate the application of the program, two models for generating the fatigue parameters K_1 and K_2 have been incorporated into the program. These are Rauhut's and Lytton's models.

If Rauhut's model is used (INDEX2=0), K_1 and K_2 are calculated as follows:

$$K_1 = 7.87 \times 10^{-7} e^{0.001336(T^2 - 70^2)}$$

and

$$k_2 = 1.75 - 0.252 \log K_1$$

where T is pavement temperature in °F.

If Lytton's model is used (INDEX2=1) K_1 and K_2 are calculated using the following equations derived from fracture mechanics theory:

$$K_1 = \frac{d^{1-\frac{n}{2}}\left[1 - \left[\frac{C_o}{d}\right]^{1-nq}\right]}{A(1-nq)\ (Er)^n}$$

$K_2 = n$

where

d = the thickness of the surface layer, inches

C_o = the maximum radius of aggregates in the mix, inches

$n = \frac{2}{m}$; m = the slope of the creep compliance curve obtained from McLeod's nomograph and calculated internally by the program

r, q = 4.397 and 1.180, respectively.

$\log A = 7.0889 - 2.4755\ K_2 - 2.1163 \log E$, and

E = flexural stiffness of the mix.

The user also has the option of providing his/her own set of input data if these are available (INDEX2=2). The fatigue model parameters K_1 and K_2 can be determined from laboratory fatigue testing of asphalt concrete samples. The user must specify fatigue properties for each given season in CARD 11-II.

CARD 11-II: (E10.3, F10.1) Asphalt Concrete Fatigue Constants

If INDEX2=2, the following should be input. Otherwise skip this card.

Columns	Variable	Entry
1-10	AK1(I)	Fatigue parameter K_1 for I^{th} season
11-20	AK2(I)	Fatigue parameter K_2 for I^{th} season

CARD 11-III: (I10, 4F10.0) Asphalt Concrete Mixture Properties for Lytton's Model

If INDEX2=1 (Lytton's Model), the following should be input. Otherwise, skip this card.

Columns	Variable	Entry
10	MODE	Flag indicating the viscosity of asphalt binder at either 140°F or 275°F = 1, viscosity at 275°F in centistokes

		= 2, viscosity at 140°F in poises
11-20	VISCO	viscosity dependent on MODE
21-30	PEN	Penetration at 77°F
31-40	VOID	Percent air voids
41-50	CO	Maximum radius (inches) of aggregate in the mix

CARD 12: (3F10.1) Coefficients of Variation of Asphalt Concrete Fatigue Constants.

Columns	Variable	Entry
1-10	CK1	Coefficient of variation of K_1
11-20	CK1	Coefficient of variation of K_2
21-30	CK12	Coefficient of correlation between K_1 and K_2

The program requires the coefficients of variation of K_1 and K_2, and the coefficient of correlation between these two parameters to calculate the expected area of cracking. Typical values of the coefficients of variation of K_1 and K_2, and the coefficient of correlation between K_1 and K_2 are 0.2, 0.04, and -0.9 respectively.

CARD 13: (2F10.1) Slope Variance Constants

Columns	Variable	Entry
1-10	COEB	Constant B of the slope variance - rut depth variance relationship
11-20	COEC	Constant C of the slope variance - rut depth variance relationship

The slope variance is calculated from the following equation:

$$E\,[SV] = 2\,B\,\mathrm{Var}\,(RD)/C^2$$

where

$E\,[SV]$ = expected value of slope variance

$\mathrm{Var}\,[RD]$ = rut depth variance

B, C = constants

Typical values of the constants B and C in the above equation are 1.0 and 0.058 respectively.

CARD 14: (F10-1) Initial Serviceability Index

Columns	Variable	Entry
1-10	BPSI	Initial present serviceability index

CARD 15-I: (I10, 9X, A1) Printout Control

Columns	Variable	Entry
10	WRIOUT	Printout option (0, 1, or 2)
20	NNOPT	The style of the printout of stresses if WRIOUT=1

The user has three printout options. The first option (WRIOUT=0) provides a summary printout of the input data and the performance predictions generated by the program in terms of rutting, fatigue cracking, and serviceability loss. The second option (WRIOUT=1) provides the user with all of the output information available in the first option plus a separate listing of the stresses at each finite element of the pavement structure, and the displacements at the nodal points. For the microcomputer version of FLEXPASS used in Florida COMPAS, this listing has the filename "STRS_ _.OUT" where the 2 blank spaces refer to the scenario and traffic direction associated with the given run. The first blank space can take on values of 1 or 2 depending on whether the output data are for the current or alternate scenario respectively. The second blank space takes on a value of 1 if the output data are associated with the traffic direction first considered by the user, and 2 if the data are for the opposite direction of travel.

If WRIOUT = 1 is selected, the user should specify the style of the printout of the stresses and displacements (NNOPT). These pavement response variables can either be printed by row (NNOPT=H) or by column (NNOPT=V). If NNOPT is not specified, both options are printed.

The third option (WRIOUT=2) enables the user to obtain a selective printout of the stresses and displacements. Under this option, the user should specify in Card 15-II, the number of points for which stresses and displacements are to be printed.

CARD 15-II: (I10) Number of Points for Printout of Stresses/Displacements

Columns	Variable	Entry
1-10	NLWRI	Number of points for printout of stresses and displacements

If WRIOUT=2, the user specifies in this card the number of points for which stresses and displacements are to be printed. A maximum of 50 points can be specified.

CARD 15-III: (2F10.1) Point Coordinates

Columns	Variable	Entry
1-10	XXO(I)	X-coordinate of point I
11-20	YYO(I)	Y-coordinate of point I

NLWRI cards must follow CARD 15-II. On each card are specified the X-Y coordinates of each point of which stresses and displacements are to be printed. X-Y coordinates are referenced from the top-left corner of the finite element mesh which coincides with the midpoint of the loaded area. The X-coordinate specifies the radial distance of the point selected from the left most column boundary while the Y-coordinate specifies the depth of the point from the surface (row boundary = 1). For each selected point, the FLEXPASS program internally picks out the finite elements closest to the X-Y coordinates specified. Stresses and displacements for the elements selected are then printed out.

DESCRIPTION OF FLEXPASS OUTPUT

As mentioned previously there are three output options in the FLEXPASS program. The first option (WRIOUT=0) provides a summary printout of the input data and the performance predictions for rutting, fatigue, cracking and serviceability loss. The second option (WRIOUT=1) provides the user with all of the output information available in the first option plus a separate listing of the stresses at all finite elements and displacements at all nodes. The third option (WRIOUT=2) provides a summary printout of the input data, the performance predictions, and the stresses and displacements at certain points specified by the user. Figure E12 shows a sample output file from the FLEXPASS program. This output file is given the filename "FLEX_ _.OUT" by the program where the 2 blank spaces refer to the scenario and traffic direction as explained previously. The numbered items in the output are briefly described in the following.

1. General Information

Contents include the problem title, the number of finite elements and nodal points, the number of pavement materials, the applied load magnitude and load radius, and a flag indicating whether a slip condition exists between any two pavement layers.

2. Summary of Material Properties

The material properties of each pavement material or layer are echoed back to the user. As discussed in the input guide, there are four material models with which to characterize pavement materials. Models 1 and 4 are primarily for granular materials for which the resilient modulus can be characterized as being dependent on confining pressure

Figure E12. Sample Output from FLEXPASS Program
(Pages 208 through 215).

END OF ONE COMPLETE DATA SET ON FIXED.FORM.FORMAT

TRUCK 1, GROUP 2, TRIPLE AXLES 19,000 PAVEMENT SECTION 4-8.0

```
NUMBER OF NODAL POINTS------          476
NUMBER OF ELEMENTS----------          432
NUMBER OF DIFF. MATERIALS---            3
NUMBER OF APPROXIMATIONS----            1
RADIUS OF LOADED AREA ------         4.49
SURFACE PRESSURE -----------        90.00
TOTAL PLATE LOAD -----------      5700.13

INTERFACE CONDITION ----------          0

NOTE = 0   BOND CASE
     = 1   SLIP CASE
```

1

```
*********************************************************************************************************
SUMMARY OF MATERIAL PROPERTIES
*********************************************************************************************************
```

LAYER 1
THICKNESS= 4.0 INCHES DENSITY= 145.0 PCF KO= 0.43

SEASONAL CHANGE	MONTHS	MODULUS PSI	TEMPERATURE	A.C. %	POISSON RATIO
1	7.0	500000.0	70.0	5.5	0.30
2	5.0	300000.0	90.0	5.5	0.30

2

NOTE THE MODULUS OF THIS LAYER IS ASSUMED A CONSTANT

LAYER 2
THICKNESS= 8.0 INCHES DENSITY= 130.0 PCF KO= 0.54

SEASONAL CHANGE	A	N	MAXSR	MINSIG	MODULUS AFTER FAILURE	WATER CONTENT	POISSON RATIO
1	4000.0	0.600	5.0	0.01	15000.0	10.0	0.35
2	4000.0	0.600	5.0	0.01	15000.0	10.0	0.35

NOTE : THE MODULUS OF THIS LAYER IS A FUNCTION OF THE SUM OF THREE PRINCIPAL STRESSES

```
                                    N
    MODULUS = A*(SIG1 + SIG2 + SIG3)
                SIG1
        FOR     ---- < MAXSR   ;   SIG3 > MINSIG
```

SIG3
OTHERWISE: MODULUS = MODULUS AFTER FAILURE

LAYER 3
THICKNESS=390.0 INCHES DENSITY= 110.0 PCF KO= 0.54

SEASONAL CHANGE	X1 (PSI)	X2 (PSI)	X3	X4	MODULUS AFTER FAILURE	WATER CONTENT	POISSON RATIO	DS LOWER LIMIT	DS UPPER LIMIT
1	6.2	12340.0	-1110.0	-178.0	6000.0	12.0	0.35	2.00	32.80
2	6.2	12340.0	-1110.0	-178.0	6000.0	12.0	0.35	2.00	32.80

NOTE : THE MODULUS OF THIS LAYER IS A FUNCTION OF THE DEVIATOR STRESS(DS).
MODULUS = X2 + X3 * (DS - X1) ; X1 > DS
MODULUS = X2 + X4 * (DS - X1) ; X1 < DS

STRESSES ARE CORRECTED

MAXIMUM NUMBER OF ITERATIONS 3

MATERIAL NO. 1 COHESION 0.000 FRICTION ANGLE 0.000
MATERIAL NO. 2 COHESION 0.000 FRICTION ANGLE 40.000
MATERIAL NO. 3 COHESION 16.400 FRICTION ANGLE 0.000

****

PRESSURE BOUNDARY CONDITIONS

I	J	PRESSURE
6	5	90.00
5	4	90.00
4	3	90.00
3	2	90.00
2	1	90.00

3

****

AXLE AND TIRE CONFIGURATION, REQUIRED ANALYSIS PERIOD, AND TRAFFIC RATE

****

TRIPLE AXLES; AXLE SPACING = 48.0 INCHES
DUAL TIRES; TIRE SPACING = 12.0 INCHES
NUMBER OF INCREMENTAL ANALYSIS PERIOD = 9

4

INCREMENTAL

ANALYSIS PERIOD (YEAR)	SEASON	TRAFFIC RATE (PASS/DAY)
1	1	50.0
	2	50.0
2	1	50.0
	2	50.0
4	1	55.0
	2	55.0
6	1	60.0
	2	60.0
8	1	70.0
	2	70.0
10	1	75.0
	2	75.0
12	1	85.0
	2	85.0
15	1	90.0
	2	90.0
20	1	95.0
	2	95.0

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****

FINITE ELEMENT MESH SPECIFIED BY USER

****

NUMBER OF COLUMNS IN THE MESH: 16
NUMBER OF ROWS IN THE MESH: 27

NUMBERS AND DISTANCES OF COLUMN BOUNDARIES

COLUMN BOUNDARY	RADIAL DISTANCE (INCHES)
1	0.00
6	4.49
9	10.00
10	11.00
11	13.00
12	18.00
13	25.00
14	38.00
15	58.00
16	78.00
17	98.00

5

NUMBERS AND DISTANCES OF ROW BOUNDARIES

ROW BOUNDARY LAYER ELEVATION THICKNESS

		(INCHES)	(INCHES)
1	1	402.00	
3	1	401.00	
5	1	399.00	
7	2	398.00	4.00
9	2	397.00	
10	2	396.00	
12	2	392.00	
14	3	390.00	8.00
16	3	388.00	
18	3	384.00	
20	3	376.00	
21	3	370.00	
22	3	360.00	
23	3	340.00	
25	3	260.00	
27	3	100.00	
28	3	0.00	390.00

****
PERMANENT DEFORMATION PROPERTIES
****

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LAYER 1

SEASONAL CHANGE	EO/ER	RHO	BETA
1	0.388D+04	0.563D+12	0.728D-01
1	0.388D+04	0.563D+12	0.728D-01
1	0.388D+04	0.563D+12	0.728D-01
1	0.388D+04	0.563D+12	0.728D-01
1	0.388D+04	0.563D+12	0.728D-01
1	0.388D+04	0.563D+12	0.728D-01
2	0.250D+04	0.250D+12	0.130D+00
2	0.250D+04	0.250D+12	0.130D+00
2	0.250D+04	0.250D+12	0.130D+00
2	0.250D+04	0.250D+12	0.130D+00
2	0.250D+04	0.250D+12	0.130D+00
2	0.250D+04	0.250D+12	0.130D+00

6

LAYER 2

SEASONAL CHANGE	EO/ER	RHO	BETA

*** NOTE ***
THE PARAMETERS OF PERMANENT DEFORMATION ARE GENERATED BY THE PROGRAM

LAYER 3

SEASONAL CHANGE	EO/ER	RHO	BETA

*** NOTE ***
THE PARAMETERS OF PERMANENT DEFORMATION ARE GENERATED BY THE PROGRAM

****
THE PARAMETERS OF FATIGUE, K1 AND K2, AND TEMPERATURE
****

SEASONAL CHANGE	K1	K2	TEMPERATURE

7

*** NOTE ***
THE PARAMETERS OF FATIGUE, K1 AND K2, ARE BASE ON LYTTON AND TSENG METHOD

****
COEFFICIENTS OF ROUGHNESS PROPERTIES AND VARIATION COEF. FATIGUE PROPERTIES
****

ROUGHNESS PROPERTY COEFFICIENT B = 1.000
ROUGHNESS PROPERTY COEFFICIENT C = 0.058
COEFFICIENT OF VARIATION K1 = 0.200
COEFFICIENT OF VARIATION K2 = 0.040
CORRELATION COEFFICIENT OF K1 AND K2 = -0.900

8

****
STRESSES AND DISPLACEMENTS AT PRESCRIBED POINTS
****

		COORDINATES		DISPLACEMENTS			STRESSES	
SEASON	EL NO.	R	Z	UR	UZ	SIGR	SIGZ	SIGT
1	1	0.00	402.00	0.0000D+00	-0.1587D-01	0.2017D+03	0.9062D+02	0.2014D+03
	1	0.00	401.50	0.0000D+00	-0.1591D-01			
	1	0.90	401.50	-0.1653D-03	-0.1582D-01			
	1	0.90	402.00	-0.2425D-03	-0.1579D-01			

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SEASON	EL NO.	R	Z	UR	UZ	SIGR	SIGZ	SIGT
1	81	0.00	398.50	0.0000D+00	-0.1560D-01	-0.1599D+03	0.2593D+02	-0.1596D+03
	81	0.00	398.00	0.0000D+00	-0.1548D-01			
	81	0.90	398.00	0.2487D-03	-0.1540D-01			
	81	0.90	398.50	0.1794D-03	-0.1552D-01			
1	86	4.49	398.50	0.7146D-03	-0.1400D-01	-0.5151D+02	0.1031D+02	-0.9533D+02
	86	4.49	398.00	0.9831D-03	-0.1393D-01			
	86	6.33	398.00	0.1090D-02	-0.1276D-01			
	86	6.33	398.50	0.7985D-03	-0.1281D-01			

		COORDINATES		DISPLACEMENTS			STRESSES	
SEASON	EL NO.	R	Z	UR	UZ	SIGR	SIGZ	SIGT
2	1	0.00	402.00	0.0000D+00	-0.1831D-01	0.1665D+03	0.9056D+02	0.1663D+03
	1	0.00	401.50	0.0000D+00	-0.1832D-01			
	1	0.90	401.50	-0.2152D-03	-0.1821D-01			
	1	0.90	402.00	-0.3178D-03	-0.1819D-01			
2	81	0.00	398.50	0.0000D+00	-0.1778D-01	-0.1136D+03	0.3714D+02	-0.1134D+03
	81	0.00	398.00	0.0000D+00	-0.1760D-01			
	81	0.90	398.00	0.3116D-03	-0.1749D-01			
	81	0.90	398.50	0.2289D-03	-0.1767D-01			
2	86	4.49	398.50	0.9075D-03	-0.1569D-01	-0.3447D+02	0.1263D+02	-0.6918D+02
	86	4.49	398.00	0.1240D-02	-0.1560D-01			
	86	6.33	398.00	0.1362D-02	-0.1408D-01			
	86	6.33	398.50	0.9993D-03	-0.1413D-01			

****

RUT DEPTH

****

YEARS	SEASON	LOADING CYCLE	RUT DEPTH	VARIANCE RUT DEPTH
1	1	10640.	3.57539E-01	1.72068E-03
	2	18240.	3.65204E-01	1.73858E-03
2	1	28880.	3.85878E-01	1.77697E-03
	2	36480.	3.88624E-01	1.78320E-03
4	1	68248.	4.12484E-01	1.81708E-03
	2	76608.	4.13728E-01	1.81945E-03
6	1	111264.	4.28516E-01	1.83579E-03
	2	120384.	4.29387E-01	1.83718E-03
8	1	160816.	4.41279E-01	1.84872E-03
	2	171456.	4.42035E-01	1.84976E-03
10	1	214776.	4.51590E-01	1.85800E-03
	2	226176.	4.52249E-01	1.85879E-03
12	1	275272.	4.60828E-01	1.86570E-03
	2	288192.	4.61461E-01	1.86638E-03
15	1	373008.	4.72469E-01	1.87455E-03
	2	386688.	4.73025E-01	1.87507E-03
20	1	545528.	4.87814E-01	1.88498E-03
	2	559968.	4.88285E-01	1.88537E-03

10

****
FATIGUE CRACKING
****

MODULI STIFFNESS IS CALCULATED FROM McLEOD METHOD

```
VISCOSITY @ 140 F POISES....... = 2000.0
PENETRATION @ 77 F IN 0.1MM.... =   45.0
ASPHALT CONTENT IN THE MIX.... =    5.5 %
AIR VOID IN THE MIX........... =    4.0 %
MAXIMUM SIZE OF AGGREGATE..... =  0.375 INCHES
```

TEMPERATURE DEGREE-F	RADIAL STRAIN	K1	K2
70.0	0.2783D-03	0.1250D-05	3.0280
90.0	0.3488D-03	0.5973D-04	2.5762

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YEARS	SEASON	DAMAGE INDEX	AREA CRACKED
1	1	0.1910D+00	0.1850D+03
	2	0.3804D+00	0.2865D+03
2	1	0.5714D+00	0.3737D+03
	2	0.7608D+00	0.4435D+03
4	1	0.1388D+01	0.6428D+03
	2	0.1596D+01	0.6990D+03
6	1	0.2280D+01	0.8711D+03
	2	0.2507D+01	0.9229D+03
8	1	0.3301D+01	0.1000D+04
	2	0.3565D+01	0.1000D+04
10	1	0.4416D+01	0.1000D+04
	2	0.4698D+01	0.1000D+04
12	1	0.5659D+01	0.1000D+04
	2	0.5979D+01	0.1000D+04
15	1	0.7672D+01	0.1000D+04
	2	0.8010D+01	0.1000D+04
20	1	0.1122D+02	0.1000D+04
	2	0.1158D+02	0.1000D+04

****
PERFORMANCE
****

INITIAL SERVICEABILITY INDEX = 4.2

YEARS	SEASON	TRAFFIC VOLUME	SLOPE VARIANCE	AREA CRACKED	RUT DEPTH	SERVICEABILITY INDEX
1	1	10640.	0.1023D+01	0.1850D+03	0.3575D+00	3.3031
	2	18240.	0.1034D+01	0.2865D+03	0.3652D+00	3.2579
2	1	28880.	0.1056D+01	0.3737D+03	0.3859D+00	3.2031
	2	36480.	0.1060D+01	0.4435D+03	0.3886D+00	3.1814
4	1	68248.	0.1080D+01	0.6428D+03	0.4125D+00	3.1041
	2	76608.	0.1082D+01	0.6990D+03	0.4137D+00	3.0912
6	1	111264.	0.1091D+01	0.8711D+03	0.4285D+00	3.0394
	2	120384.	0.1092D+01	0.9229D+03	0.4294D+00	3.0294
8	1	160816.	0.1099D+01	0.1000D+04	0.4413D+00	3.0000
	2	171456.	0.1100D+01	0.1000D+04	0.4420D+00	2.9988
10	1	214776.	0.1105D+01	0.1000D+04	0.4516D+00	2.9851
	2	226176.	0.1105D+01	0.1000D+04	0.4522D+00	2.9841
12	1	275272.	0.1109D+01	0.1000D+04	0.4608D+00	2.9716
	2	288192.	0.1110D+01	0.1000D+04	0.4615D+00	2.9707
15	1	373008.	0.1114D+01	0.1000D+04	0.4725D+00	2.9546
	2	386688.	0.1115D+01	0.1000D+04	0.4730D+00	2.9537
20	1	545528.	0.1121D+01	0.1000D+04	0.4878D+00	2.9318
	2	559968.	0.1121D+01	0.1000D+04	0.4883D+00	2.9311

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(Model 1) or bulk stress (Model 4). Model 2 is used for fine-grained soils for which the resilient modulus is primarily a function of the deviatoric stress. Model 3 is for materials which are not stress dependent (e.g., asphalt concrete).

The material model parameters x_1 to x_4 for each layer are shown in this group of output data. Also printed for each layer are: 1) layer thickness; 2) layer density; 3) Poisson's ratio; 4) coefficients of earth pressure at rest; 5) cohesive strength; and 6) friction angle.

3. Summary of Applied Loads

Two types of loads, either uniform pressure or point loads, may be specified for a program run. For a uniform pressure condition, the output includes the nodal points, I and J, between which a specified uniform pressure is applied. However, if the loads applied were point loads, the horizontal (H) and vertical (V) nodal forces will be printed out instead.

4. Axle Configuration and Traffic Data

Information on the axle configuration, as well as the specified traffic rate for each season of a given year in the design period, are printed out.

5. Finite Element Mesh

The finite element mesh data generated by the program (NGM=0) or provided by the user (NGM=1) are also printed out. As a check to the finite element mesh, the program calculates internally the layer thicknesses from data on the row boundaries. The calculated layer thicknesses are printed out in this section of the output and should match the thicknesses specified by the user.

6. Permanent Deformation Properties

Permanent deformation properties which are required to calculate rut depth are either input by the user or generated internally by the program. For the user input mode, the three parameters, EO/ER (ϵ_0/ϵ_r), RHO (ρ), and BETA (β) are printed out. Otherwise a message saying that permanent deformation parameters are generated by the program is printed.

7. Fatigue Parameters K_1 and K_2

If the fatigue parameters are calculated internally by the program, a message is printed out showing by what model (i.e., Rauhut's or Lytton's) were the fatigue parameters K_1 and K_2 calculated. Otherwise the values specified by the user for these parameters are printed.

8. Coefficients of Slope Variance-Rut Depth Variance Relationship and Variation Coefficients of Fatigue Parameters

The coefficients of variation of the fatigue parameters K_1 and K_2, and the correlation coefficient between K_1 and K_2 are shown. These variables are used to calculate the area of cracking. In addition, the coefficients B and C of the relationship between slope variance and rut depth variance are printed out.

9. Stresses and Displacements at Prescribed Points

If the user chose WRIOUT=2 for printout control, the displacements and stresses at certain elements are provided. Under this option, the user specifies, during program input, coordinates of points for which stresses and displacements are to be printed. The FLEXPASS program then picks out the elements of the finite element mesh falling closest to the coordinates specified, and prints out the stresses and displacements for these elements.

The output shows the coordinates of the selected elements in terms of the radial distance R to the centerline (Z) of an axi-symmetric solid (see Figure E13), and the elevation Z from the bottom of the pavement structure. Also included in the output are: 1) the radial nodal displacements UR; 2) the vertical nodal displacements UZ; 3) the radial normal stress SIGZ (σ_r); 4) the vertical normal stress SIGZ (σ_z); and 5) the tangential normal stress SIGT (σ_t). The element stresses are illustrated in Figure E13 and act at the center of the element. Compressive stresses are positive in the program.

If, during the input phase, the user chose WRIOUT=0, only a summary of the input data and the performance predictions will be printed. Therefore, this section of the output will be omitted. However, if the user chose WRIOUT=1, a separate listing of the displacements and stresses at all elements will be provided. Figure E14 shows a partial listing of the output produced under this option. The radial and vertical nodal displacements, and the stresses at the center of the elements are printed out for each iteration of the Mohr-Coulomb correction procedure. In addition, the following pavement response variables are provided under this option: 1) shear stress TAURZ (τ_{rz}); 2) major principal stress SIG1 (σ_1); 3) minor principal stress SIG3(σ_3); 4) the angle the principal stress plane makes with the horizontal axis R (see Figure E13); 5) the principal stress ratio σ_1/σ_3; and 6) the maximum shear stress TAUMAX given by $(\sigma_1-\sigma_3)/2$.

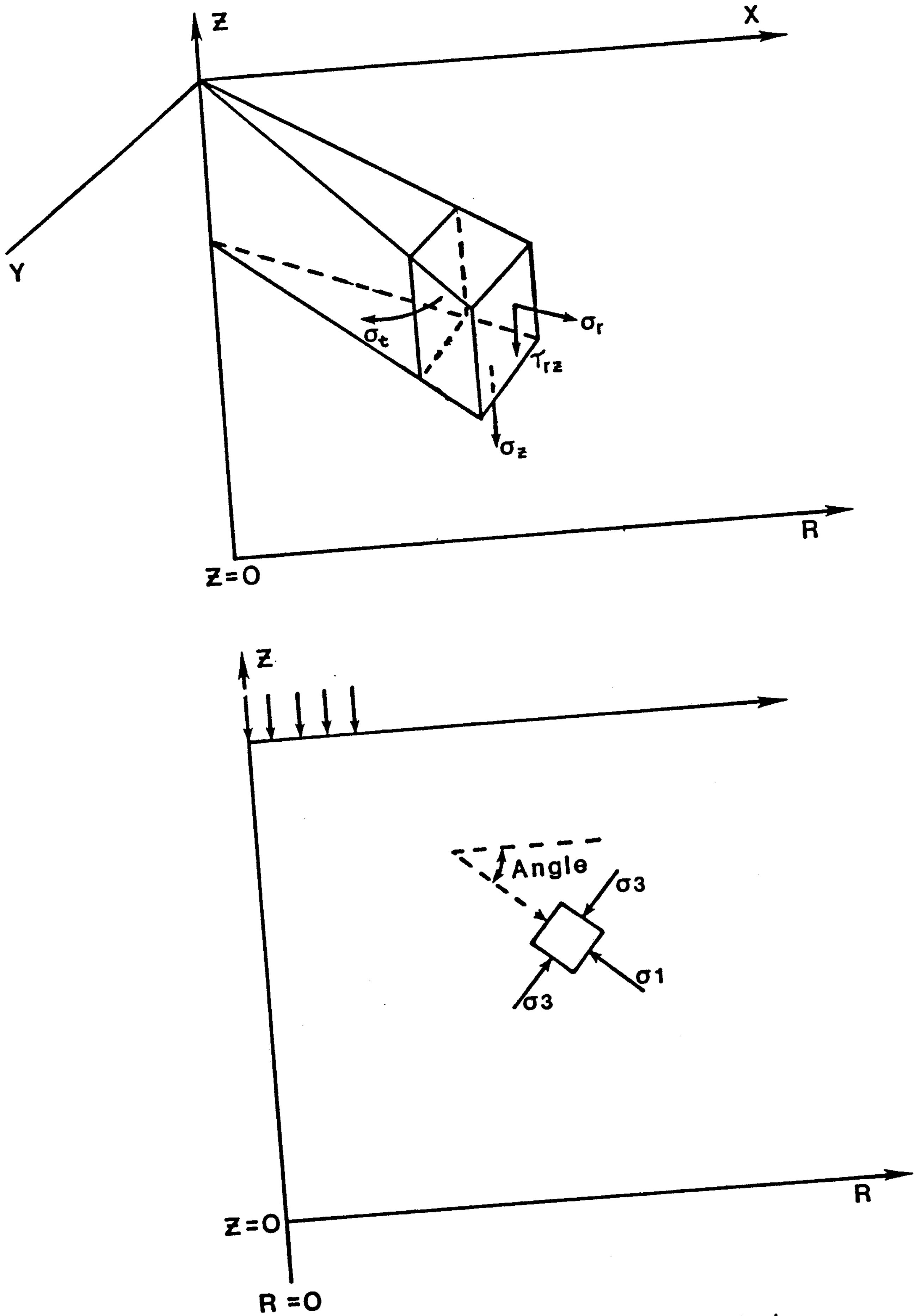

Figure E13. Output Notations - Stress Analysis.

STEP NUMBER 1 ITERATION NUMBER 0

N.P. NUMBER	RADIAL DISPLACEMENT	VERTICAL DISPLACEMENT
1	0.0000000E+00	-0.1173506E-01
2	-0.1979928E-03	-0.1166167E-01
3	-0.3796687E-03	-0.1148172E-01
4	-0.5448106E-03	-0.1119124E-01
5	-0.6868801E-03	-0.1079012E-01
6	-0.7808544E-03	-0.1021569E-01
7	-0.8010680E-03	-0.9850485E-02
8	-0.7975384E-03	-0.9304861E-02
9	-0.7264530E-03	-0.6839675E-02
10	-0.6357986E-03	-0.6471441E-02
11	-0.3926673E-03	-0.4539401E-02
12	-0.2676661E-03	-0.1952567E-02
13	-0.1575179E-03	-0.1157391E-02
14	-0.8920415E-04	-0.9328253E-03
15	-0.6802477E-04	-0.8984837E-03
16	-0.4924864E-04	-0.8693053E-03
17	-0.2485515E-04	-0.6795937E-03
18	-0.1605287E-04	-0.5510802E-03
19	-0.1137079E-04	-0.4646267E-03
20	-0.9611860E-05	-0.4585089E-03
21	-0.8511728E-05	-0.4548913E-03
22	-0.7469324E-05	-0.4517610E-03
23	-0.6461818E-05	-0.4490702E-03
24	-0.4765097E-05	-0.4448579E-03
25	-0.2438161E-05	-0.4397726E-03
26	0.0000000E+00	-0.4366044E-03
27	0.0000000E+00	-0.1174863E-01
28	-0.1328728E-03	-0.1167249E-01
29	-0.2565590E-03	-0.1148779E-01
30	-0.3637583E-03	-0.1119140E-01
⋮	⋮	⋮

STEP NUMBER 1 ITERATION NUMBER 3
FIRST LINE WITH GRAVITY, SECOND LINE -CORRECTED- (IF GIVEN)

EL.	R	Z	MODULUS	SIGR	SIGZ	SIGT	TAURZ	SIG1	SIG3	ANGLE	RATIO	TAUMAX
1	0.45	401.75	0.500E+06	0.191E+03	0.904E+02	0.191E+03	-0.403E+01	0.191E+03	0.902E+02	-0.229E+01	0.212E+01	0.504E+02
2	1.35	401.75	0.500E+06	0.180E+03	0.895E+02	0.184E+03	-0.321E+01	0.180E+03	0.893E+02	-0.202E+01	0.202E+01	0.455E+02
3	2.24	401.75	0.500E+06	0.167E+03	0.891E+02	0.176E+03	-0.503E+01	0.168E+03	0.888E+02	-0.367E+01	0.189E+01	0.394E+02
4	3.14	401.75	0.500E+06	0.148E+03	0.917E+02	0.166E+03	-0.653E+01	0.149E+03	0.909E+02	-0.650E+01	0.164E+01	0.290E+02
	⋮					⋮				⋮		

Figure E14. Partial Listing of File Containing Stresses and Displacements For All Elements

10. Rut Depth Predictions

Predictions of rut depth and rut depth variance at various loading cycles are printed out.

11. Fatigue Cracking Predictions

If the user chose the Lytton's model for predicting the fatigue parameters K_1 and K_2, the properties of the asphaltic mix specified by the user are printed out. These include the bitumen viscosity and penetration value, the asphalt content, air void content, and the maximum size of aggregate in the mix. The fatigue parameters K_1 and K_2 at corresponding temperatures are also printed together with the radial strain at the bottom of the asphalt layer. In addition, the predicted damage index and cracked area (in $ft^2/1000\ ft^2$) at various times during the design period are given.

12. Summary of Performance Predictions

A summary of the performance predictions for slope variance, fatigue cracking, rutting, and serviceability index at various times during the design period is provided.

APPENDIX F
USER'S GUIDE TO OVERLAY PROGRAM

Card 1 (1X, I4, F5.2, I5)

The Florida District number (NDIST) where project is located and the project length (XLEN) in miles, and a code (IDAMFP) to indicate whether the FLEXPASS program was used to evaluate pavement performance are entered on this card. If IDAMFP is zero, then the damage equations developed for Florida are used to evaluate pavement performance. If IDAMFP is 1, then the time to initial failure is determined from the FLEXPASS runs and the performance of subsequent overlays are determined using the damage and ODE equations.

Card 2 (1X, I4, 9I5)

The number of lanes (LANES) in project is entered on this card.

Card 3 (1X, I4, 9I5)

If the number of lanes entered in Card 2 is greater than 1, the user must specify the value for KODE1 where KODE1 = 1 is for a divided highway and KODE1 = 2 is for an undivided highway. If LANES = 1 in Card 2, skip this card.

Card 4 (1X, I4, 9I5)

If LANES > 1 in Card 2 and KODE1 = 1 in Card 3, the user must specify the value for KODE2 where KODE2 = 1 indicates that the overlay analysis is to be conducted for only one selected analysis section within the project (e.g., the worst section), and KODE2 = 2 indicates that the evaluation is to be done for two selected analysis sections, one for each traffic direction. If LANES = 1 in Card 2 or if LANES is greater than 1 but KODE1 = 2 in Card 3, skip this card.

Card 5 (1X, I4, 9I5)

Number of layers [NLAYS (i)] above subgrade is entered for each traffic direction i where the number of traffic directions (NTRAF) for the analysis is determined from the variables LANES, KODE1, and KODE2. If LANES = 1 in Card 2, the number of traffic directions NTRAF is 1. If LANES is greater than 1, and KODE1 = 1 in card 3, the number of traffic directions is given by KODE2 in Card 4. If LANES is greater than 1 but KODE1 = 2, NTRAF is 1.

Card 6 (1X, F9.0, F10.2)

For each traffic direction i (i = 1, 2), the modulus [EMOD (J, I)] and thickness [THICK (J, I)] of each layer j are entered on this card using the format shown. For a given traffic direction, the number of layers (including the subgrade) for which the moduli and thicknesses are specified is equal to [NLAYS (i) + 1] where NLAYS (i) is entered in Card 5. There will be a total of NTRAF* [NLAYS (i) + 1] records in this card group. Each record will contain the modulus and thickness of a given layer of the analysis section selected for traffic direction i. The layer modulus must be in psi and the thickness in inches. For the subgrade, the user should leave the field for layer thickness blank. The subgrade is assumed to be of infinite dimensions in the analysis.

Card 7 (1X, F9.2, 7F10.2)

The current PSI of the selected analysis section for each traffic direction i (i = 1, 2 depending on NTRAF) is entered in this card group. There will be NTRAF records in this group with each record having the appropriate value for current PSI for each traffic direction.

Card 8 (1X, F9.2. 7F10.2)

The failure criteria for each traffic direction i (i = 1, 2 depending on NTRAF) are entered for the following distress types: serviceability loss, fatigue cracking, and rutting. The failure levels for fatigue cracking and rutting are specified in ft^2 / 1000 ft^2 and inches respectively. Typical values used for design are:

1. Terminal serviceability index of 2.5
2. Maximum cracked area of 600 ft^2 / 1000 ft^2
3. Maximum rut depth of 0.5 inch

As with card 7, there will be NTRAF records in this card group with each record having the appropriate failure criteria for serviceability loss, fatigue cracking, and rutting.

Card 9 (1X, F9.2, 7F10.2)

For each traffic direction i (i = 1, 2 depending on NTRAF), the following information on the analysis section should be provided:

1. percent asphalt cement
2. penetration at 77° F (in 0.1 mm)
3. viscosity at 140° F (in poises)
4. ring and ball softening point (°F)
5. percent air voids

The values for the above variables may be determined from construction records.

There will be NTRAF records in this card group, with each record having values for the above variables entered in the order shown.

Card 10 (1X, I4, 4F10.2)

The following information regarding the overlay are entered on this card:

1. MODE - a variable indicating whether the viscosity of the overlay binder at 275° F is given (MODE = 1) or whether the viscosity at 140° F is provided (MODE = 2)
2. viscosity of overlay binder (VISCO) - if MODE = 1, the viscosity at 275° F in centistokes is entered; if MODE = 2, the viscosity at 140° F in poises is entered
3. penetration (PEN) of the overlay binder in 0.1 mm
4. percent asphalt (ASP) for the overlay
5. percent air voids (VOID) for the overlay

Card 11 (1X, F9.2, 3F10.2, I5)

The following information regarding the overlay are entered on this card:

1. minimum overlay thickness (HOMIN) to consider in the analysis, inches
2. maximum overlay thickness (HOMAX) to consider in the analysis, inches
3. depth of milling (HMILL) in inches
4. predicted PSI immediately after placement of the overlay

5. damage level IDMG at which the overlay is to be designed for reflection cracking. Possible values for IDMG are as follows:

   a) IDMG = 1 corresponds to a damage level where there are approximately 33 full-width transverse cracks per 500 feet of roadway, i.e., crack spacing is approximately 15 feet
   b) IDMG = 2 corresponds to a damage level where there are approximately 40 full-width transverse cracks per 500 feet of roadway, i.e., crack spacing is 12.5 feet.
   c) IDMG = 3 corresponds to a damage level where there are approximately 50 full-width transverse cracks per 500 feet of roadway, i.e., crack spacing is 10 feet.

Card 12 (1X, F9.2, 7F10.2)

On this card, the user provides the following environmental data representative of the project location:

1. the year-round service temperature TSERV, °F
2. the minimum air temperature TMIN, °F
3. the 24-hour temperature drop DELT, °F
4. the average annual amplitude of solar radiation SA (langleys / day)

If the user enters a -99.0 for any of the above variables, a default value will be used in the program that is representative of the Florida District where the project is located.

Card 13 (1X, F9.0, F10.2)

The analysis period (PERIOD) in years and the percent growth rate in traffic (GRATEP) are entered on this card.

An example input file to the overlay program is shown in Figure F1. In addition, Figures F2 and F3 show example output files. Figure F2 is a sample listing of FLOVECHO.INP, which is a file created by OVERLAY that contains an echo of the input data provided by the user. Figure F3 is a samaple listing of FLOVLAY5.OUT which presents a tabular summary of the predicted fatigue cracking, rutting, serviceability loss, and growth in reflection cracking with time during the analysis period. It is noted that predictions of reflection crack growth are only made for the overlaid pavement. At the time of the first overlay, it is assumed that reflection cracks have propagated all the way to the top of the existing asphalt concrete layer. Thus, the initial crack height is equal to the thickness of the existing surface layer minus any required depth of milling. In addition, the schedule of overlays, the overlay thicknesses, and the estimated quantities of level-up are included in the output.

```
 3 0.20     0
 4
 2
 2
 650000.      4.00
 30000.     10.00
 6000.
 3.50      0.00      0.00
 2.50    600.00      0.60
 6.50     80.00   3000.00    100.00      4.00
 2   3000.00     80.00      6.50      5.00
 2.00      6.00      0.00      3.80    1
68.00      7.00     21.00    152.60
20.      3.35
```

Figure F1. Sample Input File for the OVERLAY Program.

ECHO OF INPUT DATA FOR FLORIDA OVERLAY PROGRAM.

District: 3
Section length (miles): .20
Damage Equations are used to evaluate pavement performance.

Number of lanes: 4
Highway code is: 2 (1=Divided/2=Undivided)

LAYER	MODULUS (psi)	THICKNESS (inches)	TRAFFIC DIRECTION
1	650000.	4.00	1
2	30000.	10.00	1
3	6000.	.00	1

Current conditions for traffic direction 1
Current PSI: 3.50

Failure criteria for traffic direction 1
Terminal Serviceability Index: 2.50
Failure Level of Cracking (sq. ft./1000 sq. ft.): 600.00
Failure Rut Depth (inches): .60

Input data for existing asphalt concrete layer:

Traffic Direction: 1
Asphalt content of existing asphalt layer (%): 6.50
Penetration at 77 degrees F (0.1mm): 80.00
Viscosity at 140 degrees F (poises): 3000.
Ring and ball softening point (degrees F): 100.00
Percent air voids of existing asphalt layer: 4.00

Input data for asphalt concrete overlay.

Viscosity at 140 degrees F (poises): 3000.
Penetration at 77 degrees F (0.1mm): 80.00
Asphalt content (percent): 6.50
Air voids content (percent): 5.00

Minimum overlay thickness (inches): 2.00
Maximum overlay thickness (inches): 6.00
Depth of milling (inches): 0.00
PSI immediately after an overlay: 3.80
Damage level at which to design the overlay: 1

Environmental data:

Service temperature (deg. F): 68.00
Minimum monthly air temperature (deg. F): 7.00
24-hour temperature drop (deg. F): 21.00
Amplitude of solar radiation (langleys/day): 152.60

Analysis period (years): 20.00
Growth rate of 18-kip ESALs (percent): 3.35

Figure F2. Sample Listing of FLOVECHO.INP.

```
*******************************************************************************
PROJECT IDENTIFICATION SHEET
*******************************************************************************

    District: 3

    County: LEON

    State Project Number: 12345-6789

    Work Program Item Number:     100.

    Federal Aid Project Number: 123-ABC

    Beginning milepost:      .0000

    Ending milepost:      .2000

    Highway: IH-10

    Date: OCTOBER 9, 1990
```

Figure F3. Sample Listing of FLOVLAY5.OUT

****
SCENARIO: 1 TRAFFIC DIRECTION: 1
****

Year	Cumulative 18-kip ESALs	PSI	Fatigue Cracking (sq ft per 1000 sq ft)	Rutting (inches)	Crack Height (inches)	Overlay Thickness (inches)	Level-up (cubic yds)
.00	0.	3.50	.000	.00			
1.00	36525.	2.79	324.287	.47			
2.00	75607.	2.69	454.592	.51			
3.00	117424.	2.63	529.751	.53			
4.00	162169.	2.59	581.372	.55			
4.44	183254.	2.57	600.000	.56			
4.44	183254.	3.80	.000	.00	4.00	5.23	38.76
5.00	210046.	3.76	.000	.13	4.02		
6.00	261274.	3.74	.000	.18	4.04		
7.00	316088.	3.72	.000	.20	4.07		
8.00	374739.	3.71	.000	.21	4.10		
9.00	437496.	3.70	.000	.22	4.13		
10.00	504646.	3.69	.001	.23	4.16		
11.00	576496.	3.68	.004	.24	4.20		
12.00	653376.	3.67	.010	.25	4.24		
13.00	735637.	3.67	.023	.26	4.29		
14.00	823657.	3.66	.048	.26	4.34		
15.00	917838.	3.65	.090	.27	4.39		
16.00	1018612.	3.65	.156	.27	4.45		
17.00	1126439.	3.64	.254	.28	4.52		
18.00	1241815.	3.64	.395	.28	4.60		
19.00	1365268.	3.63	.589	.29	4.69		
20.00	1497361.	3.62	.849	.29	4.80		
21.00	1638702.	3.62	1.186	.29	4.92		
22.00	1789936.	3.61	1.616	.30	5.07		
23.00	1951757.	3.61	2.151	.30	5.25		
24.00	2124905.	3.60	2.808	.31	5.48		
25.00	2310173.	3.59	3.601	.31	5.76		
26.00	2508410.	3.59	4.546	.31	6.13		
27.00	2720524.	3.58	5.659	.32	6.62		
28.00	2947486.	3.58	6.955	.32	7.27		
29.00	3190335.	3.57	8.450	.32	8.15		
29.99	3446545.	3.56	10.134	.33	9.23		

Figure F3. Sample Listing of FLOVLAY5.OUT (Continued)

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SCENARIO: 2 TRAFFIC DIRECTION: 1

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Year	Cumulative 18-kip ESALs	PSI	Fatigue Cracking (sq ft per 1000 sq ft)	Rutting (inches)	Crack Height (inches)	Overlay Thickness (inches)	Level-up (cubic yds)
.00	0.	3.50	.000	.00			
1.00	54788.	2.73	397.259	.49			
2.00	113410.	2.63	523.996	.53			
3.00	176136.	2.58	594.021	.56			
3.11	183254.	2.57	600.000	.56			
3.11	183254.	3.80	.000	.00	4.00	5.35	38.76
4.00	243253.	3.75	.000	.16	4.02		
5.00	315069.	3.72	.000	.19	4.05		
6.00	391911.	3.71	.000	.21	4.08		
7.00	474132.	3.70	.000	.22	4.11		
8.00	562109.	3.69	.001	.24	4.14		
9.00	656244.	3.68	.004	.24	4.17		
10.00	756969.	3.67	.012	.25	4.21		
11.00	864744.	3.66	.028	.26	4.25		
12.00	980064.	3.66	.060	.27	4.29		
13.00	1103456.	3.65	.114	.27	4.34		
14.00	1235485.	3.64	.199	.28	4.39		
15.00	1376757.	3.64	.326	.28	4.45		
16.00	1527917.	3.63	.507	.29	4.52		
17.00	1689659.	3.62	.755	.29	4.59		
18.00	1862723.	3.62	1.083	.29	4.68		
19.00	2047901.	3.61	1.507	.30	4.77		
20.00	2246042.	3.61	2.042	.30	4.88		
21.00	2458053.	3.60	2.704	.31	5.01		
22.00	2684904.	3.59	3.510	.31	5.17		
23.00	2927635.	3.59	4.475	.31	5.36		
24.00	3187357.	3.58	5.615	.32	5.59		
25.00	3465260.	3.58	6.948	.32	5.88		
26.00	3762615.	3.57	8.489	.32	6.25		
27.00	4080786.	3.56	10.252	.33	6.74		
28.00	4421229.	3.56	12.254	.33	7.38		
29.00	4785503.	3.55	14.508	.33	8.23		
30.00	5174646.	3.54	17.022	.34	9.28		

Figure F3. Sample Listing of FLOVLAY5.OUT (Continued)