TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle

Modification and Implementation of the
Rigid Pavement Design System

5. Report Date

January 1975

6. Performing Organization Code

7. Author(s)

Robert F. Carmichael and B. F. McCullough

8. Performing Organization Report No.

Research Report 123-26

9. Performing Organization Name and Address

Center for Highway Research
The University of Texas at Austin
Austin, Texas 78712

10. Work Unit No.

11. Contract or Grant No.

Research Study 1-8-69-123

12. Sponsoring Agency Name and Address

Texas Highway Department
Planning & Research Division
P. O. Box 5051
Austin, Texas 78763

13. Type of Report and Period Covered

Interim

14. Sponsoring Agency Code

15. Supplementary Notes

Work done in cooperation with the Federal Highway Administration, Department of Transportation.
Research Study Title: A System Analysis of Pavement Design and Research Implementation

16. Abstract

The rigid pavement design system computer program, RPS-3, designed as a result of this study is the third in a series of such systems developed under the project entitled "A System Analysis of Pavement Design and Research Implementation" (Ref 1), sponsored by the Texas Highway Department in cooperation with the Federal Highway Administration.

The rigid pavement design system programs, designated RPS, have been developed in conjunction with flexible pavement design system programs, designated FPS, under the auspices of the Center for Highway Research at The University of Texas at Austin and the Texas Transportation Institute at Texas A&M University and the Texas Highway Department. At the time this particular study was begun, two versions of RPS and thirteen versions of FPS had been developed by the Project. The development of the two previous programs of the rigid pavement design system is documented in Refs 2 and 3.

A revised rigid pavement system computer program, RPS-3, is presented and documented. Details of model changes are explained. The most significant changes were made in the traffic delay cost subroutine, TDS. The program's modularization is outlined and each new subroutine is flow charted and explained. A discussion of RPS-3 implementation is also included, to serve as a guideline for the program's future use. The report also contains a complete set of sample RPS-3 problems and a complete input guide as well as a discussion of the most common errors encountered in the use of RPS-3. This report is also intended to be a User's Manual for the RPS-3 program.

17. Key Words

rigid pavement, design system, user errors, modularization, implementation, traffic delay cost, flow chart

18. Distribution Statement

19. Security Classif. (of this report)

Unclassified

20. Security Classif. (of this page)

Unclassified

21. No. of Pages

242

22. Price

MODIFICATION AND IMPLEMENTATION OF THE RIGID PAVEMENT DESIGN SYSTEM

by

Robert F. Carmichael
B. F. McCullough

Research Report 123-26

A System Analysis of Pavement Design
and Research Implementation

Research Project 1-8-69-123

conducted

in cooperation with the
U. S. Department of Transportation
Federal Highway Administration

by the

Texas Highway Department

Texas Transportation Institute
Texas A&M University

Center for Highway Research
The University of Texas at Austin

January 1975

PREFACE

This report provides a detailed documentation of the rigid pavement design system program RPS-3. The information includes discussions on modularization of the program, model changes made to the program, and a trial implementation study made using the program. The report also contains an analysis of common user errors, a complete program flow chart, a program listing, and a program input guide. This report is in essence a User's Manual with instructions to the designer.

December 1974

Robert F. Carmichael
B. F. McCullough

LIST OF REPORTS

Report No. 123-1, "A Systems Approach Applied to Pavement Design and Research," by W. Ronald Hudson, B. Frank McCullough, F. H. Scrivner, and James L. Brown, describes a long-range comprehensive research program to develop a pavement systems analysis and presents a working systems model for the design of flexible pavements. March 1970

Report No. 123-2, "A Recommended Texas Highway Department Pavement Design System User's Manual," by James L. Brown, Larry J. Buttler, and Hugo E. Orellana, is a manual of instructions to Texas Highway Department personnel for obtaining and processing data for flexible pavement design system. March 1970

Report No. 123-3, "Characterization of the Swelling Clay Parameter Used in the Pavement Design System," by Arthur W. Witt, III, and B. Frank McCullough, describes the results of a study of the swelling clays parameter used in pavement design system. August 1970

Report No. 123-4, "Developing A Pavement Feedback Data System," by R. C. G. Haas, describes the initial planning and development of a pavement feedback data system. February 1971

Report No. 123-5, "A Systems Analysis of Rigid Pavement Design," by Ramesh K. Kher, W. R. Hudson, and B. F. McCullough, describes the development of a working systems model for the design of rigid pavements. November 1970

Report No. 123-6, "Calculation of the Elastic Moduli of a Two Layer Pavement System from Measured Surface Deflections," by F. H. Scrivner, C. H. Michalak, and William M. Moore, describes a computer program which will serve as a subsystem of a future Flexible Pavement System founded on linear elastic theory. March 1971

Report No. 123-6A, "Calculation of the Elastic Moduli of a Two Layer Pavement System from Measured Surface Deflections, Part II," by Frank H. Scrivner, Chester H. Michalak, and William M. Moore, is a supplement to Report No. 123-6 and describes the effect of a change in the specified location of one of the deflection points. December 1971

Report No. 123-7, "Annual Report on Important 1970-71 Pavement Research Needs," by B. Frank McCullough, James L. Brown, W. Ronald Hudson, and F. H. Scrivner, describes a list of priority research items based on findings from use of the pavement design system. April 1971

Report No. 123-8, "A Sensitivity Analysis of Flexible Pavement System FPS2," by Ramesh K. Kher, B. Frank McCullough, and W. Ronald Hudson, describes the overall importance of this system, the relative importance of the variables of the system and recommendations for efficient use of the computer program. August 1971

Report No. 123-9, "Skid Resistance Considerations in the Flexible Pavement Design System," by David C. Steitle and B. Frank McCullough, describes skid resistance consideration in the Flexible Pavement System based on the testing of aggregates in the laboratory to predict field performance and presents a nomograph for the field engineer to use to eliminate aggregates which would not provide adequate skid resistance performance. April 1972

Report No. 123-10, "Flexible Pavement System - Second Generation, Incorporating Fatigue and Stochastic Concepts," by Surendra Prakash Jain, B. Frank McCullough and W. Ronald Hudson, describes the development of new structural design models for the design of flexible pavement which will replace the empirical relationship used at present in flexible pavement systems to simulate the transformation between the input variables and performance of a pavement. January 1972

Report No. 123-11, "Flexible Pavement System Computer Program Documentation," by Dale L. Schafer, provides documentation and an easily updated documentation system for the computer program FPS-9. April 1972

Report No. 123-12, "A Pavement Feedback Data System," by Oren G. Strom, W. Ronald Hudson, and James L. Brown, defines a data system to acquire, store, and analyze performance feedback data from in-service flexible pavements. May 1972

Report No. 123-13, "Benefit Analysis for Pavement Design System," by Frank McFarland, presents a method for relating motorist's costs to the pavement serviceability index and a discussion of several different methods of economic analysis. April 1972

Report No. 123-14, "Prediction of Low-Temperature and Thermal-Fatigue Cracking in Flexible Pavements," by Mohamed Y. Shahin and B. Frank McCullough, describes a design system for predicting temperature cracking in asphalt concrete surfaces. August 1972

Report No. 123-15, "FPS-11 Flexible Pavement System Computer Program Documentation," by Hugo E. Orellana, gives the documentation of the computer program FPS-11, October 1972. April 1972

Report No. 123-16, "Fatigue and Stress Analysis Concepts for Modifying the Rigid Pavement Design System," by Piti Yimprasett and B. Frank McCullough, describes the fatigue of concrete and stress analyses of rigid pavement. October 1972

Report No. 123-17, "The Optimization of a Flexible Pavement System Using Linear Elasticity," by Danny Y. Lu, Chia Shun Shih, and Frank H. Scrivner, describes the integration of the current Flexible Pavement System computer program and Shell Oil Company's program BISTRO, for elastic layered systems, with special emphasis on economy of computation and evaluation of structural feasibility of materials. March 1973

Report No. 123-18, "Probabilistic Design Concepts Applied to Flexible Pavement System Design," by Michael I. Darter and W. Ronald Hudson, describes the development and implementation of the probabilistic design approach and its incorporation into the Texas flexible pavement design system for new construction and asphalt concrete overlay. May 1973

Report No. 123-19, "The Use of Condition Surveys, Profile Studies, and Maintenance Studies in Relating Pavement Distress to Pavement Performance," by Robert P. Smith and B. Frank McCullough, introduces the area of relating pavement distress to pavement performance, presents work accomplished in this area and gives recommendations for future research, August 1973.

Report No. 123-20, "Implementation of a Complex Research Development of Flexible Pavement Design System into Texas Highway Department Design Operations," by Larry Buttler and Hugo Orellana, describes the step by step process used in incorporating the implementation research into the actual working operation.

Report No. 123-21, "Rigid Pavement Design System, Input Guide for Program RPS2 in Use by the Texas Highway Department," by Robert F. Carmichael and B. Frank McCullough, describes the input of variables necessary to use in the Texas rigid pavement design system program RPS2, May 1974.

Report No. 123-22, "An Integrated Pavement Design Processor," by Danny Y. Lu, Chia Shun Shih, Frank H. Scrivner and Robert L. Lytton, provides a comprehensive decision framework with a capacity to drive different pavement design programs at the user's command through interactive queries between the computer and the design engineer.

Report No. 123-23, "Stochastic Design Parameters and Lack-of-Fit of Performance Model in the Texas Flexible Pavement Design System," by Malvin Holsen and W. Ronald Hudson, describes a study of initial serviceability index of flexible pavements and a method for quantifying lack-of-fit of the performance equation.

Report No. 123-24, "The Effect of Varying the Modulus and Thickness of Asphaltic Concrete Surfacing Materials," by Danny Y. Lu and Frank H. Scrivner, investigates the effect on the principal stresses and strains in asphaltic concrete resulting from varying the thickness and modulus of that material when used as the surfacing of a typical flexible pavement (being prepared for submission).

Report No. 123-25, "Elastic Layer Theory as a Model of Displacements Measured Within Flexible Pavement Structures Loaded by the Dynaflect," by Frank H. Scrivner et al, describes the fitting of an empirical model to the study of 136 (TTI) data (being prepared for submission).

Report No. 123-26, "Modification and Implementation of the Rigid Pavement Design System," by Robert F. Carmichael and B. Frank McCullough, describes the new RPS-3 version of the rigid pavement design system in detail and complete with an input guide, documentation, and listing.

ABSTRACT

The rigid pavement design system computer program, RPS-3, designed as a result of this study is the third in a series of such systems developed under the project entitled "A System Analysis of Pavement Design and Research Implementation" (Ref 1), sponsored by the Texas Highway Department in cooperation with the Federal Highway Administration.

The rigid pavement design system programs, designated RPS, have been developed in conjunction with flexible pavement design system programs, designated FPS, under the auspices of the Center for Highway Research at The University of Texas at Austin and the Texas Transportation Institute at Texas A&M University and the Texas Highway Department. At the time this particular study was begun, two versions of RPS and thirteen versions of FPS had been developed by the Project. The development of the two previous programs of the rigid pavement design system is documented in Refs 2 and 3.

A revised rigid pavement system computer program, RPS-3, is presented and documented. Details of model changes are explained. The most significant changes were made in the traffic delay cost subroutine, TDS. The program's modularization is outlined and each new subroutine is flow charted and explained. A discussion of RPS-3 implementation is also included, to serve as a guideline for the program's future use. The report also contains a complete set of sample RPS-3 problems and a complete input guide as well as a discussion of the most common errors encountered in the use of RPS-3. This report is also intended to be a User's Manual for the RPS-3 program.

KEY WORDS: rigid pavement, design system, user errors, modularization, implementation, traffic delay cost, flow chart.

SUMMARY

A newly documented version of the rigid pavement design system, computer program RPS-3, has been developed from the basic RPS-2 program. The new program has been changed in a number of ways to make the program more implementable. The program has been modularized into a total of eleven subroutines, each having a distinctive function which has been documented. This modularization makes RPS-3 the most easily changeable version of the rigid pavement design system. Future modifications will be much easier because of the modularization. A complete documentation of how to run the new program, the input guide, was prepared to allow easier program usage by highway design engineers. An attempt has been made to answer any questions a user may have concerning a particular variable or its input value.

Finally, a study was undertaken to evaluate how effective and accurate the RPS-2 program was in actual use. The results of this verification study led to the formation of certain recommendations concerning future implementation. The results are applicable to RPS-3 because both programs utilize the same design models.

IMPLEMENTATION STATEMENT

This report describes the implementation process for the new rigid pavement design system, RPS-3. As such, it is an implementation of part of Project 123 findings. Making the RPS-3 program usable by highway design engineers was the major goal of the study. RPS-3 has many qualities which will make it easier to implement than RPS-2, but it retains the major design procedures of the rigid pavement system developed in RPS-2. A trial implementation of the RPS-2 program has been tried in Houston, Texas, and the results are report in Chapter 5. The results of the study in Houston, Texas, are applicable to RPS-3 also because both programs use the same design equations.

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CHAPTER 1. INTRODUCTION

The rigid pavement design system computer program, RPS-3, designed as a result of this study is the third in a series of such systems developed under a project entitled, "A System Analysis of Pavement Design and Research Implementation," (Ref 1) sponsored by the Texas Highway Department in cooperation with the Federal Highway Administration.

The rigid pavement design system programs, designated RPS, have been developed in conjunction with flexible pavement design system programs, designated FPS, under the auspices of the Center for Highway Research at The University of Texas at Austin and The Texas Transportation Institute at Texas A&M University and with support of the Texas Highway Department. At the time this particular study was begun, two versions of RPS and thirteen versions of FPS had been developed by the Project. The development of the two previous programs of the rigid pavement design system is documented in Refs 2 and 3.

The rigid pavement design system computer program RPS-2 is currently used as a state-of-the-art design tool to design concrete pavements. This study was initiated to modify the RPS-2 program so that it would be better suited for implementation into more district offices of the Texas Highway Department. The new version developed by this study is named RPS-3. All the modifications made to the program are documented. The major differences of this program and previous programs are its new models, its modularization into numerous separate models which are interfaced to form the complete system, and its complete documentation with the user in mind. The system was developed because there was a need for a more implementable rigid pavement design system for highway engineers.

OBJECTIVES

The goal of this study was to develop from the original two RPS versions, a new modularized program which could be easily modified and implemented into field use. To accomplish this main goal, several objectives were established:

(1) Program RPS-3 was modularized into a number of subroutines to make future modifications easier.

(2) Program RPS-3 was completely documented with input guide, sample problems, and error analysis so that design engineers in the field could use it easily.

(3) A trial use of RPS-3 was completed as an indication of the rigid pavement design system's usefulness.

(4) The traffic delay cost (TDC) model was modified to take into account the traffic delay costs associated with concrete overlay curing.

Basically, this study provides the Texas Highway Department with a more implementable version of a rigid pavement design program.

SCOPE

The scope of this report is to document the development of RPS-3. This program is a modification of the rigid pavement design system and has many new implementation features. The program has been made easier to use from a technical standpoint and it has been refined to provide better solutions.

The needed program changes ascertained from previous experience with the program and the approach taken to accomplish these modifications are outlined in Chapter 2.

The results of specific model studies are described in detail and the changes made in the models used in RPS-2 are given in Chapter 3.

The method used to modularize the program to facilitate future changes and updating is explained in Chapter 4.

The process for implementing the program into field use for the Texas Highway Department is described in Chapter 5.

The general aspects of the new RPS-3 user's guide and a discussion of the most common user errors which occur with RPS-3 usage are included in Chapter 6.

An illustration of the use of the program with a complete sample problem is provided in Chapter 7.

The findings of this study and suggestions for future research in the rigid pavement design system are summarized in Chapter 8.

A flow chart of the new RPS-3 program, sample outputs, a user's manual for operation of the RPS-3 program, and a program listing are provided in the appendices in order to provide a complete documentation of the program.

CHAPTER 2. SYSTEM DEVELOPMENT AND APPROACH

This chapter presents a summary of the rigid pavement design system needs, determined by reviewing the experience gained with RPS-2 and consulting with the Design Division of the Texas Highway Department. Those changes which were accomplished in the development of RPS-3 are outlined. The models which were modified and the types of implementation features which were included in the new program version are discussed. Finally, a section discussing model improvements, program modularizations, and implementation is presented on the general approach used to develop RPS-3.

SYSTEM DEVELOPMENT

The initial step of RPS-3 development was to determine the overall needs of the rigid pavement design system and to plan a course of action which would achieve those needs, as shown in Fig 2.1. First, RPS-2 was completely documented and an Input Guide (Ref 3) was developed. Next, a proposed basic format for RPS-3 was developed with design inputs from Texas Transportation Institute, the Center for Highway Research, and the Texas Highway Department. This report deals only with the developement of RPS-3.

The final three steps of the rigid pavement design system to be accomplished by later research are (1) a comparison of RPS-3 and FPS, (2) the development of RPS-4 and a modified RPS more closely resembling each other, and (3) a final covergence of the RPS design model with the FPS design model to form a total pavement design system capable of designing and optimizing solutions for both flexible and rigid types of pavements.

Table 2.1 lists the specific work items which were to be accomplished during each step of RPS development.

The five steps of development shown in Fig 2.1 constitute the major steps in the rigid pavement design system evolution. The first step of development, accomplished before this study was undertaken, was to document the RPS-2 program.

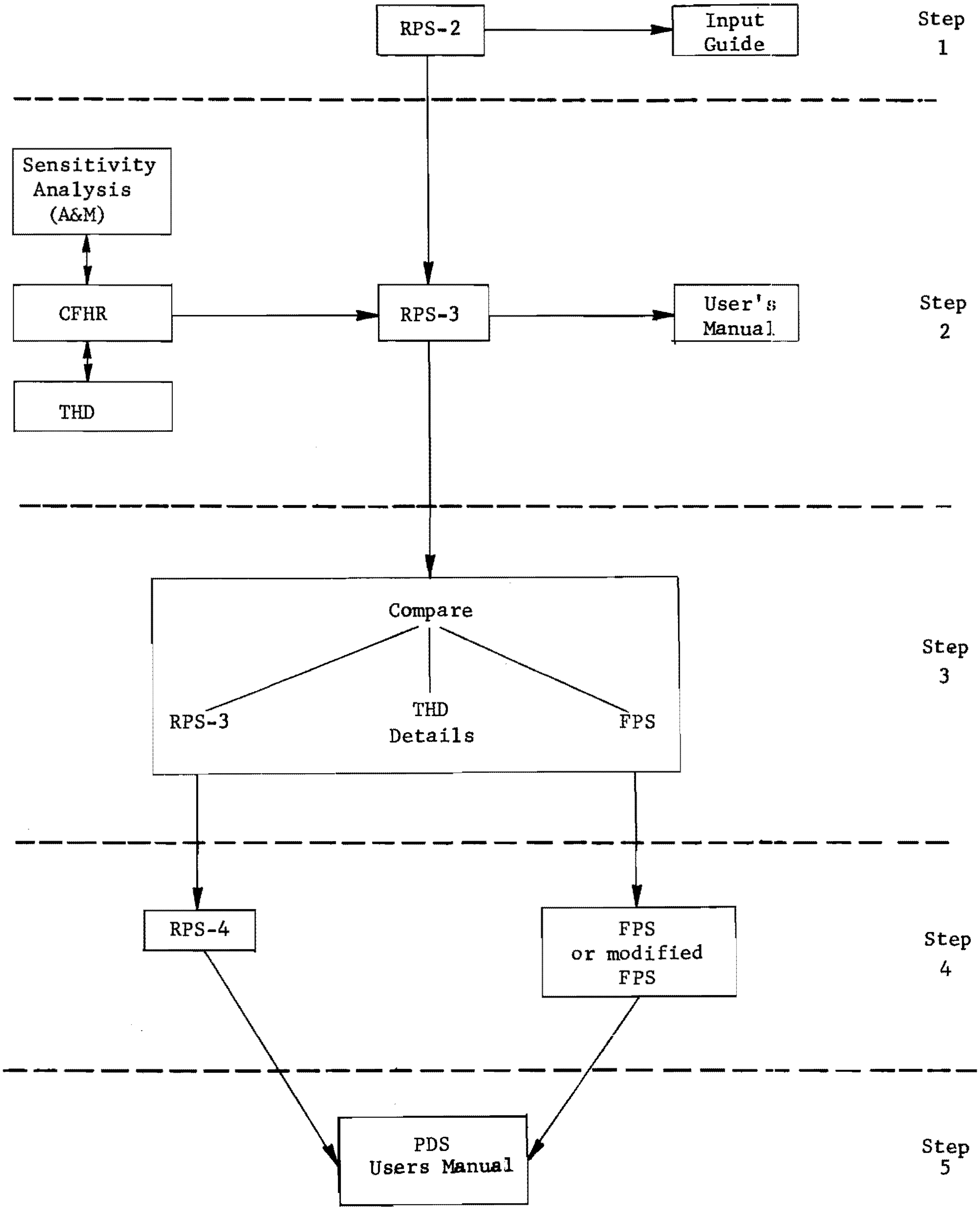


Fig 2.1. RPS development within the pavement design system structure.

TABLE 2.1. SYSTEM DEVELOPMENT WORK ITEMS

Step 1. RPS-2 Documentation and Input Guide

Step 2. RPS-3 Development

  1. Add units to the program output and clarify variable titles for the user.
  2. Modify the asphaltic-concrete stiffness input (if sensitive).
  3. Add a user's cost associated PCC overlay (curing time).
  4. Check seal coat routine (PDD overlay).
  5. Reduce number of variables in the regression equations.
  6. Modularize program with comment cards and subroutines.
  7. Fix insensitive variables.
  8. Study maintenance subroutine.
  9. Characterize concrete flexural strength.

Step 3. RPS-3 and FPS Comparison

  1. Justify differences in models between RPS and FPS if any.
  2. Make output suitable for use with typical THD design detail (example steel design).
  3. Change input format to conform with FPS input format.

Step 4. New Program Development

  1. Create RPS-4 version
  2. Create FPS-x version

Step 5. System Convergence

  1. Create total pavement design system
  2. Implement the new system

This report describes the accomplishments of Step 2 in the evolution process, the development of the RPS-3 design program. Three additional steps of development are envisioned. Step 3 will be a comparison of RPS-3 with FPS, the flexible pavement design system, and with Texas Highway Department design details. Step 4 will consist of the development of an RPS-4 version to incorporate the findings of Step 3 comparisons. Step 5, the final level of development, will be the merging of the RPS-4 version with the FPS version to form the total pavement design system.

OUTLINE OF RPS CHANGES ACCOMPLISHED

Two basic types of changes were made in RPS-2 to create RPS-3 and implement the RPS-3 program: (1) model changes, and (2) changes related to implementation. A general discussion of the modifications contained in each one of these areas is included in this section. Although these accomplishments do not encompass all the work items in Step 2, they are significant enough to create a new RPS program.

Better Models

Three of the models in the RPS-2 program were studied to ascertain how well they functioned. It was felt that if a model did not adequately simulate a real field situation, then that model would be detrimental to implementation attempts. Thus, if a particular model was not properly modeling a field situation, it was modified. In one extreme case, the seal coat model was deleted completely. The three models studied were seal coat scheduling, traffic delay cost calculation, and maintenance costs. The study and final evaluation of each of these models is discussed in Chapter 3.

Implementation Features

Many modifications were made to RPS-2 in an attempt to make the program more implementable into the THD pavement design process. Major changes included a complete reworking of input and output formats, the changing of insensitive parameters, and a modularization of the program. The input and output formats were redone because the RPS-2 version did not print the input data units and also printed some inputs under misleading titles. It was decided that the output format should appear like the input guide for the program with complete titles and units for all variables. Insensitive parameter in RPS-2 were given specific values in the program so that the designer would not have to input variables. A discussion of these variables is given in Chapter 3. Finally, a modularization of the program was accomplished to facilitate implementation. The RPS-2 computer program contained a main program of approximately 1950 cards and three subroutines of 50 cards each. Modularization of these 1950 cards into numerous subroutines was necessary for implementation, so that at any future time, if better models were developed for concrete pavement behavior, they could be added easily into the rigid pavement design system. The program was broken down into eight new subroutines in addition to the three already existing subroutines. These new subroutines and the entire modularization process are discussed in detail in Chapter 5.

One of the most valuable results of the study is the documented user's guide which accompanies the RPS-3 version. This user's guide was developed from the input guide for RPS-2.

SUMMARY OF OVERALL APPROACH TAKEN TO MEET NEEDS

Once the needs for a revised RPS program were assessed, an approach was developed to modify, modularize, and implement the new program. The approach was developed to work in stages. Initially, inadequate models were to be improved and the implementation features of units, titles, and fixed variables were to be added to the program. Once these new models and additions were tested and validated, a modularization of RPS-2 began. The modularization consisted of flow charting RPS-2 and determining where compatible pieces could be broken out and subroutines developed. Once a new subroutine was developed, a battery of runs was made to test the accuracy of the program. The RPS-2 program was used as a base from which to judge the runs. If a subroutine did not function properly, it was corrected before the initiation of the next subroutine. Once the final version had been modularized, it was deemed ready for implementation. A trial implementation was performed using the RPS-2 program. The findings of the implementation trial are relative to RPS-3 because the program's basic design techniques are the same as those used in RPS-2. A complete flow charting of the program and the user's manual for the program were then developed, so as to make RPS-3 a completely separate entity in the continuing process of the rigid pavement design system development.

CHAPTER 3. IMPROVEMENT OF MODELS

In general, this chapter discusses the changes made to various models of RPS-2 so that the models will be more useful in RPS-3. Specific model changes include (1) an improvement of the traffic delay cost model, (2) a deletion of the seal coat model, (3) a modification of the input and output models, (4) a study and recommendations on the future of the maintenance model, (5) deletion of the traffic load groups model, and (6) the collection of concrete flexural strength data for the performance model. The chapter initially presents the positive additive steps in RPS-3 development and concludes with a discussion of those design models removed.

CORRECTION OF TRAFFIC DELAY COST MODEL

The current rigid pavement design system program, RPS-2, includes a model for determining the traffic delay cost for an overlay of an existing pavement. The model was adopted for use in the RPS-2 program from Research Report 32-11 (Ref 4), which explains the model. The model will determine traffic delay costs associated with both asphaltic concrete (AC) and portland cement concrete (PCC) overlays. However, since the model predicts the traffic delay costs only during the overlay laydown and neglects the traffic delay costs during the curing period of PCC overlays, a study was conducted to determine how traffic delay costs varied during different periods of the day. A study of average daily traffic (ADT) hourly distribution was required and was undertaken to determine the distribution of traffic during a typical 24-hour period. The study included an analysis of both urban and rural sections. This section provides the study results and the documentation of the new subroutine, TDC3, models development for RPS-3.

Objectives and Approach of ADT Variation Study

The main objective of this study item was to determine ADT distribution with respect to hour of the day so that valid costs for curing PCC overlays could be calculated. The study goal was to characterize the ADT distribution for both rural and urban sections of Texas highways for use in the modified rigid pavement computer program RPS-3 to determine the traffic delay costs during curing associated with PCC overlays. The designer using the program would adequately predict traffic delay costs for all cases.

Data Collection

The data used for the study were taken from "1973 Annual Report of Permanent Automatic Traffic Recorders," published by the Planning and Research Division of the Texas Highway Department (Ref 5). The recorders listed in the report operated for twelve full months during 1973 and were located on both rural and urban highway systems. The average daily traffic volumes reported are for both directions of traffic at the recorder location. The report characterizes the ADT at each location with respect to day of the week; high hour for the year, month, and season; and hour of the day. A percent variation of the average annual daily traffic from year to year of each recorder's operation is also presented.

Section Selection. Sections to be used in the study of the automatic traffic recorder (ATR) data were selected at random from the map of sections provided in the Annual Report. Eight rural and seven urban section identification numbers were selected and then each section was checked to determine whether it fit the urban or rural classification used for the study. A rural section was to be a two-lane section of either Farm-to-Market or State Highway designation. The rural sections were randomly chosen in areas distinctly removed from major population areas. Table 3.1 lists the rural sections, the ATR identification numbers, the section locations within the state, and the number of lanes.

An urban section was adopted for use on the basis of its location within a major urban area and the fact that it was of Interstate or U. S. designation. All sections studied were to have a total of four or more lanes. The pertinent data are given in Table 3.2. The Fort Worth section, S041, has only two lanes,

TABLE 3.1. RURAL AUTOMATIC TRAFFIC RECORDERS STATIONS

Station	Highway	Number of Lanes (Both Directions)	Route
S058	FM 386	2	Mason - Katemcy
S015	US 289	2	Lampasas - Burnet
S097	US 281	2	Falfurrias - Encino
S043	US 59	2	Linden - Jefferson
S044	US 82	2	Henrietta - Ringgold
S119	US 16	2	Fredericksburg - Kerrville
S068	SH 163	2	Ozona - Juno
S060	SH 207	2	Claude - Silverton

TABLE 3.2. URBAN AUTOMATIC TRAFFIC RECORDERS STATIONS

Station	Highway	Number of Lanes (Both Directions)	City
S158	US 87	4	Amarillo
S041	US 81	2	Fort Worth
S148	IH 35E	8	Dallas
S165	IH 10	10	Houston
S140	US 59	8	Houston
S156	IH 610	8	Houston
S123	IH 10	4	El Paso
S108	IH 35	4	San Antonio
S132	IH 35	6	Austin

but the use of this section did not adversely affect the study outcome. Two additional sections reported in Table 3.2 and located in the medium sized urban areas of Amarillo and El Paso were included as a check of traffic in such areas.

ADT Calculations. To determine the fluctuation of the ADT with respect to hour of the day, Tuesday, was chosen upon which to base comparisons. In most cases, the ADT for Tuesday was approximately one hundred percent of the average annual daily traffic (AADT) for the section. After all sections' data were compared on a Tuesday basis, the ADT for three sections was determined for either Friday or Saturday to determine if Tuesday was representative of all the days of the week.

Specifically, the ADT was determined for each section, using the annual average hourly values presented for each section in the Annual Report. Each hourly volume was divided by the total annual average daily volume to determine what percentage of the total each hour contributed. Figure 3.1 shows a sample of the data from the Annual Report. The section shown had an annual average daily traffic volume of 145,058 vehicles for Tuesday, which was 108.3 percent of the average annual daily traffic. The average hourly volume of 9,818 vehicles for 8:00 - 9:00 a.m. was divided by 145,058 to determine, for example, that, for this hour, 6.77 percent of the ADT passed through the section. After this calculation was made for each hour, the data were plotted. The same data were later cumulated for the preparation of cumulative frequency distribution graphs. These same calculations were made for all sections under study.

Data Comparison

The initial approach was to independently compare the rural sections and the urban sections. Each set of ADT distribution curves compared very favorably within their own classification set and, therefore, cross comparisons were made between urban and rural sections. These comparisons were simply made by visual comparison of the superimposed cumulative distribution. The Kolmogorov-Smirnov test was used to statistically compare the cumulative frequency distribution.

Distribution Plots. The distribution plots of ADT with respect to hour of the day were unique for both the urban and rural sets. The urban

ANNUAL AVERAGE HOURLY VOLUMES
BY DAYS OF WEEK--1973

STATION — S140

LOCATION- US 59, 0.6 MI W OF IH 610, S. HOUSTON

HOUR	SUN.	MON.	TUE.	WED.	THR.	FRI.	SAT.
12-AM	2,869	1,418	1,706	1,855	2,005	2,061	3,077
01-02	2,225	850	855	933	1,048	1,066	1,942
02-03	1,660	582	623	691	759	795	1,485
03-04	858	390	405	436	471	487	851
04-05	531	437	463	466	488	514	684
05-06	534	1,210	1,217	1,200	1,227	1,226	1,016
06-07	1,003	6,289	6,551	6,475	6,430	6,410	2,390
07-08	1,440	10,453	11,018	10,977	10,978	10,982	3,784
08-09	2,087	9,392	9,818	9,834	9,773	9,911	5,126
09-10	3,298	7,497	8,002	7,855	7,924	8,077	6,274
10-11	4,092	7,320	7,435	7,417	7,477	7,850	7,160
11-12	4,571	8,023	8,074	8,082	8,181	8,666	8,051
12-PM	5,896	8,493	8,335	8,279	8,398	8,999	8,498
01-02	5,741	8,347	8,324	8,255	8,340	9,019	8,190
02-03	5,778	8,497	8,432	8,427	8,537	9,387	7,969
03-04	5,877	9,687	9,670	9,632	9,729	10,369	7,948
04-05	5,961	10,818	10,881	10,931	10,850	10,860	7,564
05-06	6,042	10,346	10,595	10,617	10,533	10,367	7,181
06-07	5,736	8,884	9,071	9,101	9,166	9,442	6,928
07-08	5,079	6,789	6,967	7,169	7,365	7,912	6,260
08-09	4,176	5,281	5,241	5,436	5,588	6,049	4,917
09-10	3,824	4,653	4,899	5,061	5,180	5,328	4,451
10-11	3,226	3,473	3,815	3,987	3,986	4,402	3,914
11-12	2,319	2,500	2,661	2,867	2,950	3,824	3,653
TOTAL	84,823	141,629	145,058	145,983	147,383	154,003	119,313
PERCENT OF AADT	63.3	105.7	108.3	109.0	110.0	115.0	89.1

ANNUAL AVERAGE WEEK TOTAL -- 938,192

AADT -- 133,948

Fig 3. 1. Sample Average Traffic Recorder data.

distributions all showed bi-modal peaks and one minor peak of ADT flow. The major peaks were between seven and nine a.m. in the morning (representing the morning rush hour work traffic) and four to six p.m. (representing evening rush hour work traffic). Most of the distributions also showed minor peaks at the noon hour. Figure 3.2 shows a characteristic urban distribution for Section S165 in Houston, Texas.

The rural distribution curves had characteristically one main peak. The peak was spread out into one main broad increase of ADT between the hours of seven a.m. and five p.m. Figure 3.3 shows a characteristic rural distribution of the "one peak" type, for Section S044 in Henrietta, Texas.

Cumulative Plots. An easy visual comparison could not be made between urban and rural sections because of the characteristic differences in the normal distribution plots. Therefore, cumulative frequency distribution plots were made for all the sections. These plots, when compared visually, were similar in all cases; rural sections to rural sections, urban sections to urban sections, and urban sections to rural sections. The cumulative frequency distribution of Section S119 in Fredericksburg, Texas, shown in Fig 3.4, is representative of the rural sections studied, while the cumulative frequency distribution of Section S041 in Fort Worth, Texas, shown in Fig 3.5, is characteristic of the urban sections studied. Comparison of the cumulative frequency distribution plots visually indicated that one generalized curve representing both rural and urban conditions could be made for the entire state, instead of separate curves for rural and urban as initially anticipated. However, it was felt that before such an action was taken, a statistical comparison to reinforce the visual conclusion should be undertaken.

Kolmogorov-Smirnov Comparison

The Kolmogorov-Smirnov test is a statistical comparison of any two cumulative frequency distributions. The maximum difference (D max) between the two sets of data is compared with a specified constant. If $A(x)$ and $B(x)$ are two cumulative functions, then the Smirnov test rejects the hypothesis that the $A(x)$ distribution is equal to the $B(x)$ distribution if the D max exceeds the specified constant:

$$P[A(x) \text{ dif } B(x)] \tag{3.1}$$

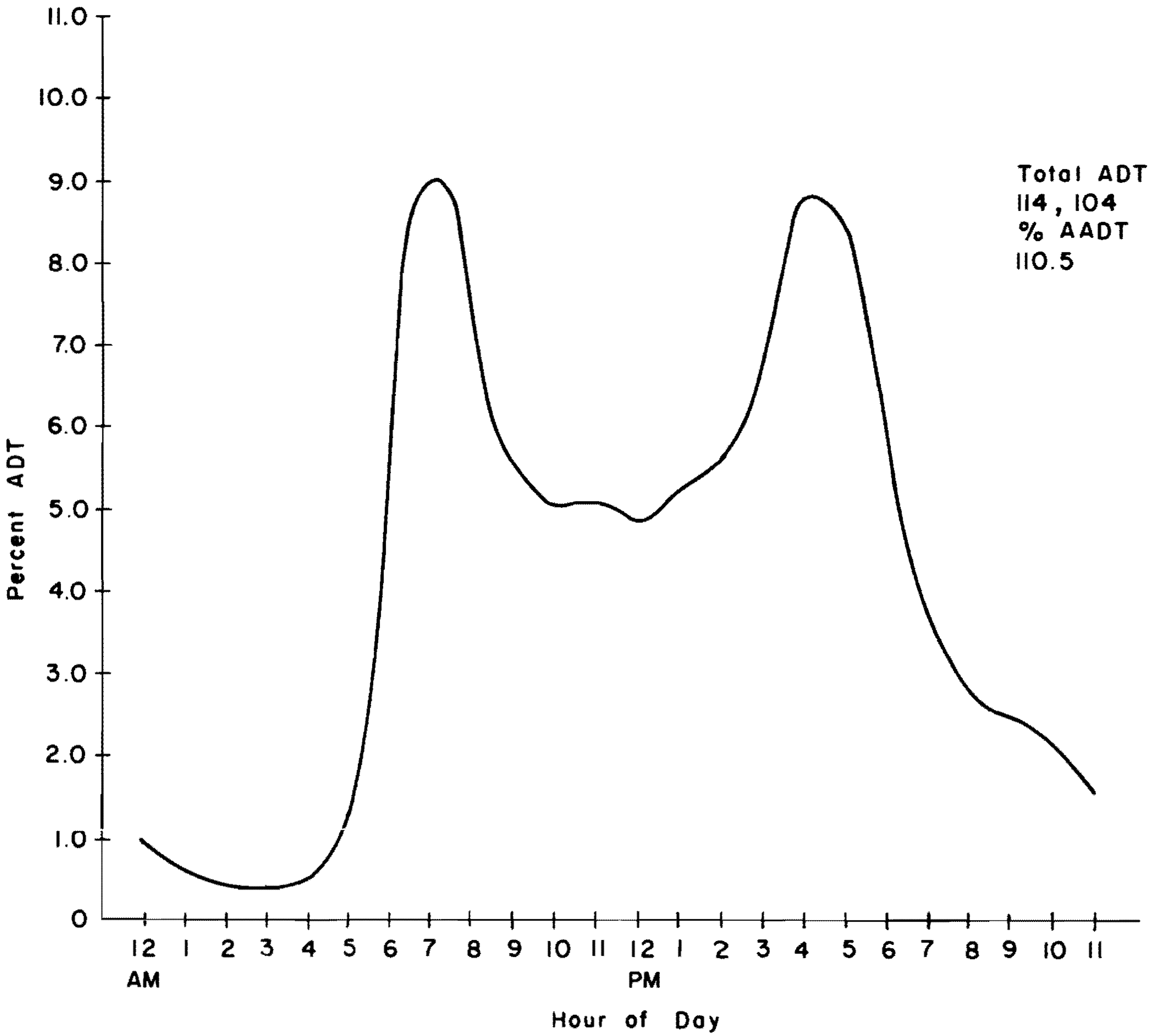


Fig 3.2. ADT distribution per hour for urban Section S165, Houston, Texas.

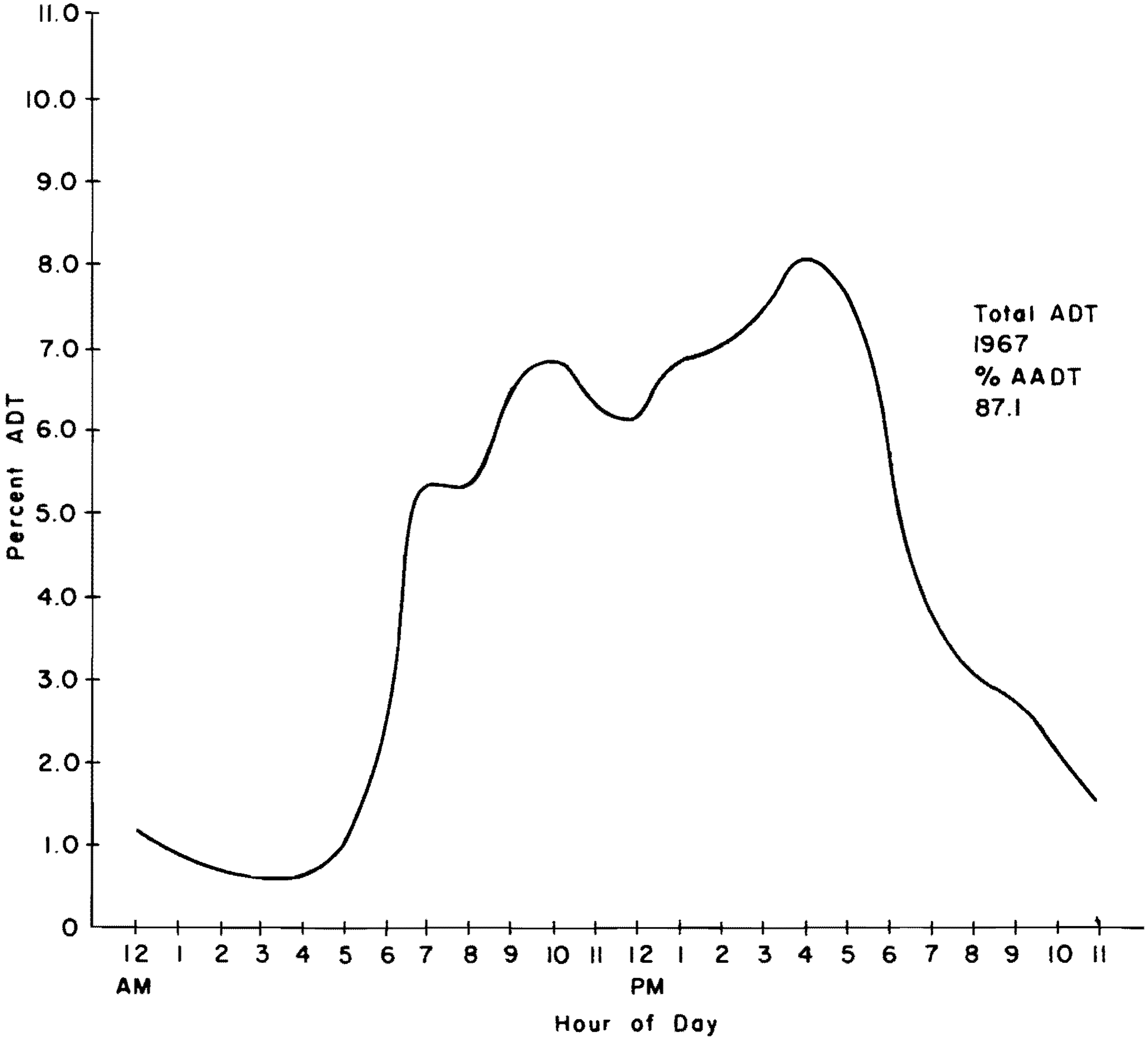


Fig 3.3. ADT distribution per hour for rural Section So44, Henrietta, Texas.

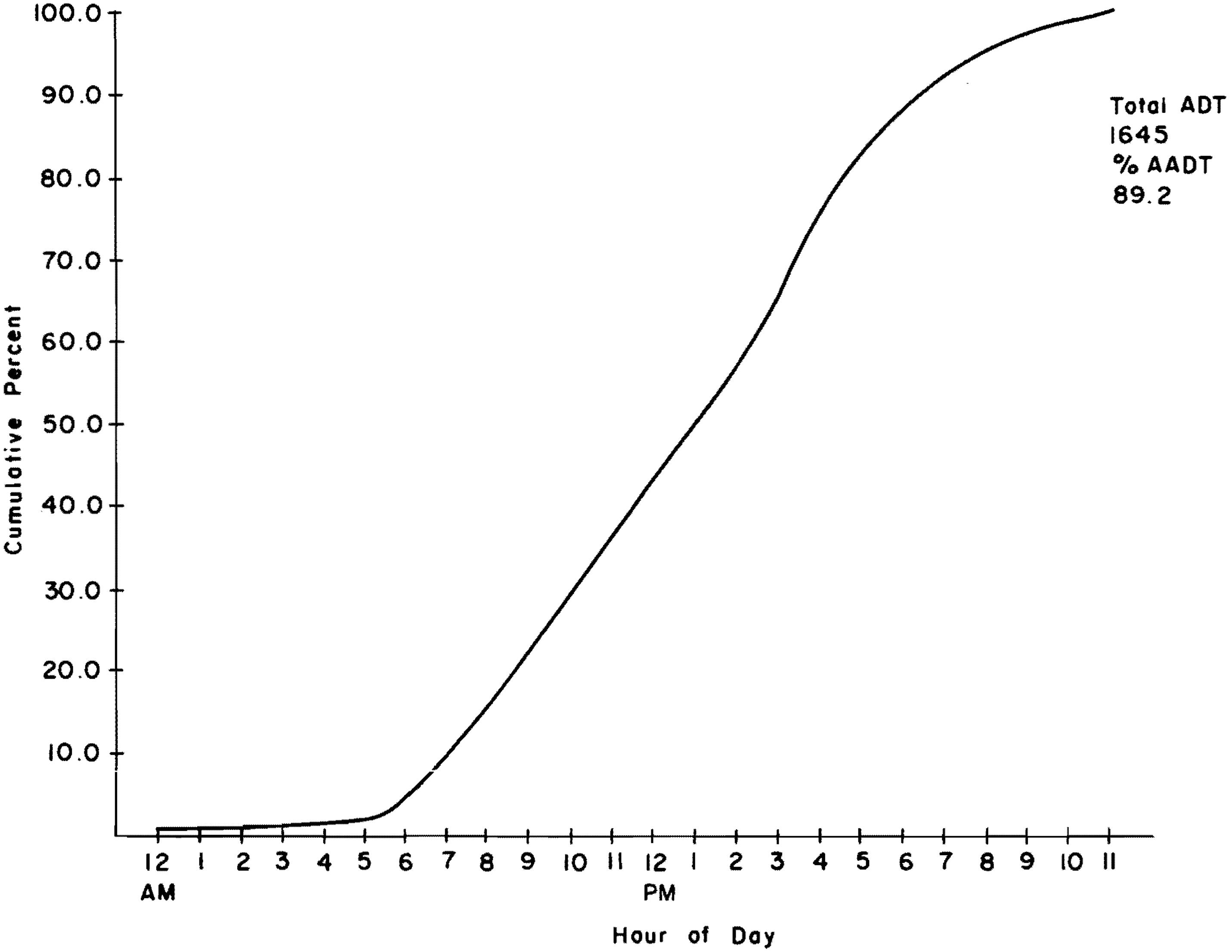


Fig 3.4. Cumulative distribution for rural Section S119, Fredericksburg, Texas.

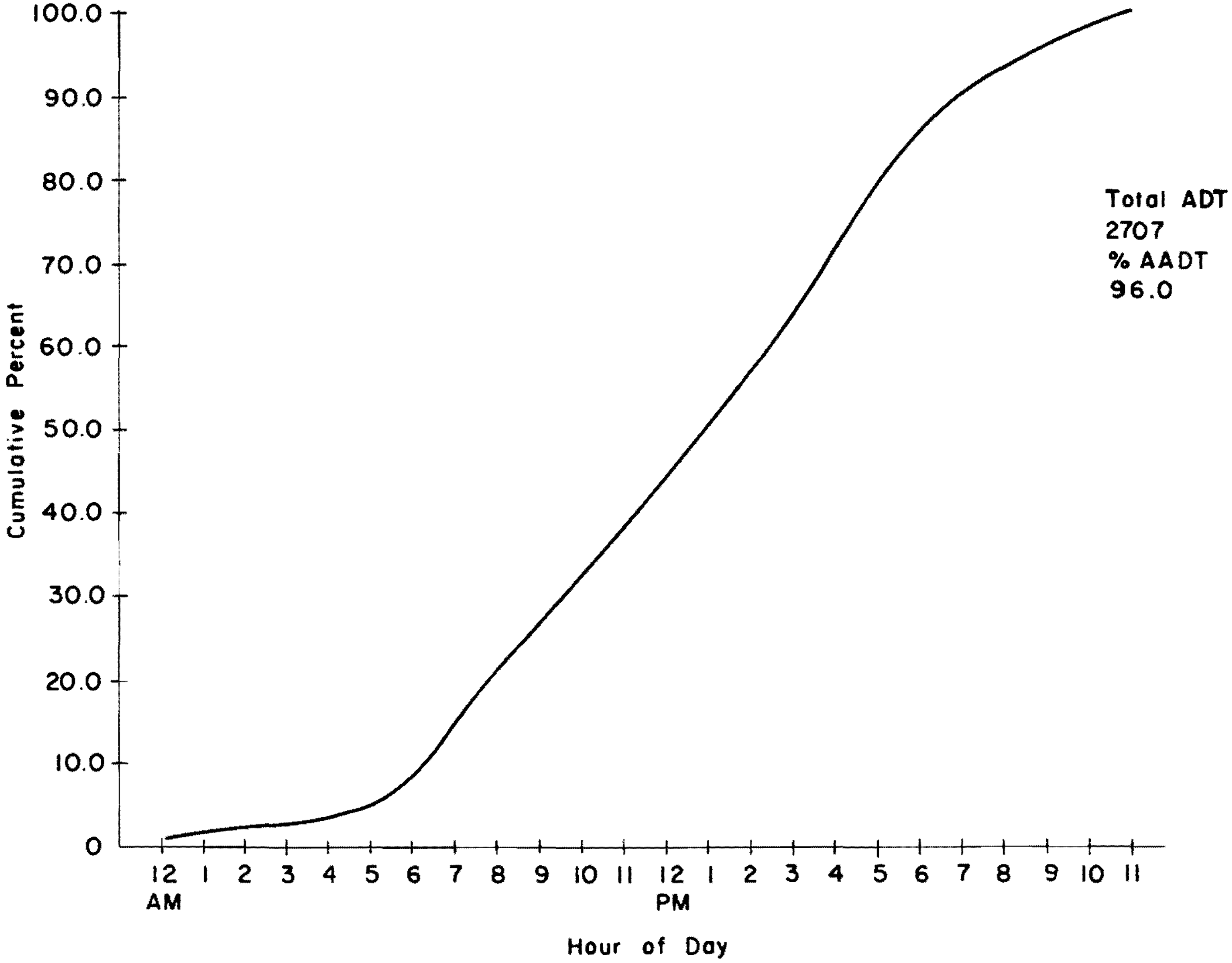


Fig 3.5 . . Cumulative distribution for urban Section S041, Fort Worth, Texas.

The constant is determined by establishing an allowable Type-1 error. A Type-1 error is the error of saying something is true when it is not.

For all comparisons of this study, the constant α was determined at a 0.05 level so that

$$P\{D > C\} = \propto = 0.05 \tag{3.2}$$

This means that the test was made with the acceptance that five percent of the time when the curves compared favorably, they might actually be different. This level is a practical level at which to test because it is a reasonably difficult level to meet. The constant calculated for the test is a function of the sample sizes. The equation

$$C = 1.36\sqrt{\frac{m + n}{mn}} \tag{3.3}$$

was used, with m and n being the respective sample sizes of the two distributions. Both m and n are equal to 24; C is equal to 0.39. All the comparisons made for the study passed the test by a wide margin of safety. Table 3.3 shows a summary of all six comparison sets made for the study. The first set of comparisons is for rural sections compared to rural sections. The largest difference was 0.0957, which is well below the 0.39 level. The second set of comparisons is for the urban sections compared to one another. The largest difference for these comparisons was 0.0599. The third set of comparisons is between rural and urban sections. The largest D max was 0.100. The final two sets of comparisons are for medium urban areas and day of the week. The medium urban area comparisons indicated that there were no significant differences in these sections when they were compared to the urban and rural sections. The day of the week comparisons were made to check the choice of Tuesday as a study day. The results shown in Table 3.3 indicate the choice was reasonable and did not bias the data.

The Kolmogorov-Smirnov tests reinforced the assumptions made from visual examinations of the plots, i.e., statistically, the traffic patterns for all sections had the same basic pattern of fluctuation.

TABLE 3.3. KOLMOGOROV-SMIRNOV COMPARISONS

Comparisons	D max	Hour of D max
Rural		
Ozona - Claude	0.0421	3 - 4 p.m.
Mason - Fredericksburg	0.0603	4 - 5 p.m.
Falfurrias - Lampasas	0.0548	7 - 8 a.m.
Linden - Henrietta	0.0957	6 - 7 a.m,
Ozona - Mason	0.0511	3 - 4 p.m.
Claude - Fredericksburg	0.0492	4 - 5 p.m.
Falfurrias - Linden	0.0223	5 - 6 p.m.
Lampasas - Henrietta	0.0246	8 - 9 a.m.
Falfurrias - Claude	0.0824	5 - 6 a.m.
Linden - Mason	0.0913	6 - 7 a.m.
Urban		
Dallas - Fort Worth	0.0358	6 - 7 p.m.
Houston (140) - San Antonio	0.0251	7 - 8 a.m.
Houston (165) - Austin	0.0599	10 - 11 a.m.
Dallas - Houston (140)	0.0346	7 - 8 a.m.
Fort Worth - San Antonio	0.0217	8 - 9 p.m.
Houston (165) - Houston (140)	0.0423	5 - 6 p.m.
Austin - San Antonio	0.0405	4 - 5 p.m.
Rural to Urban		
Ozona - Dallas	0.0686	7 - 8 a.m.
Mason - Fort Worth	0.0990	7 - 8 a.m.
Linden - San Antonio	0.0397	8 - 9 a.m.
Claude - Houston (14)	0.0704	8 - 9 a.m.
Falfurrias - Austin	0.0600	3 - 4 p.m,
Henrietta - Houston (165)	0.0820	8 - 9 a.m.
Lampasas - Dallas	0.1000	8 - 9 a.m.
Fredericksburg - Fort Worth	0.0810	7 - 8 a.m.

TABLE 3.3. (Continued)

Comparisons	D max	Hour of D max
Medium Urban Area		
El Paso - Amarillo	0.0360	8 - 9 a.m.
Amarillo - Lampasas	0.0380	7 - 8 a.m.
Day of Week		
Linden Tuesday - Linden Saturday	0.0313	5 - 6 p.m.
Houston (165) Tuesday - Houston (165) Saturday	0.0550	6 - 7 p.m.
Houston (140) Tuesday - Houston (140) Friday	0.0346	7 - 8 a.m.
Ozona Tuesday - Linden Saturday	0.0590	5 - 6 a.m. 8 - 9 a.m.
Dallas Tuesday - Houston (165) Saturday	0.0476	3 - 4 p.m.

Conclusions

The major conclusion drawn from the study of ADT distribution was that one cumulative curve could be developed for both urban and rural conditions. The curve which was derived from the data for every section is shown in Fig 3.6. The points on this average cumulative frequency distribution are the average of the percents from Tuesday data for all sections. For calculation of traffic delay cost, this information was input into computer program RPS-3 as a cumulative curve which was used with the ADT input to estimate vehicles per hour (VPH) for any hour of the day desired.

The initial use of the information was primarily for the calculation of the traffic delay costs associated with the curing of concrete overlays. However, one additional benefit gained from this study information is the capability for the designer to specify when an overlay should occur in order to minimize traffic delay costs. For example, if the designer knows his district asphaltic overlays are constructed only during off peak traffic periods such as 10 a.m. to 3 p.m., then calculations may be made of the cost of such an overlay, using the results of this study.

Summary and Implementation

The generalized curve is very useful to the rigid pavement design system program and its existence in the system will provide more flexibility in the designer's decision making process. Since the designer can correctly determine the cost difference associated with overlay type and input the times of the day for overlaying, the program more realistically represents the actual field situation and thus is more useful in implementation.

Computer Mechanics of Model

This section explains the new TDC3 subroutine placed in RPS-3. The new subroutine uses the information gained in the study of ADT distribution, which has been described.

The computer model developed to calculate traffic delay costs using the data obtained from the study of ADT distribution is explained in this section. The model is a modified version of the traffic delay cost model outlined in Report 32-11 (Ref 4) and used in RPS-2. All the equations and cost tables of

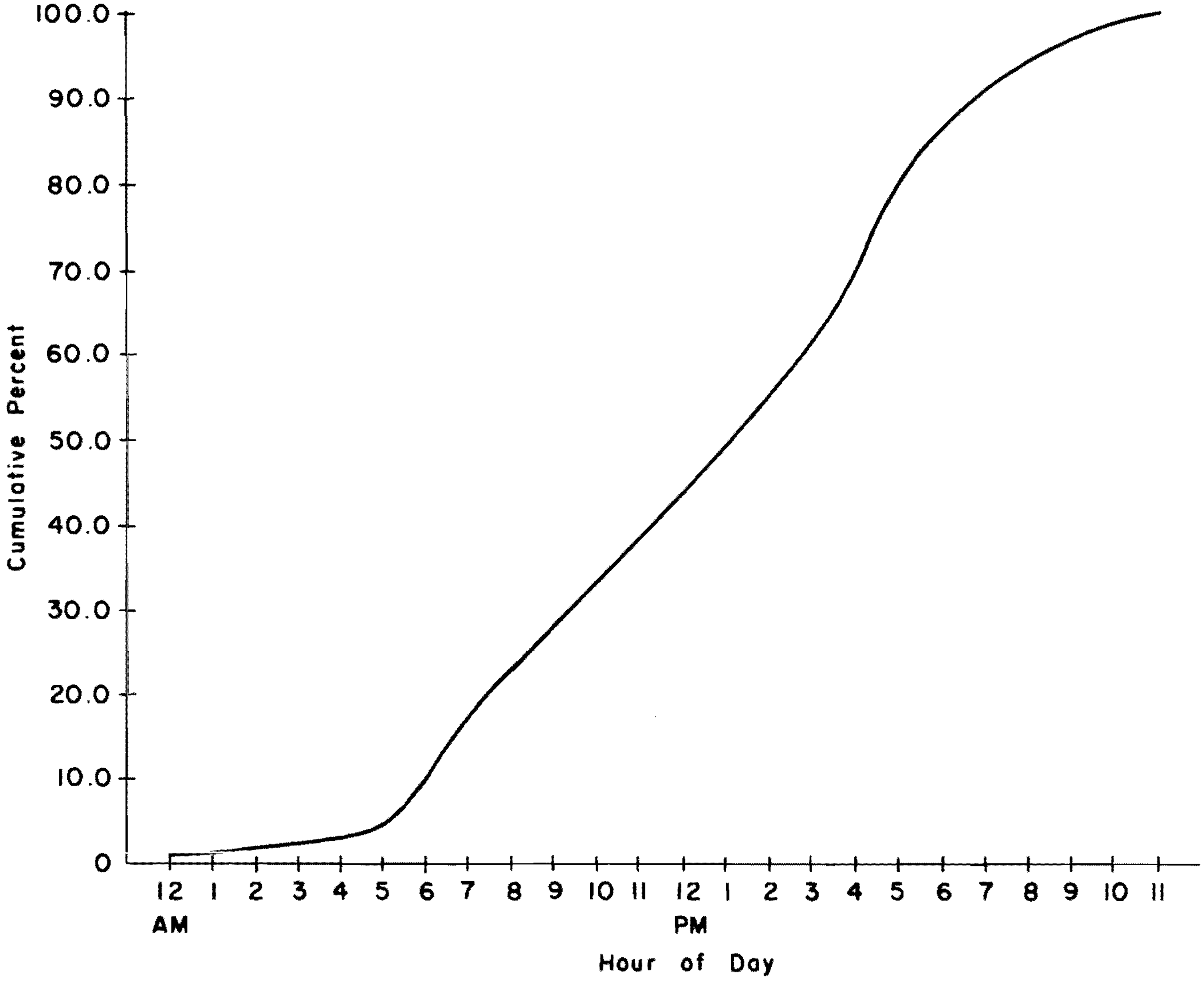


Fig 3.6. Average cumulative percent for all Texas Sections.

the model in RPS-2 were retained, but the ADT distribution data were added. The old model calculated a delay cost per hour depending upon the location (urban or rural), the traffic (an average ADT arriving per hour at the overlay site), and the model used for overlaying and its associated variables.

The new model utilizes the concept of summing all of the delay costs hour by hour for a day of construction. If the pavement is overlaid with a concrete overlay, the model determines delay costs on an hour by hour basis for a day of curing. The respective sums are multiplied by the number of days in each category.

Initially, the new traffic delay model subroutine TDC3 determines the hours to construct the overlay (HTCCO for concrete overlay or HTCAO for asphalt overlay), using the production rate variable hours per square yard, HPSY, and the total number of square yards to be overlaid, SYARDS, in the equation

$$\text{HTCAO} = \text{HTCCO} = \text{HPSY (SYARDS)} \qquad (3.4)$$

The difference between asphalt and concrete is established by the program, but the variable HPSY comes into the subroutine in the correct form. The subroutine then calculates the number of days necessary to construct the overlay by dividing the hours to construct by the number of hours worked per day. The subroutine next calls subroutine VPHCAL to calculate the vehicles per hour using the ADT at the time of the overlay and the data from the ADT distribution study. Subroutine VPHCAL calculates the vehicles per hour (VPH) for all the hours of the day, using the average daily traffic at the time of the overlay multiplied by the percentage curve developed from the ADT distribution study. VPHCAL merely provides the 24 values of VPH to TDC3 so that costs may be determined. The TDC3 subroutine now begins several iterations to determine costs. All the cost calculations are the same as those in Report 32-11 (Ref 4) with the exception of the reduced delay costs associated with the concrete curing.

The subroutine first loops through the cost equations between the hour of the day when overlay construction begins and the hour of the day when overlay construction ends. These loops sum the delay cost per hour as a function of the vehicles per hour using the following equation (Ref 4):

$$\mathrm{DCH} = \mathrm{VPH}*(\mathrm{PO1}*(\mathrm{CO1} + \mathrm{CO2} + \mathrm{CO3}) + (1.-\mathrm{PO1})*(\mathrm{CO3} + \mathrm{CO4}) + \mathrm{PO2}*\mathrm{CO5}) + \mathrm{VPH}*(\mathrm{PN1}*(\mathrm{CN1} + \mathrm{CN2} + \mathrm{CN3}) + (1.-\mathrm{PN1})*(\mathrm{CN3} + \mathrm{CH4}) + \mathrm{PN2}*\mathrm{CN5}) \tag{3.5}$$

This delay cost is saved as variable DCH1, and the program resets the last hour of construction as the initial hour and 12 midnight as the final hour. It then loops through the costs again using these two indices and a reduced equation for costs, which will be explained later:

$$\mathrm{DCH} = \mathrm{VPH} * (\mathrm{CO3} + \mathrm{CO4} + \mathrm{CN3} + \mathrm{CN4}) \tag{3.6}$$

These costs are saved as variable DCH2, and the program resets the initial hour to one a.m. and the final hour to the hour before the construction begins. Using these indices the program again uses the reduced costs and stores the results in variable DCH3.

For its final loop, the program loops from 1 to 24 to determine the costs for an entire day of curing. It uses the reduced cost equation and saves the results as variable DCH4.

The program does the last three looping sequences only if the road is to be overlaid with concrete. If the roadway is to be overlaid with asphalt, the program merely saves the delay cost for the construction period.

In the case of concrete, the total delay cost for the overlay job is equal to

$$\mathrm{DCHTOT} = (\mathrm{DCH1} + \mathrm{DCH2} + \mathrm{DCH3})(\mathrm{NDAYCO}) + (\mathrm{DCH4})(\mathrm{NDAYCU}) \tag{3.7}$$

This is the delay cost per day for a construction day times the number of days taken to construct the overlay, plus the delay cost per day for a curing day times the number of days of curing. The DCHTOT is converted to a unit of square yards by dividing by the number of square yards overlaid, in the equation

$$\mathrm{DCSYCO} = \frac{\mathrm{DCHTOT}}{\mathrm{SYARDS}} \tag{3.8}$$

This delay cost per square yard is converted to a traffic delay cost per square yard on a present worth basis by the equation

$$\text{TDCSY} = \frac{\text{DCSYCO}}{\left(1 + \frac{\text{RINT}}{100}\right)^{\text{PLAT}}} \tag{3.9}$$

where RINT is the percent value of money and PLAT is the time at which the overlay occurs.

If the overlay is asphalt, the results are similarly calculated, except that the loop is activated only during the construction period; therefore,

$$\text{DCSYAO} = \frac{(\text{NDAYCO} * \text{DCHT})}{\text{SYARDS}} \tag{3.10}$$

where NDAYCA is the number of days to construction the asphalt overlay, and DCHT is the total sum of hourly delay costs for the hours of construction.

The total traffic delay cost is calculated identically as for concrete:

$$\text{TDCSY} = \frac{\text{DCSYAO}}{\left(1.0 + \frac{\text{RINT}}{100}\right)^{\text{PLAT}}} \tag{3.11}$$

The subroutine flow chart in Appendix 1 clearly shows the looping process. This feature was necessary because military time had to be used to express the hours of the day.

The reduced equation for delay costs assumes that there will be no delay due to men and equipment interference, CO5, no delay costs associated with the cost of one cycle of stopping from and returning to the approach speed per vehicle, CO1, and no costs associated with the cost of idling and time loss per vehicle, CO2. These costs were considered to be insignificant during periods of the day when there is no construction and for curing days. The reduced cost consists only of costs of driving at reduced speed per vehicle, CO3, and the cost of one cycle of slowing to the through speed and returning to the approach speed per vehicle, CO4.

Asphalt overlays use the full costs, but only during the time of construction, since asphalt overlays do not delay traffic significantly unless the overlay is actually taking place.

MODIFICATION OF INPUT AND OUTPUT MODELS

A complete review and modification of the input and output formats of RPS-2 was undertaken as part of the development of RPS-3. The new formats are contained in Subroutine INPUT, which prints out the input data, and Subroutine OUTPUT which prints out the final designs.

The reason for this modification was that many of the variables which the designer was asked to input had no units specified. As the input guide for RPS-2, Research Report 123-21 (Ref 3), was being written, all the units were added to the input and output formats. In addition, many of the variables titles were altered to simplify and clarify their meaning.

These modifications have made the input guide and the computer output comparable to one another. This is a beneficial characteristic because the designer may check inputs for accuracy.

MAINTENANCE SUBROUTINE STUDY

The RPS-2 program and the flexible pavement system, FPS, program calculated maintenance costs with two different models. The FPS program was developed to design flexible pavements using the same system concepts as the RPS system. Because the FPS system had already been implemented and was in use by highway design engineers, it was decided that possibly the new RPS-3 version could use the FPS maintenance model. Since designers were familiar with the model already, it was felt that this modification might prove beneficial to RPS-3.

With these problems in mind, work was begun to evaluate both models and to make necessary changes. The RPS model, Subroutine MANCE, was obtained from NCHRP Report 42 (Ref 6). The FPS model, Subroutine PWRM, was the result of a joint study by Texas Transportation Institute and the Texas Highway Department (Ref 4).

The valuation for the current work was done with the idea of choosing the model which would require easily obtained inputs from the design engineers.

Because costs obtained from both the models seemed unreliable, the initial step of the study was to completely check the logic and programing of both models. This study indicated that both models are correctly programed for solution of their respective theories.

Even though the models are based on different premises, it was decided that the next step of study would be to compare models on similar sets of data. The MANCE model is based upon environment, traffic, and road characteristic maintenance costs, while the PWRM model is based on the historical trend of maintenance costs per square yard per year. Table 3.4 shows the major input of both models, their similarities, and their differences. Test runs made with the input data given equal values in each model indicated that the MANCE subroutine predicted higher costs than the PWRM subroutine. The fact that MANCE took into account the environmental factor, number of days freezing, the average daily traffic growth rates, and an indicator as to the type of road, seemed to give MANCE an advantage over PWRM for realistic use in RPS. Both the RPS model, MANCE, and the FPS model, PWRM, predict maintenance costs which have not been verified with current field data. The model inputs in both cases are not easily attainable and designers are forced to use only estimated inputs.

One recommendation as to how future studies should be conducted became apparent. A study of maintenance records should be made to determine what types of maintenance data are available to highway engineers, and then a realistic comparison of MANCE and PWRM may be made using the actual maintenance records for asphalt and concrete roadways.

The decision was made to leave the MANCE model intact in RPS-3 because it seems to contain more variables relating to the real situation, especially the index dividing urban and rural costs. The Input Guide in Appendix 3 gives an explanation of the composite costs and gives the values suggested by NCHRP-42 for use. It should be remembered that these values may be low today because of the increased cost of materials and labor.

TABLE 3.4. MAINTENANCE MODELS

Model MANCE Variables	Model PWRM Variables	Description
PLF	T	Time from year "0" to the loss of serviceability
PLP	TPRIM	Initial value of analysis year
AP	CL	Analysis period (years)
RINT	RATE	Rate of interest
DFTY	-	Number days freezing during the year
CLW	-	Composite labor wage
CERR	-	Composite equipment rental rate
CMAT	-	Composite material cost
-	C1	Routine maintenance cost/square yard during first year
-	C2	Incremental increase in routine maintenance cost
ADTGR	-	Average daily traffic growth rate
ITYPE	-	Type of facility urban or rural

CONCRETE FLEXURAL STRENGTH STUDY

The rigid pavement system program RPS-2 requires the designer to input the following concrete material variables:

(1) number of days at which concrete strength was measured (7 or 28 day),
(2) concrete flexural strength, mean value,
(3) percent coefficient of variation of the flexural strength of the concrete,
(4) modulus of elasticity of the concrete, E ,
(5) standard deviation of the E value,
(6) unit weight of the concrete,
(7) type of strength test (center point or third point loading) and
(8) tensile strength of the concrete.

It is a definite problem for the design engineer to obtain input values for the material properties used by RPS. Another important point to be made is that even though some data are available to the design engineer on these properties as related to a specific "cement factor," this information is highly dependent on the source and type of aggregate used in the mix. With this problem in mind, a study was undertaken to classify the concrete flexural strength.

The concrete flexural strength and modulus of elasticity are important and primary variables in the RPS design system and also are values closely correlated with a concrete aggregate source and a cement factor per cubic yard.

Data Collection

Construction files were taken from Texas Department construction records for concrete pavement jobs in 10 districts. The following information was obtained in each district on all jobs of at least one million dollars constructed within the last eight years:

(1) aggregate source,
(2) cement factor (cement per cubic yard),
(3) flexural strength values from beam specimens,
(4) water-cement ratios,
(5) slump, and
(6) percent air entrainment.

A total of 36 jobs were studied. From these 36 jobs, a total of 88 different design mixes were identified. For example, a job in a particular location might retain the same aggregate source and cement factor, but during the construction the water-cement ratio may be varied, thereby producing two different mix designs for one job. Slump and percent air entrainment data were obtained for 64 of the designs. The data were kept separated by district throughout the analysis.

Data Analysis

The next step of the study was an attempt to determine if a relation could be drawn between flexural strength and the other variables. A multiple regression analysis was run to determine if flexural strength could be predicted as a function of type of aggregate, cement factor, water-cement ratio, percent air, and slump. However, the data obtained indicated that only 43 percent of the variation in flexural strength could be determined to be a function of these variables. Since this information was not good enough to use in design practice, it was decided that a district average and coefficient of variation should be compiled to give guideline values for use in RPS-3. The total overall average strength was 686.6 psi for the 3009 flexural beam breaks recorded. Table 3.5 shows the district averages and coefficients of variation by district, with each districts' projects totaled.

Project 183 conducted at the Center for Highway Research provided the observations from the indirect tensile testing of 867 cores from 10 PCC projects (Ref 7). Marshall and Kennedy determined that the coefficient of variation of the tensile strength for each project was approximately 20 percent for individual specimens. The reason this coefficient of variation is greater than the ones resulting from the flexural beam break data is that the indirect tensile specimens were randomly selected from pavement sections. The flexural beam break data is more biased data, because groups of beams are made under more tightly controlled conditions at intervals during the construction.

Project 183 also provided the following information on the values of elastic modulus and percent coefficient of variation for Portland cement concrete (Ref 7).

"(1) Mean modulus values for all specimens varied from 3.36×10^6 psi to 5.02×10^6 psi and averaged 3.99×10^6 psi, and (2) The within

TABLE 3 5. CONCRETE FLEXURAL STRENGTH STUDY RESULTS

District	Number of Projects	Number of Beam Break Data	Mean Flexural Strength (PSI)	Standard Deviation (PSI)	Percent Coefficient of Variation in Flexural Strength
2	4	412	677	58.9	8.7
3	4	490	730	61.1	8.4
4	1	160	587	42.2	7.2
9	4	258	705	71.2	10.1
11	1	65	501	58.8	11.7
12	7	360	703	87.1	12.4
13	5	587	746	84.5	11.3
15	1	56	675	43.6	6.5
18	6	411	666	98.4	14.8
24	4	208	566	66.8	11.8

> project coefficient of variation ranged from 22 percent to 42 percent and averaged 34 percent for individual specimens."

Conclusions

In the multiple regression study, the type of aggregate and the cement factor explained together 42 percent of the variation. The variation was not significantly increased by the addition of water-cement ratio, percent air, or slump in the regression equations. These three variables all have an important part in determining flexural strength. Therefore, the only conclusion drawn was that the data obtained may have been insufficient or possibly the complex nature of these variable interrelations was not properly characterized for the regression study.

DELETION OF SEAL COAT CAPABILITIES

The inputs of the minimum time for first seal coat after an asphalt concrete overlay, the minimum time between seal coats, and the cost per lane mile of a seal coat were utilized in RPS-2. The program determined from these data the number of seal coats after an overlay until the performance period life was met. The program then calculated a present worth-cost of these seal coats and the schedule of their placement. However, the seal coats in no way affected the performance life calculations on each section.

The deletion of this model was accomplished in the new RPS-3 version for basic reasons.

(1) The inputs minimum time to seal coat of the overlay and minimum time between seal coats are normally not critical to initial roadway design, because a seal coat is for the purpose of restoring a skid resistant surface and does not affect the pavement's structural life.

(2) The costs associated with seal coating had little or no effect on the designs chosen through the program optimization process.

(3) The outputs from the model were of no real use to the design engineer. The outputs consisted of the costs, which were minimal, as mentioned previously, and a seal coat schedule which was not realistic. The schedule was unrealistic because the inputs were not easily obtainable nor were they significant to the real design of the pavement. The schedule was merely an addition of the seal coat time periods to the pavement life at the time of the overlay.

For these reasons all the computations in RPS-2 pertaining to seal coats were removed in the development of RPS-3.

DELETION OF THE TRAFFIC VOLUME DATA

In the RPS-3 version, the capability of the designer to input traffic volume data has been removed. This deletion of traffic models was undertaken because of the availability to the designer of other traffic volume information which is easier to input. Instead of having to input the load group ranges, the number of axles, and the type of axle for each load group, the user need only to input the ADT and total 18-kip equivalent single-axle wheel load, ESAWL, for the analysis period. These traffic inputs are discussed in Chapter 6 and the Input Guide in Appendix 3.

The equations and checks for this option have been retained in program RPS-3 in case future investigation proves a need for their use. The use of the traffic load group input option may be reinstated in RPS-3 because the equations remain intact in Subroutine TRAFFIC. Two changes to Subroutine INPUT which will reinstate the option are the addition of an input variable entitled PSN2 to Card 2 (Program Controls Card) and the removal of the statement setting PSN2 equal to "1". If this option is ever exercised, the input guide should explain that an input value of 1 for PSN2, will make the program select the total 18-kip traffic input and a value of 0 for PSN2 will cause the program to select the load group input and equations. Also, the load group input cards used in RPS2 must be added to the input guide.

SUMMARY OF MODEL CHANGES

The changes to RPS-2 models which are documented in this chapter are the only changes made in the development of RPS-3. A summary list of the changed computer models is as follows:

(1) The traffic delay cost model was modified to account for traffic delay costs incurred because of concrete curing time.

(2) The input and output formats of RPS-2 were changed to more adequately define variable units and characteristics.

(3) The seal coat models used in RPS-2 were omitted in RPS-3.

(4) The traffic load group option was omitted as a designer option; however, the equations have been left in RPS-3 and may be used in the future.

Two additional models were studied without any changes being made to program operation:

(1) The maintenance model was studied to determine possible future modifications.

(2) The concrete flexural strength model was studied to determine if cement factor, water cement ratio, and aggregate type could be used to determine characteristic flexural strength values.

Once these model changes and studies were complete, the modularization process began. Chapter 4 will describe the modularization process in detail.

CHAPTER 4. MODULARIZATION OF THE RPS-3 PROGRAM

As was previously outlined, the RPS-2 computer program was very large and unwieldy. It consisted of one main program and three subroutines. This aspect of RPS-2 was undesirable for a number of reasons.

(1) Its size prevented the modification or change of any model without a complete understanding of the entire program.

(2) The program was difficult for a design engineer to learn even if he only wanted to investigate how one particular design factor was calculated.

(3) The overall program logic was not easily deciphered because the complicated looping for design was obscured by the program's size.

The RPS-2 version had three subroutines: AGE2, which calculated the pavement performance life based on the modified AASHO equation; TDC2, which calculated the traffic delay cost associated with pavement overlays; and MANCE, which calculated maintenance costs for a pavement during its performance life. The flow charts for these subroutines are included in Appendix 1. The program was inflexible and hard to modify simply because of its size. For example, if a new reinforcement model were to be developed it would be impossible to implement the model into RPS-2 without a complete understanding of the entire program. For this reason, modularization was one of the most important tasks to be accomplished before implementation of the new version RPS-3.

The main goal of modularization was to subdivide the new version into a main program deck with numerous subroutines without limiting the program's ability to design. Not only would the program then be easier to change, but the program would be easier to understand for those desiring to learn its operational characteristics.

First a group of six reference data decks were prepared. These six problems were written to test every combination of RPS-2 design capability. The six problems were run and the outputs were placed in a master notebook. Then as each new subroutine was broken out of the main program these six data decks were run to verify that the system still produced the same pavement designs. Once a subroutine was compared favorably with the six sample problems, a copy of the program was saved; another new subroutine was formed from another part of the RPS-2 main deck; and the testing program initiated again.

In this iterative fashion, eight new subroutines were added to the program. The original three subroutines, AGE2, TDC2, and MANCE, were retained, and the eight added were ORDER, REINF, NUMBER, TRAFFIC, INPUT, OUTPUT, INITIAL, and VPHCAL.

The new main program in RPS-3 consists of approximately 380 statements, with the subroutines making up the remainder of the program.

The remainder of this chapter presents an explanation of the function and operational flow of each new subroutine. After the subroutines have been explained, there is a discussion of how these subroutines fit into the overall program flow. The total program, including all the subroutines, is flow charted in Appendix 1. A listing of the program is presented in Appendix 4.

EXPLANATION OF NEW SUBROUTINES

The new subroutines included in this discussion are ORDER, REINF, INITIAL, NUMBER, TRAFFIC, INPUT, OUTPUT, and VPHCAL. The discussion of the modified subroutine TDC3 was presented in Chapter 3. The discussion of the two remaining subroutines in RPS-3, AGE 2 and MANCE, is included in this section because they were not completely documented during their development.

The discussion of each subroutine includes a statement as to the general function of the subroutine and a discussion of the operational flow within each subroutine. The flow diagrams for all subroutines appear in Appendix 1.

Subroutine ORDER

Subroutine ORDER stores and optimizes the design strategies for later printing as output designs.

The subroutine is essentially composed of a do loop which loops twice to correctly compare and store each design strategy it receives. First, the design is indexed according to its design combination category. There are five design combinations: (1) JCP with AC overlay, (2) CRCP with AC overlay,

(3) JCP with CC overlay, (4) CRCP with CC overlay, and (5) JCP or CRCP without overlay. The new design being optimized is compared to the most optimal design of the same combination already stored. If the new design is more economical, it replaces the old design; if not, then the loop goes back to its beginning. The new design is then compared with all the NREQ designs (number of designs required by designer for OUTPUT). If it is less expensive than the most expensive design being kept, then it will replace that design; if not, the new design being analyzed is rejected and the next design is analyzed. Once all the designs have been analyzed, they are arranged in increasing order of total cost.

The OUTPUT subroutine then prints out the NREQ designs, the optimal design for each combination, and a summary of the total number of designs. Figure 4.1 presents a conceptual representation of the subroutine flow (Ref 2).

Subroutine REINF

Subroutine REINF designs the reinforcement steel for both JCP and CRCP pavements, using either bar or wire mesh reinforcement.

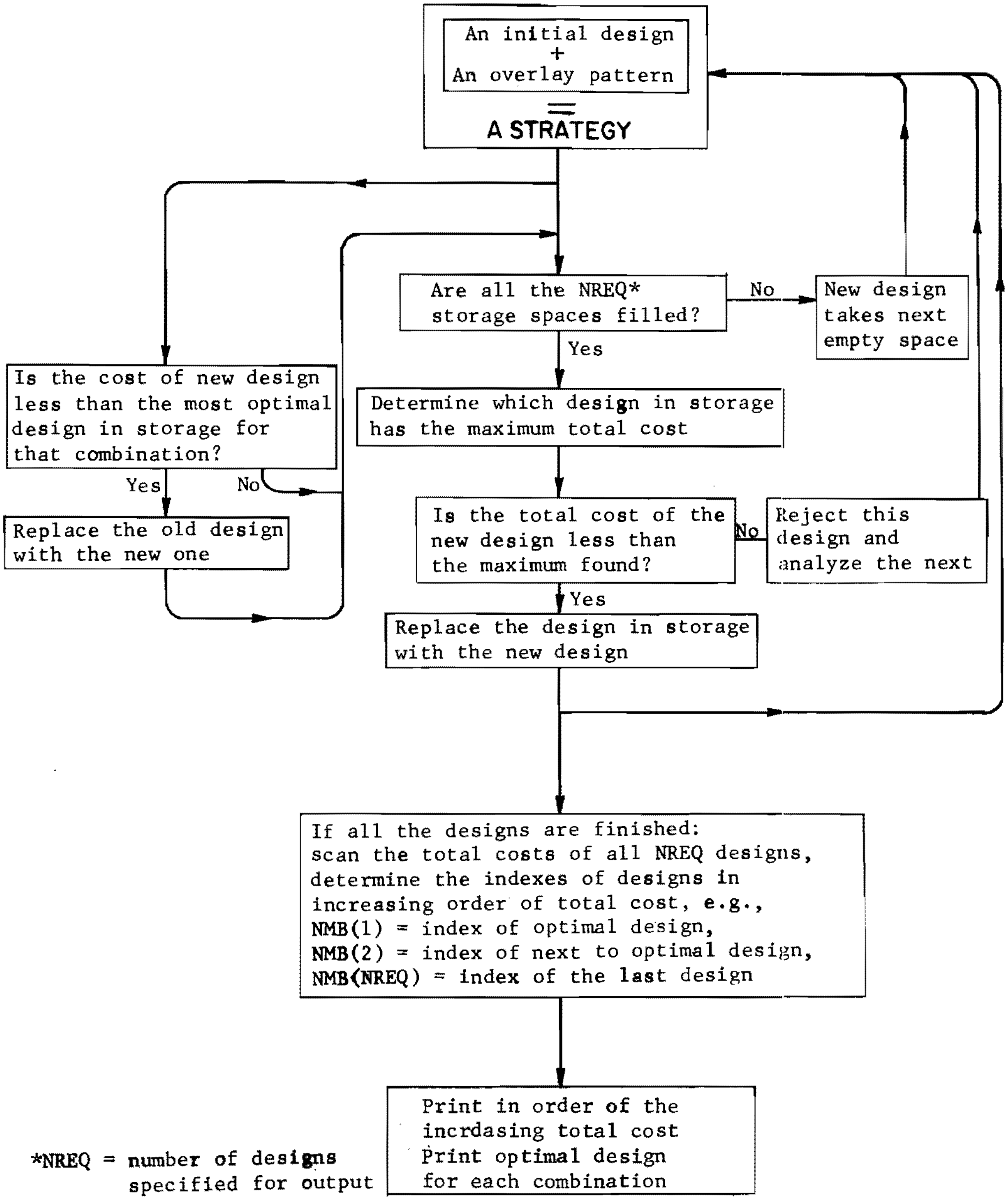
Initially, the subroutine determines the combination of reinforcement the designer desires. If the designer is specifying one combination only, the program will recognize this and skip all unnecessary calculations. If the designer is specifying CRCP with bars and wire mesh, the program will recognize this and not make any joint calculations or extra reinforcement calculations.

After designing the spacing for the type of reinforcement necessary, the subroutine determines the costs involved and totals these costs with others to provide an initial cost of the pavement, including subgrade preparation, concrete, subbase, joints, tie bars, and reinforcement steel. The design models used are outlined in Research Report 123-5 (Ref 2).

The flow chart for subroutine REINF is very detailed and the logic of this subroutine is straightforward.

Subroutine INITIAL

Subroutine INITIAL initializes the storage of variables and creates the initial arrays for the subroutine ORDER. The subroutine also calculates the cost of subgrade preparation for the designs.



*NREQ = number of designs specified for output

Fig 4.1. Optimization procedure RPS-3.

Initially, the subroutine searches for the NREQ (number of designs for which the designer has asked). If the designer has made no choice, the subroutine prepares to give him 12 designs automatically. The subroutine then creates the arrays for all the combinations so that the most optimum design in each combination may be saved. The subroutine then creates an array to store NREQ designs and initializes a maximum cost against which to test all subsequent design costs. The subroutine then determines the cost of the subgrade preparation from the input of cost per lane mile of subgrade preparation. This cost is retained since it is applicable for all designs.

Subroutine NUMBER

Subroutine NUMBER determines the total number of initial designs possible for all combinations of concrete and subbase thicknesses derived using the thickness increment input by the designer. First, the subroutine determines with the use of a counter and stepping function, the number of initial designs a subbase can generate. It does this for each subbase until it has accounted for NSB, the number of subbases. Next, the subroutine uses a similar counting system to determine the number of designs generated by all the concretes and their respective thickness ranges. The subroutine then uses these two totals to determine the total number of initial designs possible. If the number of thickness combinations for subbase material is less than the number of subbases, the program will stop and print an error message indicating to the designer that there is an error in the subbase thickness input. For this reason, the designer must still input a 1 for the NSB even if the minimum and maximum thicknesses are equal to zero for designing the subgrade without subbase. The flow chart for subroutine NUMBER shows in detail, the subbase loop and then indicates that the concrete loop is identical in logic and format.

Subroutine TRAFFIC

Subroutine TRAFFIC determines the total 18-kip equivalent axle wheel loadings for a design using either the input 18-kip ESAWL or the traffic load range data. The subroutine initially begins by looping for the number of subbases and determining for each thickness the allowable 18-kip ESAWL. The subbase thickness is used only if the load group data are input into the program. The program checks an index and if the total 18-kip ESAWL is input, it skips over the load range calculations. This subroutine places the traffic calculation in one easy location for future changes. For example, it is now easier to input information on truck traffic if desired.

Subroutine INPUT

Subroutine INPUT reads and prints out all the design information read into the program by the user. The subroutine reads all the inputs initially, then it prints them out. As the subroutine reads variables, some are set if they are not input by the user; these include:

(1) Concrete increment thickness will default to 1.0-inch if not given.
(2) Subbase thickness will be limited to a maximum of 18.0 inches if the input is greater than 18.0 inches.
(3) The increment in spacing tried for transverse joints will be set to 10 feet if equal to zero.
(4) If the type of concrete flexural test is not specified, the program will assume it to be third-point loading.
(5) If the number of days at which the flexural test was made is not input, the program will set it to 28 days.
(6) If the tensile strength of the concrete is not input, the program assumes it to be 40 percent of the flexural strength.

In printing out the data, RPS-3 makes many checks to insure that only those items read in are printed out. For example, if the designer is overlaying with AC, the program will not print out the titles for CC overlay data. The printing out of inputs has been completely checked in the course of RPS-3 development. Units have been added to all formats and titles have been changed to clarify their meanings. The confidence level variables which were not printed out in RPS-2 are now printed out as the last input. The data are not printed out in exactly the same order as read; however, the titles clearly identify the variables.

The modularization of subroutine INPUT is important because it facilitates the final pavement design system (PDS) development. It will now be easier for the RPS inputs to be modified to be compatible with FPS.

Subroutine OUTPUT

Subroutine OUTPUT prints all the final design information. The subroutine prints the optimum design in each category as follows:

(1) JCP design with AC overlay,

(2) JCP design with CC overlay,

(3) CRCP design with AC overlay,

(4) CRCP design with CC overlay, and

(5) initial design lasting analysis period without overlay.

For each of the designs, subroutine OUTPUT provides a complete summary of thickness, materials, reinforcement type and spacing, subsequent overlay construction necessary, total life expected of design, and itemized and total costs.

The subroutine then prints out a summary table of the NREQ, designs for which the designer has asked. There are six designs per page with each page consisting of the identical design data which were provided for each of the optimum designs in every category. Following each summary page is a reinforcement design for each pavement design. The subroutine will print six per page up to the maximum of 23 designs.

Finally, after all the designs have been printed out, the subroutine will print out two design analysis tables, the initial design analysis table and the overlay subsystem analysis. The format of these tables has not been changed and gives the following information (Ref 2).

Initial Design Analysis. This design analysis describes the following:

(1) the total initial designs possible for the problem,

(2) number of designs rejected because their initial thicknesses are greater than the allowable value,

(3) number of designs rejected because their initial lives are less than the allowable minimum time to the first overlay,

(4) number of designs rejected because their costs are more than the money available for initial construction,

(5) number of acceptable initial designs lasting the analysis period,

(6) number of unacceptable initial designs lasting the analysis period, and,

(7) number of initial designs for which overlay strategies are formulated.

Overlay Subsystem Analysis. This subsystem analysis describes the following for each combination analyzed by the program:

(1) total number of acceptable strategies,

(2) number of strategies rejected during analysis because of maximum overlay thickness restraints,

(3) number of strategies rejected during analysis because the lives of the overlays provided are less than the minimum specified time between overlays,

(4) number of strategies rejected because the number of overlays required is more than eight, and

(5) number of times when each subroutine is called.

The initial design analysis is more informative to the designer than the overlay subsystem analysis overall because some of the subsystem analysis deals with the program's calling of certain subroutines and is useful only to one who understands the program's internal working. However, the first four outputs of the analysis listed above are useful. The design combination number at the top of the overlay subsystem analysis refer to (1) jointed concrete pavement with an AC overlay, (2) jointed concrete pavement with PCC overlay, (3) continuously reinforced pavement with an AC overlay, and (4) continuously reinforced pavement with a PCC overlay.

Subroutine VPHCAL

Subroutine VPHCAL uses the average daily traffic at the time of an overlay with the percentages of ADT for each hour of the day to calculate vehicles per hour, VPH, on an hourly basis.

This subroutine is short and its operation is simple. The subroutine uses the percentages of ADT per hour throughout the day to determine the number of vehicles per hour. The calculations and the source of percentage data are discussed in Chapter 3.

OVERALL PROGRAM FLOW

This section discusses the overall program flow of RPS-3 which is similar to the process of design generation used in RPS-2 (Ref 2) is shown in Fig 4.2. A new flow diagram was developed to explain how the new subroutines fit into the overall design process. Figure 4.3 shows the flow of RPS-3. The program

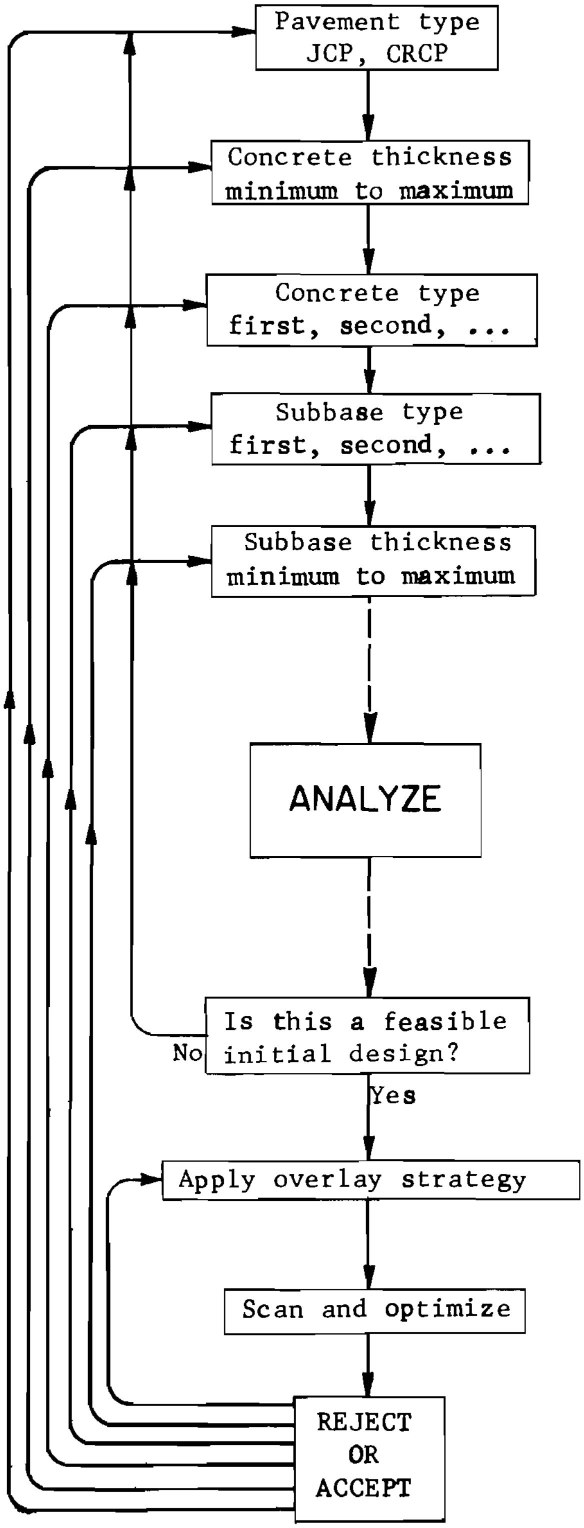


Fig 4.2. Process of generating designs in RPS-2

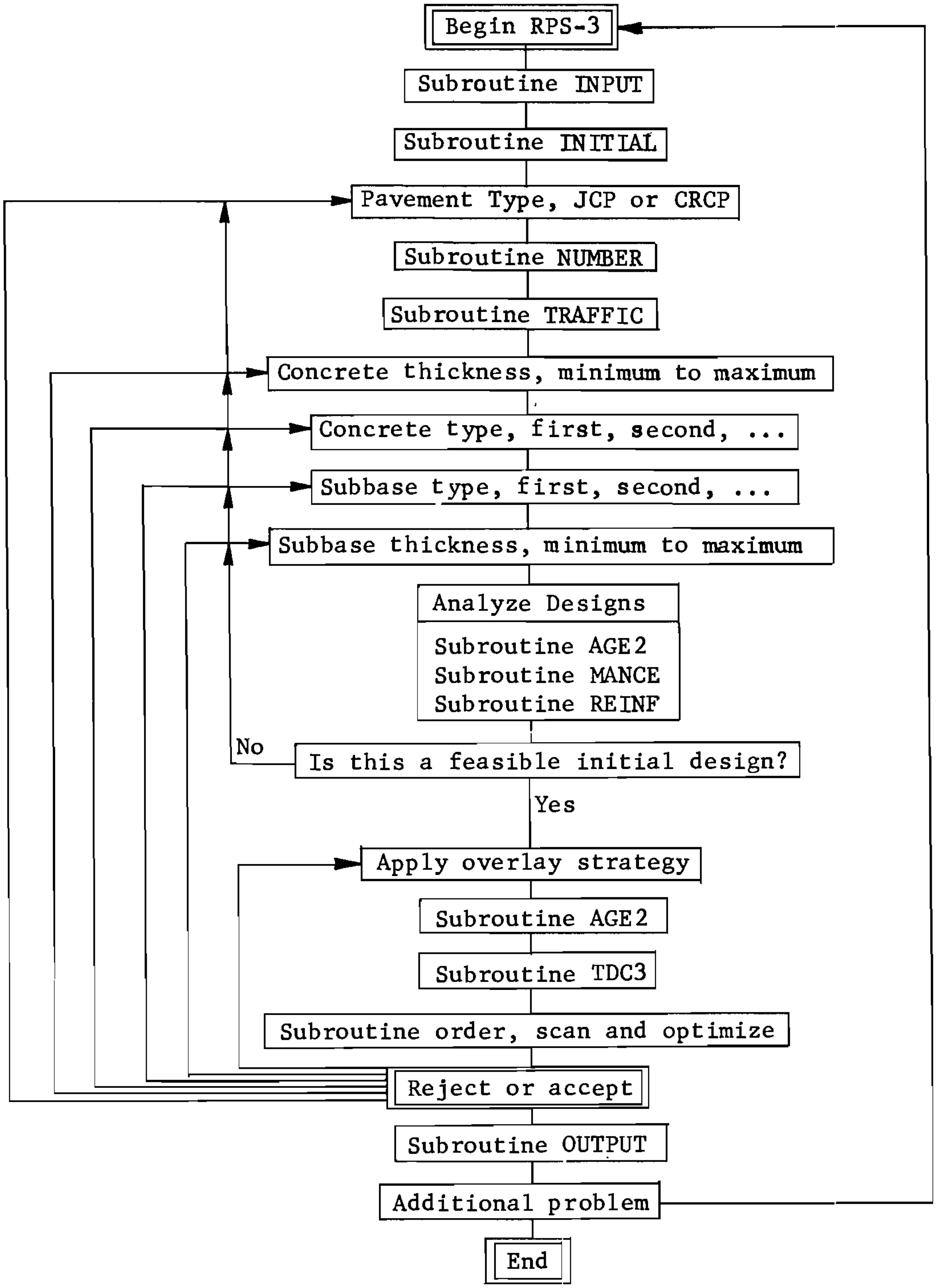


Fig 4.3. Process of generating designs in RPS-3.

generates designs and will print up to a maximum of 23 design strategies in order of increasing cost. The main program calls all the subroutines and directs the flow shown in Fig 4.3. The flow diagram for the main program of RPS-3 is included in Appendix 1.

The RPS-3 program is considerably different from RPS-2 in the following ways:

(1) The main program of RPS-3 is 380 statements, whereas the main part of RPS-2 has approximately six times as many.

(2) RPS-3 has eleven subroutines and RPS-2 has only three.

(3) RPS-3 is now in a form which is more compatible with recognized computer techniques; it will therefore be easier for a computer programmer to learn.

SUMMARY OF RPS-3 MODULARIZATION

The modularization of RPS-2 to produce RPS-3 was accomplished without distrubing the design capability of the separate models. The two important results obtained from this work were

(1) RPS-3 program flow is easier to decipher and understand.

(2) Future modification of models in RPS-3 will be easier to perform.

The verification process utilized to check new subroutines of the modularized program was very successful. After the final subroutine was pulled out and the program tested, the results compared exactly with the results of the six reference design problems run with RPS-2. The iterative checking after each subroutine creation also allowed for programming bugs to be removed.

Once the modularization was complete, the final version of RPS-3 was prepared by adding sequential numbering to identify the statements and comments to assist the programmer and user. The RPS-3 version was added to the Center for Highway Research computer library.

After the program was complete, a study was undertaken to verify the accuracy of the rigid pavement design system to predict actual field situations.

Chapter 5 presents a pilot study which was made in Houston, Texas using RPS-2. The results of this study are applicable to RPS-3 because both programs predict the same results.

CHAPTER 5. IMPLEMENTATION

This chapter outlines a proposed procedure for the implementation of RPS-3, and will cite trial uses of the RPS-2 program which have been made. Recommendations concerning the future implementation, usage, and modification of RPS-3 will be made. The development of RPS-3 was done in light of future implementation and the program contains many useful implementation features.

FUTURE RPS-3 IMPLEMENTATION

The general procedure for the implementation of RPS-3 should consist of three main areas of work: (1) introduction of the program to Texas Highway Department design engineers, (2) practical usage and problem solving with RPS-3, and (3) modification of RPS-3, resulting from feedback obtained from design engineers who use the program. A factorial analysis of these three main functions is given in Fig 5.1. This factorial was developed as a guide to the necessary operations in the implementation process.

Initially, the program must go through a period of formal introduction to the users. A careful process for choosing Texas Highway Department Districts which will use RPS-3 first is necessary. This is so that those Districts which are familiar with concrete pavement design can be chosen for implementation studies. These Districts should be contacted and supplied information concerning RPS-3. As a final part of RPS-3 introduction, someone familiar with the program should call on each District individually and introduce the program. This personal implementation will hasten the acceptance of the program and provide the Texas Highway Department design engineers with someone who can be questioned regarding the particulars of the program.

After the program has been introduced and the district engineers have had an opportunity to test its application, a problem solving step should begin. Problems should be chosen from real District jobs and data gathered

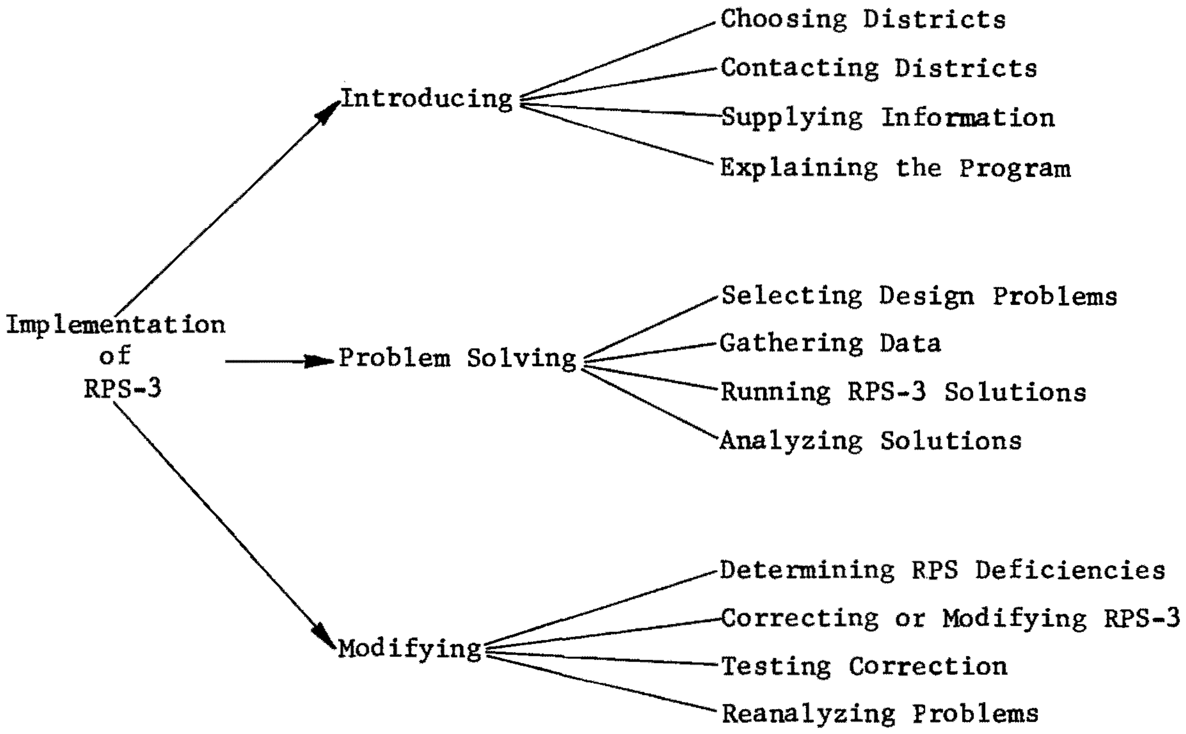


Fig 5.1. Factorial of RPS-3 implementation functions.

on the jobs. The RPS-3 program can then be used by the design engineers on problems with which they are familiar. Once the problems have been run, the solutions can be analyzed in an orderly fashion to determine how well RPS-3 has functioned. This evaluation process will be subjective and based on the District design engineer's experience.

Finally, the problem solving step should generate new ideas for future RPS-3 modification. The problem solving will help identify RPS-3 deficiences which can be corrected or modified in additional (RPS-X) versions. Once any correction is made, it is important that testing and documentation follow so that the RPS system will remain homogeneous. Finally, after a correction has been made, the program should be evaluated again by the Districts.

The implementation process is continuous once it has begun. Whenever any new modifications are made, they are passed to the user. The user likewise makes notes of suspected defects and proposes needed modifications. The initial introduction of a system, however, is important to the system's acceptance.

SPECIFIC TRIAL USE OF RPS-2

An evaluation of the accuracy of the AASHO equations to predict concrete pavement performance periods was undertaken with RPS-2. Since this particular model in RPS-3 remains unchanged, the study is applicable as a verification of RPS-3. Future use of RPS-3 for similar trials should be easier because the program's input guide has been written for easy field use. The process outlined in this section is basically a check of existing RPS design capability. The findings of this section should support the implementation of the program.

Before a designer can judge a particular pavement design and how it has performed, he must undertake a comprehensive study to diagnose the nature of the pavement's identity, its particular design characteristics, its construction, and the loads to which it has been subjected, both environmental and traffic. All of these detailed particulars function together to produce the performance life. A diagnostic study was performed to evaluate four in-service concrete pavements in Houston, Texas. A general performance survey had been conducted on the sections and more detailed information was desired. It was decided that an in-depth study should be made to determine more fully why the sections were behaving as they were.

As a part of the scope, the report gives a method of approach to the experiment design and the procedures followed in collecting all the necessary data.

Approach and Experiment Design

Four in-service concrete pavements are in themselves not an adequate size experiment because there are many different concrete pavement design combinations. First, it was decided to choose only CRCP sections. The pavement sections chosen were all sections on the Interstate System, either IH-610 or IH-45. They were also very similar in design and relative age. The four basic sections were given a current pavement condition rating of good, fair, or poor by the urban office engineers, as an estimate of the section's present condition. Table 5.1 also lists the Present Serviceability Rating (PSR) values from a performance survey made by NCHRP Project 1-15 personnel from the Center for Highway Research and the values closely agree with the pavement condition estimates made by Texas Highway Department personnel. Mays meter readings were collected also for each section and the present serviceability index (PSI) values derived from these readings are given in Table 5.2. As Table 5.1 shows, pavements of all conditions (poor, fair, and good) and of both old and medium ages were studied. It was, therefore, decided that the four chosen sections would be sufficient for the experiment, although not ideal.

After the experiment sections were chosen, field measurements and samples were taken. Laboratory tests were run on these samples, and the data was analyzed to ascertain in particular what caused the pavement to perform as it had. This amount of data was necessary for a verification study, but for design use of the program, this data are not required.

Procedure for Data Collection

This section explains the procedures adopted to collect laboratory and job file data. These data provided a sound base for analyses of the sections under study.

TABLE 5.1. BASIC INFORMATION FOR EACH TEST SECTION

Project	Section	Relative age	Actual age (years)	Pavement Condition[1]	PSR[2]	Subbase type (sand shell)
I610W - Memorial, Woodway	271-17-8	Medium	7	Fair	3.2	Cement stabilized
I610W - San Felipe, Westheimer	271-17-19	Medium	10	Poor	2.6	Cement stabilized
I610N - Yale, Main	271-14-26	Medium	9	Poor	2.8	Cement stabilized
I45N - Cavalcade, Patton	500-3-68	Old	13	Good	3.8	Cement stabilized

1. A current pavement condition evaluation assigned by Houston Urban Office personnel
2. PSR ratings from a survey made by NCHRP Project 1-15 personnel from the Center for Highway Research

TABLE 5.2. SUMMARY OF DATA - CRCP INVENTORY FORM

Project	Pavement Structure Thickness		Materials			Traffic One Direction[1]			Construction		Environmental Data			Miscellaneous	
	Con-crete (in.)	Sub-base (in.)	Concrete		Subbase Type	ADT (× 10^5)	Commercial Vehicles Per Day (× 10^3)	18K ESAWL (× 10^6)	Con-tractor	Concrete Mix Method	High Temp. °F	Low Temp. °F	Curing Temp. °F	Mays Meter Readings psi	No. of Days Until Traffic
			Cement Factor SKS/SY	W/C GAL/SK											
IH 610 Memorial Woodway	8	6	5.0	5.5	Cement Stab. Sand Shell	.80	5.28	9.20	Austin Worth	Central Mix Plant	94	75	85	3.15	173
IH 610 San Felipe Westheimer	8	6	4.5	6.0	Cement Stab. Sand Shell	.80	5.28	13.142	Brown Root	Traveling Drum Mixer	78	76	77	3.25	196
IH 610 Yale Main	8	6	4.5	5.8	Cement Stab. Sand Shell	.63	4.20	10.174	Holland Little	Traveling Drum Mixer	82	82	85	3.15	338
IH 45 Cavalcade Patton	8	6	5.0	6.0	Cement Stab. Sand Shell	.56	2.30	3.573	Cage Bros.	Central Mix Plant	92	89	90	3.30	41

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[1] Traffic count made April 1973.

Field Data. Each of the four 1200-foot sections was closed to traffic by Texas Highway Department crews while measurements and evaluations were being collected for each individual section. Physical measurements consisted of deflections, crack width, crack spacing, steel reinforcement depth, Mays Meter measurements, and various distress manifestations.

Two deflection measurements were made every 200 feet, one between two cracks and one at a crack, or a total of 12 measurements for the 1200-foot sections. An additional 12 measurements were made on the center line of each 1200-foot section at a spacing of 15 feet or less. Three crack widths were measured as outlined in the Project 1-15 report (Ref 8). Steel depth was obtained using a Pachometer.

Experimental Laboratory Data. Cores on each section were taken while the team was in the field. These cores were of the concrete, subbase, and subgrade of each section. The cores were taken both at cracks and between cracks.

First, before any tests and measurements were made, all the cores were photographed and measurements of height, diameter, and weight were made for each core to determine its density.

Next, indirect tensile tests were performed upon the uncracked concrete and subbase samples to obtain Young's modulus of elasticity values and the indirect tensile strengths.

Information from THD Job Files. The final step in gathering information for analyses was to obtain the particulars from the Texas Highway Department job files on each of the four sections. Table 5.2 shows a summary of the additional information obtained by the investigation, the cement factors, the water-cement ratios, traffic data (both ADT and 18-kip ESAWL), number of days curing before traffic allowed on facility, high temperature, low temperature, curing temperature, and Mays Meter readings.

Diagnostic Study. Once the data had been collected, the diagnostic studies were initiated. The objective of this diagnosis was to explain each sections' performance with respect to its individual characteristics. The diagnostic work was also for the purpose of making general conclusions about the designs. Each analysis will be specifically explained in the following subsections.

Comparisons of Section Differences. A study of the pavement's characteristics was performed initially to determine if there were any obvious differences in the sections which would explain their behavior. Table 5.2 shows the specific information collected from the Texas Highway Department files for each section. The bar graphs in Figs 5.2 through 5.9 were plotted from these data for ease of assimilation. The information studied included pavement age, Mays Meter readings, average daily traffic, commerical vehicles per day, number of total 18-kip loadings, number of days until pavements were opened to traffic, month in which the concrete was placed, and the high and low temperature during concrete placement.

For the four sections chosen, age did not seem to be a critical factor. Although the IH-45 Cavalcade to Patton section was the oldest section, as shown in Figure 5.2, its current condition was "good" as shown in Table 5.1. It also had a PSR value of 3.8, the best given to the four sections by D-10 personnel. It would be expected after looking at the ages that the IH-610 section from Memorial to Woodway was performing better than the IH-45 section, but this was not indicated by either the current condition rating or the PSR values. The Memorial to Woodway section was, however, in better condition than the remaining two sections, as would be expected.

The Mays Meter readings shown in Fig 5.3 seem to verify both the current condition ratings and the PSR values given the pavements by raters. The IH-45 Cavalcade to Patton section had the best average Mays Meter reading. From the Mays Meter readings, all the sections would appear to be performing approximately the same. However, the current condition ratings are significant since they are made by the Texas Highway Department personnel who are aware of each section's required maintenance and user response. The THD personnel rated the Memorial to Woodway section in "fair" condition, with the San Felipe to Westheimer and Yale to Main sections being rated "poor". The PSR values given these sections by NCHRP Project 1-15 personnel confirm this appraisal.

The traffic variables considered were the average daily traffic, commercial vehicles, number of 18-kip equivalent single-axle wheel loads (ESAWL) and number of days until traffic, shown in Fig 5.4 through Fig 5.7. As these figures indicate, the section which was in the best condition had the least ADT, commercial vehicles, and 18-kip ESAWL. Figure 5.6, the 18-kip ESAWL

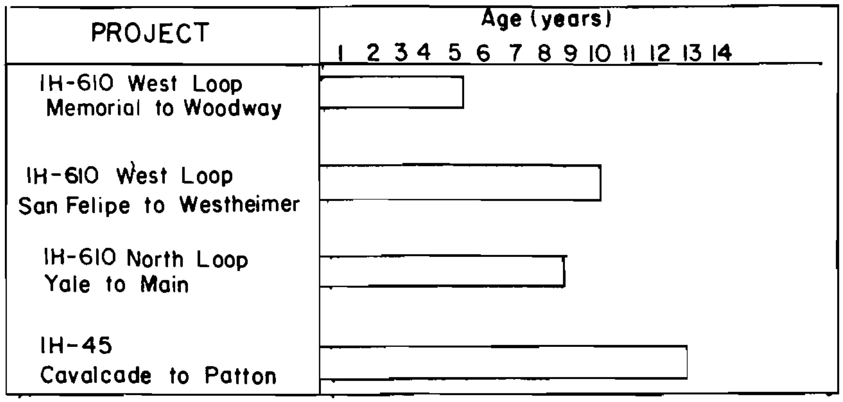

Fig 5.2. Age of sections in years.

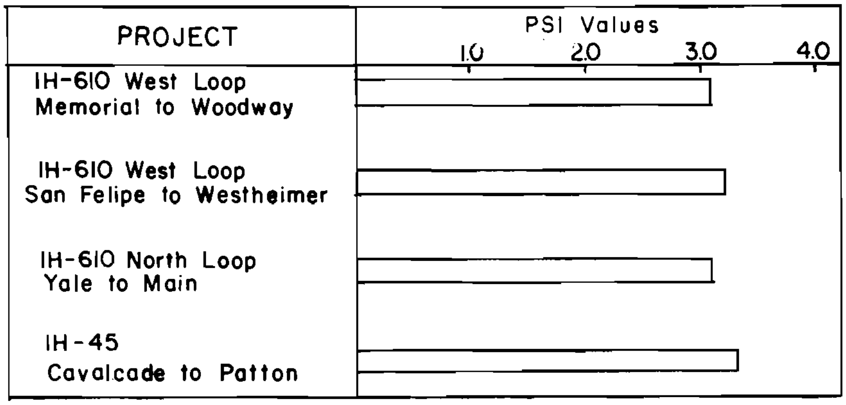

Fig 5.3. Mays Meter readings converted to PSI for each section.

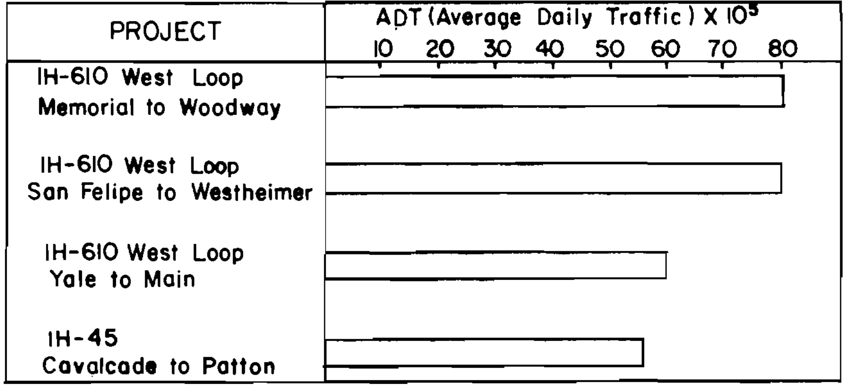

Fig 5.4. Average daily traffic for each section.

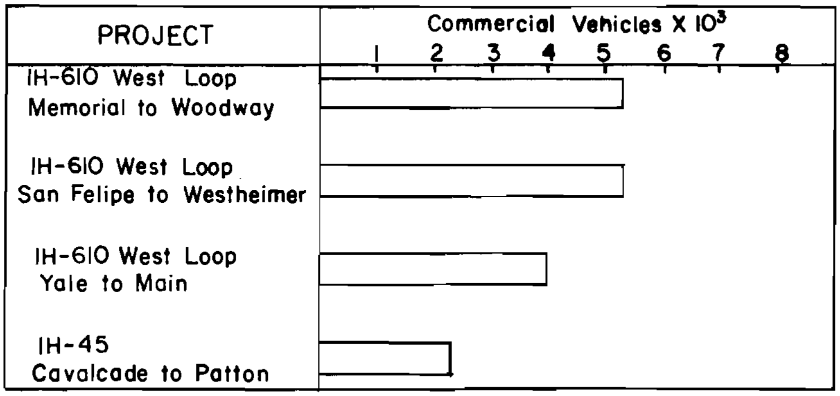

Fig 5.5. Commercial vehicles per day for each section.

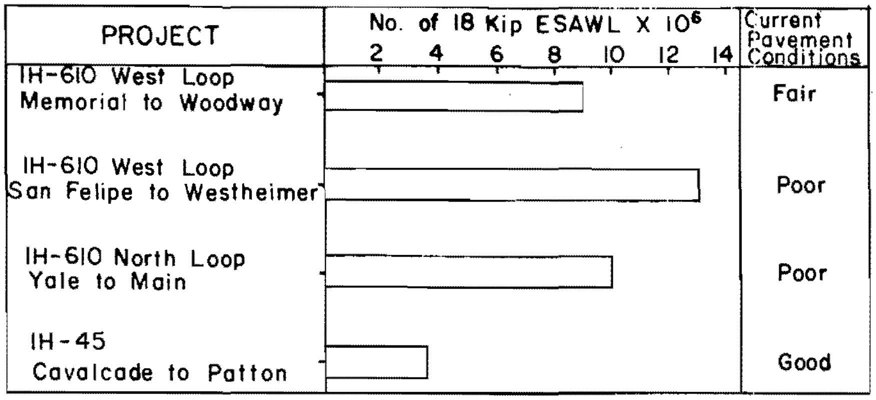

Fig 5.6. Number of total 18-kip loadings to date on the pavements.

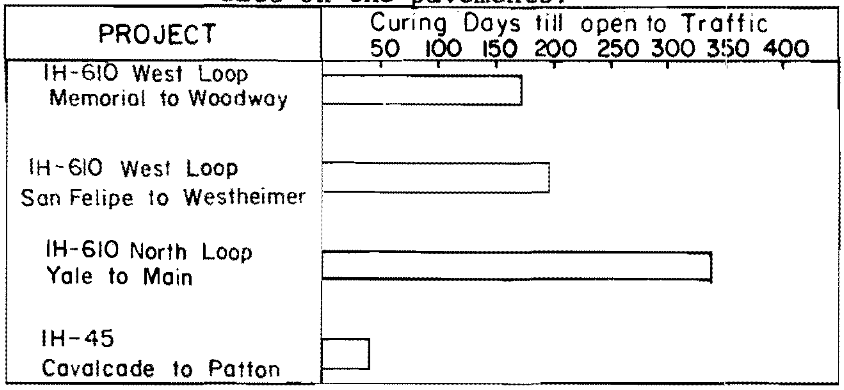

Fig 5.7. Number of days until pavement open to traffic.

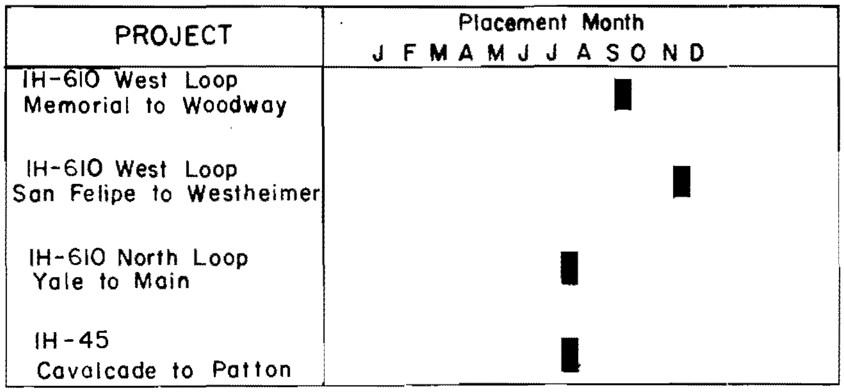

Fig 5.8. Month in which concrete was placed.

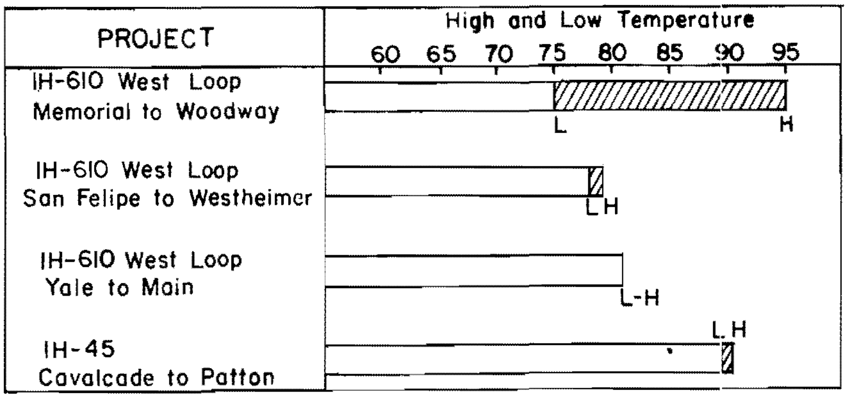

Fig 5.9. High and low temperature during concrete placement.

plot, was especially significant because the current condition ratings and the PSR values both relate exactly one to one with the amount of 18-kip ESAWL each section has carried. The current pavement condition is written on the graph for emphasis. Figure 5.7 indicates that the time until traffic was turned upon the facilities may have been important. There are, however, so many variables involved that no conclusions could be drawn from these data.

Finally, the placement month of construction and the temperatures at which the pavement was poured were considered to ascertain their influence. Figure 5.8 shows the placement month for each section, which did not seem to be a significant factor. The temperature during placement, shown in Fig 5.9 also did not appear to be significant. The limited number of sections studied is the probable reason for these observations. The temperature of placement is definitely important and the Texas Highway Department limits the minimum temperature of concrete placement.

There were no specific material or structural differences, because all four pavement sections consisted of eight inches of continuously reinforced concrete pavements using quartz gravel, six inches of cement stabilized sand-shell subbase, and clay subgrades. The cement stabilized sand-shell base was 65 percent oyster shell and 35 percent San Jacinto sand with one and one-half sacks of cement per ton of mix. The deformed bar reinforcement was identical on all four sections, with 0.6 percent longitudinal steel and 0.08 percent transverse steel being used. All projects used 60,000 psi yield point steel in bar sizes of Number 4 in the transverse direction and Number 5 in the longitudinal direction. The subgrade material had a modulus of subgrade reaction of 115 pounds per cubic foot, determined by the density test, and was unstabliized.

Material Strength. The cores from the concrete slab and cement-treated subbase were tested to determine the mean indirect tensile-strength and elastic modulus for each section. Table 5.3 shows the results of the analysis. The concrete cores from the IH-45 Cavalcade to Patton section, had the highest indirect tensile strength, which may be another reason why this section is in the best condition. It would, however, be unrealistic to generalize this statement because, for example, the IH-610 Memorial to Woodway and the IH-610 Yale to Main sections have approximately the same strengths for concrete and yet, the IH-610 Memorial to Woodway section is in better condition and has a

TABLE 5.3. RESULTS FROM INDIRECT TENSILE TESTS OF CORES FROM HOUSTON PROJECTS

Test Section	Subbase*		Pavement*	
	Elastic Modulus[1] (psi) × 10^6	Tensile Strength[2] (psi)	Elastic Modulus[3] (psi) × 10^6	Tensile Strength[4] (psi)
IH-610 West Loop Memorial to Woodway	1.63	200	5.59	485
IH-610 West Loop San Felipe to Westheimer	1.89	262	5.04	528
IH-610 North Loop Yale to Main	2.25	221	4.11	471
IH-45 Cavalcade to Patton	1.83	224	5.33	571

1. Mean values for Young's elastic modulus obtained from indirect tensile test and assuming a Poisson's ratio of .25 for calculations.
2. Mean values for indirect tensile strength obtained from indirect tensile test and assuming a Poisson's ratio of .25 for calculations.
3. Mean values for Young's elastic modulus obtained from indirect tensile test and assuming a Poisson's ratio of .20 for calculations.
4. Mean values for indirect tensile strength obtained from indirect tensile test and assuming a Poisson's ratio of .20 for calculations.

*The cement-treated subbase and concrete slab cores were all sawed into three equal pieces for testing. Each sawed piece was tested and the results were correlated with depth in the core. The attempts to correlate the elastic modulus and tensile strength with depth were inconclusive and the values given in this table are averages of all the tests of each material in a particular section. Report NCHRP 1-15 (Ref 8) includes the plots of elastic modulus and tensile strength versus depth for the sections summarized herein.

better PSR value. Also, the San Felipe to Westheimer section has a higher indirect tensile-strength for concrete than either of the other IH-610 sections, yet it is in "poor" condition. The strengths of the subbase cores may not be generalized in any specific fashion either. The IH-610 San Felipe to Westheimer section has the highest flexural strength for subbase, yet it is in poorer condition and has a lower PSR value than the IH-45 Cavalcade to Patton section.

Use of RPS-2

The diagnostic study of four CRCP in Houston, Texas provided a complete set of data which was used to evaluate the AASHO performance equations for concrete pavement. The data collected for the study included many of the variables necessary for the execution of the rigid pavement design system program RPS-2 which utilizes the AASHO performance equations. The study was separated into two distinct segments. First, with all the variables set, the program was used to predict the pavement life, and, second, the program was used to design the pavements for a 30-year life with overlay at 20 years. Table 5.1 gives a review of the sections considered in the study.

Life Prediction. The initial study segment used the RPS-2 program as a prediction tool to predict performance periods for the different sections. The actual pavement thicknesses, traffic, material properties, serviceability at the time of the study, and age were input into the program. With the thickness of concrete and subbase held fixed, the program only gave one design strategy as an answer. As a part of the summary of every design strategy, the program will predict a performance period based upon the traffic, thickness, and material properties. A performance period is the time a pavement is used by the public until it must be overlayed. It is the time period determined by the maximum and minimum serviceability levels. This performance period was compared with the actual age of each pavement section to determine the program's capability to predict performance periods correctly. For each pavement section, this prediction was run at every confidence level, beginning with 50 percent and increasing the confidence level until the program would stop on some level. The confidence level is an indication of the variability of the pavement section. The predictions of performance periods by the program are shown in Table 5.4. For example, the IH-610 San Felipe to Westheimer section had a predicted performance period of 12.35 years at 95 percent confidence level. This compares with an actual age of 10 years at the time this study was performed. The reason the program would not design at a higher confidence level than the 95 percent level as the example was in this case, is that the program was not allowed to overlay. The analysis period was set at the actual age; therefore, at a confidence level of 99 percent for this section, the life was less than the 10-year actual life, and, with no overlay capability, the program stopped. The reason the Cavalcade to Patton section had to be designed at the 99.9 percent confidence level before closing on the actual age that this section had the least traffic of all the sections. Therefore, there was a higher confidence of this section's lasting to its actual age of 13 years. By this same reasoning, the IH-610 Yale to Main section only closed to a confidence level of 80 percent because it had a high traffic flow and the lowest concrete strength.

Design Analysis. The information from the diagnostic study was secondly used to check the pavements' design. The procedure followed was to take the known traffic and increase it linearly to a 30 year total, give a range of values to the concrete and subbase thickness inputs while retaining the material characteristics, and allow the program to overlay the facilities at 20 years. This information was supplemented with additional design information and the RPS-2 program was allowed to design each section. Table 5.5 lists the most economical designs which the program computed for each section.

Table 5.5 reports the design thicknesses, overlay thicknesses, the initial performance life of the pavement, and the total performance life after the specified overlay.

As Table 5.5 indicates, the program would have designed the San Felipe-Westheimer, Memorial-Woodway, and Yale-Main sections thicker than the actual eight-inch CRCP and six-inch cement stabilized subbase. The program gave the Cavalcade-Patton section some designs which have thinner concrete than the eight-inches present; however, these designs have thicker subbases. The Yale to Main section, which was in poor condition, was designed by the program to have a minimum concrete thickness of 10.5 inches.

TABLE 5.4. PREDICTED AGE OF HOUSTON SECTIONS USING RPS-2 AASHO PERFORMANCE MODELS

	Level of Confidence						
Project	50 Percent	80 Percent	95 Percent	99 Percent	99.9 Percent	99.99 Percent	Current Age[1]
IH-610 Memorial-Woodway	32.19	18.22	10.01	-	-	-	7
IH-610 San Felipe-Westheimer	42.69	23.34	12.35	-	-	-	10
IH-610 Yale-Main	44.32	19.60	-	-	-	-	9
IH-45 Cavalcade-Patton	129.70	77.48	46.29	29.08	16.58	-	13

1. The approximate age of the test sections as of April 1973.

TABLE 5.5. THIRTY-YEAR DESIGNS USING HOUSTON TEST SECTION DATA

Section and Design Number	Thickness (inches)[1]			Performance Periods[2]	
	Slab	Subbase	Overlay	Initial	Total
IH-610 Memorial-Woodway	8.50	12.00	3.00	20.10	36.07
	9.00	6.00	3.00	20.22	35.46
	9.50	8.00	3.00	27.41	46.89
	9.50	12.00	0	30.98	0
IH-610 San Felipe-Westheimer	9.50	8.00	3.00	21.15	37.03
	10.00	6.00	3.00	24.23	41.61
	10.50	8.00	0	31.83	0
IH-610 Yale-Main	11.00	6.00	3.00	20.85	36.02
	10.50	12.00	3.00	21.12	36.89
	11.50	8.00	3.00	27.07	45.89
	11.50	12.00	0	30.32	0
IH-610 Cavalcade-Patton	7.00	10.00	3.00	21.17	39.18
	7.50	6.00	3.00	22.51	40.04
	8.00	8.00	0	31.78	0

1. The design alternatives given by the RPS-2 program.
2. The initial performance periods are the times to the first overlay while the total performance periods are the amounts of time the pavements last with overlays.

Conclusion

Both studies conducted with RPS-2 indicate that the program prediction of performance using the AASHO performance model as modified by THD studies gives reasonable answers. The designs which the program generated for the sections are valid designs and were what the Texas Highway Department might have built if the current traffic had been anticipated.

Although the study was performed on RPS-2, as earlier indicated, the model for predicting performance periods, subroutine AGE2, remained unchanged and this study is a valid trial verification for RPS-3.

RECOMMENDATIONS

The major recommendations concerning the RPS-3 implementation are

(1) Implementation should begin as soon as possible.

(2) Any future RPS modification should attempt to simplify input.

(3) Feedback from initial users should be investigated because these users can evaluate the program in actual field use.

(4) The RPS design program should be introduced by a team of persons familiar with the program.

These recommendations are in parallel with the ideas presented as to how a general implementation procedure would be accomplished. The potential for RPS-3 usage as a tool to design overlays on existing concrete pavements is another important aspect of RPS-3 which should be stressed.

In conclusion, the development of RPS-3 has been a major step forward in concrete pavement design because the program is the most implementable version available. The program should be used in the practical design world because of its straightforward user's manual and documentation.

CHAPTER 6. USER'S MANUAL

This chapter discusses the User's Manual prepared for RPS-3, which is in Appendix 3. The topics discussed are development of the User's Manual, generalities of the Manual's use, input variables, and the most common errors made by RPS-3 users.

DEVELOPMENT OF THE MANUAL

A User's Manual for RPS-3 was developed using the input guide for RPS-2 (Ref 3) as a basis and supplementing it with the new characteristics of RPS-3. All units were added for the variables. The program was then run to design a hypothetical pavement. The coding sheets and output from this run were discussed and included in the report. The numerous runs made with the new program input guide also allowed for a discussion of the most common errors to be included in the report. This procedure of examining the input card by card was very useful in locating problem areas which needed clarification in the new User's Manual.

GENERAL STATEMENT ON USER'S MANUAL USAGE

All efforts were made to make the input guide as self-explanatory as possible; however, some general statements concerning its use will be helpful to the user. Figure 6.1 shows the arrangement of the data cards; as indicated, as many problems as desired can be run at once.

The program requires a storage of approximately 105,000 octal when running a design problem which calls for 23 designs. The types of letters, numbers, or characters to be input in the program are explained in the input guide for each card. The black dots on the data cards indicate where the

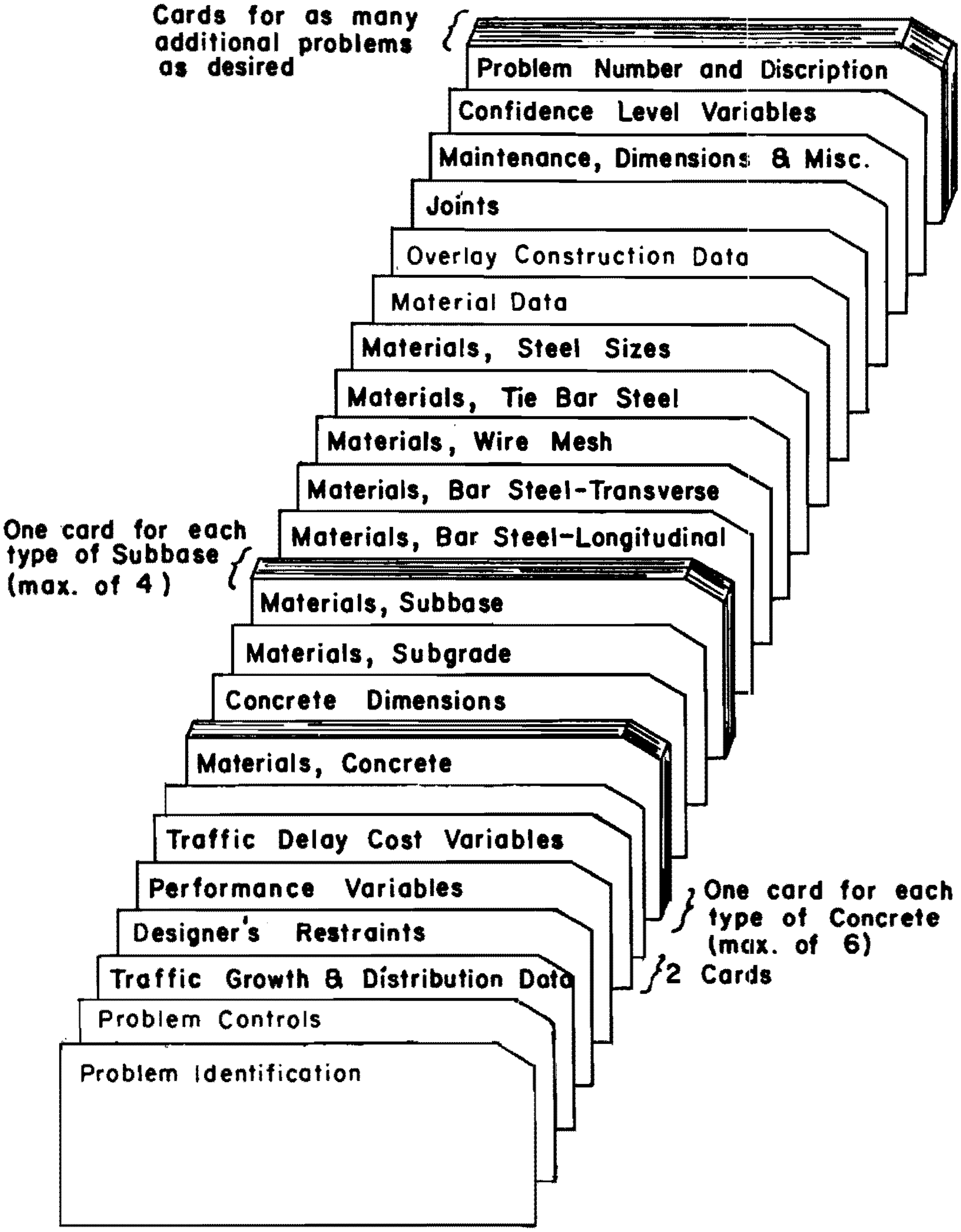

Fig 6.1. Assembly order for RPS-3 data.

decimal point is to be punched. If there is no decimal point, then the user is directed as to how to input the number.

When material properties are being entered in the program, expected values should be used, not values with factors of safety added. The program takes care of design safety with the Confidence Level Variables or with internally added factors of safety for such inputs as concrete flexural strength, tensile yield strength of steel, and subgrade support (k) value.

On the subgrade and subbase cards, the user has the option of indicating either k-value or Texas Triaxial Class Value. If one of the values is input into the program, then the other is not necessary and the variable value can be left blank. If both are input, then the program will use the subgrade k-value to structurally characterize the subgrade.

It is important that the designer carefully think through the problem. For example, the concrete overlay parameters should not be input when the designer calls for asphalt overlays to be designed. It is advisable, therefore, to plan the facility to be designed and then list the necessary data inputs on paper before proceeding with the computer input.

INPUT VARIABLES FOR RPS-3

This section focuses on the variables needed to run RPS-3. They are discussed in groups according to the input card format.

Problem Identification Variables

The first input card for RPS-3 contains the problem identification variables, NPROB and TITLE. These variables are any combination of letters and/or numbers the designer desires to use. Their function is to identify the program output for the user.

Program Controls

The second input card for RPS-3 has the variables which control the main program design function. The variables are NCS1, NCS2, NCS3, PSN1, and PSN4. Variable NCS1 allows the designer the choice of what type of pavement to design, jointed concrete (JCP), continuously reinforced concrete (CRCP), or both. Variable NCS2 gives the designer the option of determining which type of overlay the facility would have, portland cement concrete (PCC), asphaltic concrete (AC), or both. Variable NCS3 allows the designer the option of having the program design with deformed bar reinforcement, welded wire mesh reinforcement, or both. Variable PSN1 lets the designer specify that the program print out either a long or short form of output. The short output excludes reinforcement details and the involved input variable listing. Variable PSN4 is used to specify how many designs should be included in the program output. The minimum is 12 and the maximum is 23.

Traffic Growth and Distribution Variables

Card 3 of a correct RPS-3 data deck includes variables AGF, ADTGR, DDF, DFL, ADT, and WWW, which define the design traffic to be used by RPS-3. Variable AGF, the axle-growth factor, defines the percent per year of linear growth in the number of axles. The variable gives an indication of the increase of the number of axles in the traffic stream. In other words, this is an indication of increasing truck traffic. Variable ADTGR, the average daily traffic growth rate, is a linear growth rate in percent per year. This input is used by RPS-3 to determine future traffic on the facility. A normal range for this variable would be from 2 to 10 percent on a new facility. This variable may be zero percent if the facility has no traffic growth or if it is actually declining in usage.

The distribution factors, DDF and DFL, control the weight of traffic in the design lane. The directional distribution factor, DDF, is the percentage of traffic per direction to be used in design and the lane distribution factor DFL is the percentage of ADT expected in the most frequently used design lane. The next input is ADT, the initial average daily traffic expected in one direction. This is the number of vehicles per day on the planned roadway. The designer should be careful not to allow this input variable to exceed the practical capacity of 1500 vehicles per hour per lane. The final traffic variable is WWW, the total 18-kip axles expected on the facility during the analysis period. This variable is a total for both directions. All the traffic growth and distribution variables may be obtained from the Traffic Division, D-10, of the Texas Highway Department. If the information for the requested section is not available, the Traffic Section has techniques to accurately make estimates.

Designer's Restraint Variables

The designer's restraint variables are perhaps the most important inputs of RPS-3 in determining the computed designs. The variables provide limits and guidelines for the program in its generation of designs. The inputs include CMAX, TMAX, OFMIN, BOMIN, OMAXA, OMINA, OMAXC, OMINC, AP, THLEV, and ILEVEL. Table 6.1 gives the description of each of these variables and the units of the input. The values for these inputs correspond exactly to the pavement being designed. The overlay variables indicate how much overlay material will be allowed the facility to help it meet its design life, the analysis period. The average level-up thickness, THLEV, is that amount of overlay material necessary to bring the existing roadway up to a level grade. An indication of the confidence level at which the designer desires to construct the pavement is ILEVEL. For example, it may be much more important that an urban interstate freeway last its design life, than a rural interstate section. As the designer increases this confidence level, designs will generally get thicker and more expensive. The program also takes a correspondingly greater amount of time to run.

Performance Variables

The performance variables P1, P2, POV, PSS, THETA, and SACT define the serviceability life of the facility in connection with the AASHO design concept. The initial serviceability index expected for the new pavement is P1. The terminal serviceability index accepted by designers is P2, and POV is the serviceability index after an overlay. These variables define the riding quality of the pavement and all three must range in value from 0-5 (Ref 9). The probability of the common occurance of bad soil at the construction site is PSS. The swelling rate constant is THETA, and SACT is the estimated differential movement caused by swelling clay and used by the AGE2 model of RPS-3 in the prediction of the pavement section's performance life. Guidelines establishing values for these variables are given in the input guide in Appendix 3.

TABLE 6.1. DESIGNER RESTRAINT VARIABLES

Variable	Descriptive Title	Units
CMAX	Maximum funds available for initial construction	Dollars per square yard
TMAX	Maximum allowable thickness, slab plus subbase	Inches
OFMIN	Minimum allowable time to the first overlay	Years
BOMIN	Minimum allowable time between overlays	Years
OMAXA	Maximum total asphalt concrete overlay thickness	Inches
OMINA	Minimum total asphalt concrete overlay thickness at one time	Inches
OMAXC	Maximum total portland cement concrete overlay thickness	Inches
OMINC	Minimum total portland cement concrete overlay thickness at one time	Inches
AP	Length of analysis period	Years
THLEV	Average level-up thickness	Inches
ILEVEL	Confidence level desired for design	Percent

Traffic Delay Cost Variables

The traffic delay cost variables are used by subroutine TDC3 to determine the costs associated with pavement overlays. Research Report 32-11 (Ref 4) discusses the development of these models and Chapter 3 discusses their modification in RPS-3. The 15 input variables associated with traffic delay cost are well documented in the Input Guide in Appendix 3. All necessary comments on boundary conditions are listed.

Concrete Variables

The concrete variables of RPS-3 define the specific mix designs to be used in the section design. The variables are NC, ND, NP, SX, WC, E, TS, CIC, CPCYC, CSC, and PSVC.

NC	indicates how many different types of concrete the program will use for design up to a maximum of six types,
ND	indicates the number of days at which the flexural test was made on the concrete sample,
NP	indicates the number of loading points used in flexural strength testing,
SX	indicates the concrete average flexural strength,
WC	indicates the unit weight of the concrete,
E	indicates the modulus of elasticity of the specific design,
TS	indicates the tensile strength of the mix and are descriptive of each of the concrete types. A data card is made up for each concrete type.
CIC	indicates the equipment cost per lane mile for concrete placement,
CPCYC	indicates the cost per cubic yard of concrete,
CSC	indicates the cost per lane mile for surfacing the concrete and are descriptive of each concrete design mix cost, and
PSVC	indicates the final concrete input and gives an indication of the percent of salvage value of the concrete at the end of the analysis period. For example, the material would be beneficial as a base course for another road or as a fill material if torn out.

Concrete Dimension Variables

The concrete dimension variables TCMIN, TCMAX, and CINC define the concrete design thickness limits. The minimum allowable concrete thickness, TCMIN must be greater than 6.0 inches. The maximum allowable concrete thickness, TCMAX, has no established maximum value. The practical increment at which concrete can easily be poured is CINC; this is the increment at which RPS-3 makes its solutions. This variable should be no less than 0.50 inch. It must be realized by the designer using the program that changing the increment thickness from 1.0 inch to 0.5 inch will double the total amount of designs analyzed.

Subgrade Material Variable

Variables SGK, TTC, FFSG, EFSG, and CPLMSG are descriptive information of the subgrade material at the construction site. The subgrade k-value SGK, and the Texas Triaxial Class Value, TTC, may be used interchangeably in RPS-3. If both are input, SGK will be used. Variable SGK is in units of pounds per cubic inch, while TTC is a unitless value. Variable FFSG, the factor for friction between the subgrade and the concrete, and EFSG, the erodibility factor, are analogous to the friction factor and erodibility factor of the subbase and will be discussed later. Both are left zero unless the designer wishes to design the pavement to rest directly on the subgrade and then both must be input. The cost per lane mile of subgrade preparation is CPLMSG and is input in the units of dollars.

Subbase Material Variables

The subbase material variables are NSB, the number of subbases; NAME, the subbase descriptive title; EF, the subbase erodibility factor; FFSB, the subbase friction factor; ES, the subbase elastic modulus; CIS, the equipment cost per lane mile for initial subbase construction; CPCYS, the cost per cubic yard of compacted subbase; PSVS, the percent salvage value of the subbase; TSMIN, the minimum subbase thickness; TSMAX, the maximum subbase thickness; and SINC, the thickness increment for subbase solutions. In the design case mentioned earlier, a pavement designed upon the subgrade, all subbase inputs may be left zero. A 1 placed in column 5 for the NSB variable will notify the program of this particular design option.

When designing with subbase material, up to four different subbase materials may be input into RPS-3 at once.

An explanation of the erodibility factor and the friction factor is included in the User's Manual in Appendix 3. The practical increment at which the subbase may be placed and solutions made, SINC, should have a minimum value of two inches for a granular subbase and one inch for a stabilized subbase.

Steel Material Variable

There are four cards which give design information for the reinforcing steel. These cards are for longitudinal bar steel, transverse bar steel, wire mesh steel, and tie bar steel. A maximum of four different steel types may be given in each category. For each steel type, the designer must give an identification number, the tensile yield point of the steel, and a cost per pound of the steel. The bar steel information may be excluded if the designer has specified, with the control variable NCS3, a design with mesh steel only. The opposite is also true; if the designer wishes to design with deformed bar steel, then the wire mesh and tie bar steel cards may be deleted.

Steel Size Variables

There are three sets of variables which provide RPS-3 with the steel sizing infomation. The first set of variables, BARN, are the bar numbers which the program uses for reinforcement design. The second set of variables is the SL and ST variables, which are the longitudinal and transverse spacings of the welded mesh wires. The final group of variables are the TBARN variables, the bar numbers to be used for the tie bars. As with the reinforcing material cards, the unrelated inputs may be omitted. A maximum of four values for BARN, SL, ST, and TBARN inputs may be used.

Overlay Variables

The overlay material data are given by eight variables: CIOV, the equipment cost per lane mile for asphalt-concrete overlays; CPSYC, the cost per cubic yard of compacted AC overlay; PSVAC, the percent salvage value of the

AC overlay material; ACE, the asphaltic concrete modulus value; ACRP, the production rate of AC; CPR, the concrete production rate; COEF, the United States Army Corps of Engineers concrete coefficient; and CPSYR; the cost per square yard of overlay construction.

The only variable which needs any explanation is COEF, the Corps of Engineers concrete coefficient. COEF ranges from an input of 0.35 for badly cracked slabs to 1.0 for slabs in excellent condition. This input is an indication of how a concrete overlay will perform, depending on the existing slab condition.

Overlay Construction Data

The overlay construction variables, N1, N2, NDAYCU, ALANES, and OVERLEN were added to the traffic delay subroutine TDC3 to define the overlay construction more clearly. N1 and N2 are respectively the beginning and ending hour of overlay construction in military time. The number of days which a concrete overlaid facility must cure before it can accept traffic is NDAYCU. An explanation of the variable is included in Chapter 3. The number of lanes to be overlaid, ALANES, and the length of the overlaid section in one lane, OVERLEN, are used to determine the total number of square yards to be overlaid. An explanation of how these variables should be used is included in the User's Manual in Appendix 3.

Joint Variables

The joint variables are used by RPS-3 to calculate the cost of joint construction and joint spacing. The cost per foot of a transverse joint dowel's sawing and sealing is CPFTJ; CPFLJ is the cost per foot of longitudinal joints; SLV is the spacing RPS-3 will try for the lower value of jointed concrete pavement joints; and SUV is the upper value of joint spacing. The increment at which RPS-3 tries solutions for joint spacing is SPINC, and NJM is the number of construction joints per mile of CRCP. The value of NJM must be greater than or equal to zero.

Maintenance and Miscellaneous Varibles

The variables used in the RPS-3 maintenance subroutine MANCE are DFTY, CLW, CERR, and CMAT. DFTY is the number of days in the year with freezing temperature, CLW is the composite labor wage; CERR is the composite maintenance equipment rental rate; and CMAT is the cost of the maintenance material. There are guidelines for input values of these variables in the Input Guide. Additional variables to be input on the same data card are RINT, the rate of interest for money; WL, the width of the traffic lanes; and NLT, the total number of lanes in both directions at the facility.

Confidence Level Variables

The confidence level variables are used in RPS-3 for stochastic input into the design process. The variables are PSXSD, the percent coefficient of variation of flexural strength; ESD, the standard deviation of elastic modulus; XKSD, the standard deviation of the subgrade K; XJSD, the standard deviation of the continuity factor J; P1SD, the standard deviation of the initial serviceability index; P2SD, the standard deviation of the terminal serviceability index; and DSD, the standard deviation of concrete thickness. Table 6.2 gives the results of a study of 56 concrete projects (Ref 10). As the data show, 89 percent of the projects studied had a coefficient of variation, PSXSD, of less than 15 percent. Table 6.3 gives the results of a variability of deflections study (Ref 11). These standard deviations of the continuity factor J , variable XJSD in RPS-3, should be used as inputs into RPS-3 because they are the best currently available. The standard deviation of concrete thickness, DSD, shown in Table 6.4, is from Reference 10. The modulus of subgrade reaction K , was found to have an increasing standard deviation as the mean K increased (Ref 10). The overall standard deviation of K for the 59 study sections was reported to be 187 psi (Ref 10).

A study of 32 selected sections by Darter and Kher (Ref 10) produced two additional variable ranges and standard deviation values. For concrete elastic modulus, the mean range was 3×10^6 to 5×10^6 psi and the coefficient of variation was 15 percent. The initial serviceability index standard deviation, P1SD, was reported was 0.3.

The final confidence level variable P2SD has a standard deviation of the same magnitude as P1SD.

TABLE 6.2. CONCRETE FLEXURAL STRENGTH

Quality Control Standard	Percent Coefficient of Variation	Percent Projects
Excellent	Below 10	25
Good	10 to 15	64
Fair	15 to 20	7
Poor	Above 20	4

TABLE 6.3. STANDARD DEVIATION OF THE CONTINUITY FACTOR J

Value of J	Description	Standard Deviation in J
3.2	Jointed pavement without load transfer units	0.13
2.2	Continuously reinforced pavements	0.19

TABLE 6.4. STANDARD DEVIATION OF CONCRETE THICKNESS

Nominal Concrete Pavement Thickness in Inches	Standard Deviation	Number of Projects
8	0.32	14
9	0.29	8
10	0.29	5

SUMMARY OF COMMON USER ERRORS

An effort is made here to document the most common errors made by users of the rigid pavement design system program RPS-3 so that the user will be able to diagnose and avoid mistakes. Some of the blunders are subtle, and unless the user is familiar with their characteristics, they are extremely difficult to analyze. The program does give certain error messages which will help the user. The errors will be divided and discussed with respect to the types of variables involved. For example, there are certain errors associated with the traffic variables. Where at all possible, a figure or computer output sheet is used to show the user what information he will receive if he makes a mistake.

Errors Caused by Traffic Variables

The traffic variables in RPS-3 are very sensitive at high levels and will cause many different types of errors. The most common error occurs when the average daily traffic (ADT) exceeds the capacity of the facility. The ADT in one direction should not be large enough to exceed the practical capacity of 1500 vehicles per hour per lane. The errors are subtle in nature because this ADT is increased until the time of an overlay and is then used in calculating the traffic delay cost. If the ADT is too large and exceeds capacity, the program will automatically correct the problem by setting the RECVPH variable to a minimum value of 1 . A user can recognize that the program has done this because the user costs will be exorbitantly high in the magnitude of hundred of dollars per square yard. If the ADT exceeds practical capacity, the RECVPH will be a negative value and this causes the program to set RECVPH to 1 . This is done because a negative value will give unrealistic negative traffic delay costs.

Errors Caused by Decisions or Constraints

The inputs which reflect the designer's decisions on how the pavement can be built generally cause time limit errors for the program. For example, if the designer uses the option available to him and designs with a confidence level of 99.99 percent, then he must realize that the program will take an enormous amount of computational time formulating the designs to meet this restriction. If the designer chooses a confidence level of 80 percent, which is less restrictive, then the program will compute the strategies in less time.

An analysis of the initial designs and overlay designs is supplied the user at the end of the computer output for every problem. The designer can ascertain why the largest proportion of designs are being rejected and correct the erroneous input whether, for example, it be maximum funds available or any of the other restraints.

Finally, if the designer inputs the designer's constraint, maximum total thickness of initial construction, and it is less than the sum of maximum concrete thickness and the maximum subbase thickness, the program will be restricted and unable to generate any designs.

Errors Caused by Performance Variables

There are limitations placed upon the performance variables, and, if the program has failed to run, it is advisable to check the performance inputs, initial serviceability index, terminal serviceability index, and serviceability index after an overlay. The initial serviceability index must be less than 4.5 and the final serviceability index should be greater than 1.5. In some cases, the program may run with the variables outside these limits, but due to the method of the performance model derivation, the results calculated would be unrealistic.

Errors Caused by Concrete Dimensions

If the value of the practical increment for pouring concrete, which is the increment at which the design strategy solutions are made, is less than 0.5-inch, the user should be aware of the fact that the program will use a large amount of computational time.

Errors Caused by Subbase Variables

If the designer wishes to place the pavement directly upon the subgrade with no subbase, the program allows this design strategy to be calculated. However, if the designer has left the subbase card completely blank, the program will not function because of a time limit error. To correct this, the designer needs to put a 1 in column five on the subbase information card and leave the remainder of the card blank. A correct output will look like Fig 6.2. The negative zeroes shown on Fig 6.2 should not worry the user; they are acceptable and the output is correct.

Errors Caused by Overlay Variables

The RPS-3 program will allow the designer to overlay the pavements with asphalt concrete, portland cement concrete, or both. In any event, if the designer fails to give the specific overlay variables needed for each particular type of overlay, the computer will be unable to run the solutions. The United States Army Corps of Engineers concrete coefficient is the one main variable which causes errors. It has a minimum value limit of 0.35 and a maximum value limit of 1.0.

Errors Caused by Joint Information

The most common error for the user with respect to the joint design information occurs when the number of transverse construction or warping joints per mile variable for CRCP is input equal to zero. This input must be greater than zero, otherwise the program will not run.

SUMMARY

The User's Manual which this chapter outlines, has been used and checked numerous times. It is felt that the description of the different variables, deck arrangement, and common user errors will be beneficial to the RPS-3 user. The User's Manual described in this chapter is in Appendix 3 of this report. Chapter 7 outlines a sample problem complete with input coding sheets, output, and discussion.

```
RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER          JAN 1973
PROB     8       TRIAL USE OF INPUT GUIDE BY FRANK CARMICHAEL   18 FEB 74

          SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER                        1        2        3        4
*****************************************************************
PAVEMENT TYPE                      CRC      CRC      CRC      CRC
OVERLAY  TYPE                       AC       AC       AC     NONE
REINFORCEMENT TYPE                MESH     MESH     MESH     MESH

CONCRETE TYPE                        1        1        1        1
SUBBASE  TYPE                        1        1        1        1
*****************************************************************

SLAB THICKNESS                   10.00     9.00     9.00    12.00
SUBBASE THICKNESS                -0.00    -0.00    -0.00    -0.00

OVERLAY + LEVEL UP 1              4.00     4.00     7.00
OVERLAY + LEVEL UP 2                       4.00

INITIAL LIFE                     10.52     5.60     5.60    29.10

PERFORMANCE LIFE 1               24.30    13.83    21.24
PERFORMANCE LIFE 2                        27.72

TOTAL PERFORMANCE LIFE           24.30    27.72    21.24    29.10


SPACING TRANS. JOINTS                R        R        R        R
SPACING LONG. JOINTS             12.00    12.00    12.00    12.00
*****************************************************************

COST OF SUBG. PREPARATION         .142     .142     .142     .142
COST OF CONCRETE                 1.837    1.670    1.670    2.170
COST OF SUBBASE                  0.000    0.000    0.000    0.000
COST OF REINFORCEMENT            2.061    1.855    1.855    2.474
COST OF JOINTS                    .680     .680     .680     .680
COST OF TIE BARS                  .052     .047     .047     .062

INITIAL CONST. COST              4.772    4.394    4.394    5.528
OVERLAY CONST. COST               .558    1.247    1.356    0.000
TRAFFIC DELAY COST                .095     .203     .216    0.000
MAINTENANCE COST                  .377     .153     .450    1.307
SALVAGE RETURNS                  -.215    -.272    -.272    -.172
ANY ADDITIONAL COST              5.000    5.000    5.000    5.000

*****************************************************************
TOTAL COST PER SQ YARD      10.635   10.831   11.261   11.663
*****************************************************************
```

Fig 6.2. Correct design of slab on subgrade.

CHAPTER 7. SAMPLE RPS-3 PROBLEM

This chapter explains the sample problem coding sheets and computer output produced by the input given in Appendix 2. The purpose of this information is to give the user a complete example of what a typical RPS-3 problem input and output looks like and to help familiarize the user with how to use the program. The example is also helpful to the user as a reference guide for coding a problem.

CODING SHEETS

The two coding sheets in Appendix 2 are all that is necessary for one complete problem. Any number of additional problems may be coded and placed together in one computer run. The lead problem description card of the next problem simply follows the confidence level variables of the preceding problem. Following the last confidence level card of the last problem, an end-of-file card will terminate the program. The example problem is for an eight lane urban freeway.

The example problem uses a confidence level of 95 percent and designs for an analysis period of 20 years. The example uses all the different combinations: continuously reinforced concrete (CRCP), jointed reinforced concrete (JCP), portland cement concrete overlays (PCC), and asphalt concrete overlays (AC); and deformed bar and wire mesh reinforcements. The program input consists of the maximum number of concrete and subbase types.

PROBLEM OUTPUT

The computer output produced by the sample problem coded is also included in Appendix 2. The output prints out all the input variables. The variables are grouped in the same categories listed in Chapter 6 under the discussion of input variables. Even though the output is in a slightly different order than the input guide, the designer should have no trouble in locating the variables to check the input.

Once the program has completed a printing of the input variables, it begins to loop through the solutions. There are error messages which will be printed out in certain cases of input error. Once the program has completed the design work, subroutine OUTPUT begins to print out the design information. First, the most economical pavement of each combination is printed. For example, in the sample problem, the most economical JCP with an AC overlay is printed first, followed by the most economical JCP with a CC overlay, CRCP with AC overlay, and CRCP with CC overlay, in this order. Also printed next is the most economical initial design which lasts the entire analysis period without an overlay. For each economical design, all the design information is printed, including performance lives, thicknesses, material identifications, reinforcement plans, overlay strategies, and all the costs. If the short form of output switch is called on the program control card, then the reinforcement information and the most economical design summary sheets are deleted from the output, and only the summary tables are printed out.

Following the summary of the most economical design in each class is a complete summary of the designs in increasing order of total cost. The most economical designs of each category are also included in these summary tables. However, if one type of design is more economical in all cases, up to 23 designs, then the other categories will not appear. For example, in the sample output of Appendix 2, the most economical CRCP with CC overlay was printed out as costing \$11.80 per square yard. This design, however, does not appear on the summary tables because the 23rd design, a JCP with AC overlay, cost only \$11.27 and this was the final design printed in the summary table. However, the most economical CRCP with an AC overlay is included in the summary tables as design number 12, costing \$11.10.

Six designs are printed for each summary table page. Each successive page contains the reinforcement design information for the six preceding designs on the summary table.

An overall analysis of all the designs shows that there are no designs with CC overlays in the most economical 23 designs in the summary tables. This stems from the new models which take into account the traffic delay costs of CC overlays. For example, the traffic delay cost of the most economical CRCP with a CC overlay was \$.65 per square yard, while the most economical

CRCP with an AC overlay of the same thickness incurred a traffic delay cost of only $.025 per square yard. This one cost accounted for almost all the difference in the costs of these two designs. Another factor which is noticeable is that only designs with mesh reinforcement are printed out in the summary tables. However, in checking the reinforcement inputs, it can be seen that the mesh steel inputs show lower costs per pound for the steel. These costs may not accurately reflect today's fluctuating market values; however, they do indicate how the program is influenced by the costs which the designer inputs.

The final page of output is an analysis of the problem for the user. This summary design analysis gives the user information on why the majority of the designs were rejected. This is helpful to the designer in allowing the selection of variables which may be unnecessarily restrictive to the design. The sheet summarizes the initial design stage of the RPS-3 and the overlay design stage of the RPS-3. The sheet also gives the total number of designs which were optimized to produce the number of economical outputs to desired by the designer.

The total cost of each design is a per square yard cost and is a present worth value of all the initial and future costs.

This sample problem should be used as a trial coding by a person unfamiliar with RPS-3.

CHAPTER 8. SUMMARY AND FUTURE RESEARCH

The major goal of this study, the development of a modified rigid pavement design program, has been accomplished. The major accomplishments of this work have been (1) the modification of the traffic delay cost model so that it more correctly predicts costs, (2) the modularization of the program to provide easier future change, and (3) the preparation of additional contributions for implementation of the new program; including an input guide, a discussion of common user errors, an implementation study and recommendations for future pilot uses, and a sample problem for reference.

In addition to the traffic delay cost model modification, certain other models were studied including the concrete flexural strength model and the maintenance model. Recommendations are given concerning possible future changes. The traffic load model was deleted from RPS-3 input, but the model can be easily replaced if needed. The seal coat model was also deleted. The input and output format models were modified to provide for clearer variable identification. The modularization made RPS-3 more changeable and understandable. Not only is each new subroutine flowcharted, but a complete description of its function is included. This type of documentation makes RPS-3 better from a computer programming standpoint. Also, future modifications will be easier to make.

The implementation tools significantly improve the usefulness of the program. A step-by-step procedure to follow for RPS-3 is included in the sample problem input forms. The implementation study gives the complete results of a specific trial design problem. The results of the study indicate the RPS-3 program accurately predicts pavement life and reasonably designs roadway sections. The summary of common errors is thought to be one of the most beneficial implementation tools provided in this report. This type of analysis should be made with every new design program. The major obstacles to RPS-3 implementation are considered to have been overcome with this study and a realistic observation should be taken as to the feasibility of beginning the program introduction into Texas Highway Department design offices.

FUTURE RESEARCH RECOMMENDATIONS

There are three major areas of work that should receive priority in future RPS-3 development.

(1) An all-out effort should be made to implement this program into use in the highway design field.

(2) The models which determine pavement costs should be modified to include the entire cross-section design models (Ref 12).

(3) The models of RPS-3 which design steel reinforcement should be modified to make design more accurate, taking into account developments in NCHRP Report 1-15 (Ref 8) and Project 3-8-75-177 entitled, "Development and Implementation of the Design, Construction of the Design, Construction and Rehabilitation of Rigid Pavements.

It would be a mistake not to begin a pilot study to implement RPS-3, because the program was developed for this major purpose. The two model changes suggested would greatly improve the realistic way in which RPS-3 approaches the systematic design of rigid pavement.

CONCLUSIONS

The development of RPS-3 has led to a number of conclusions concerning past, present and future rigid pavement systems design.

(1) From a computer programming stand point, RPS-3 is the most acceptable program available.

(2) The implementation of RPS-3 is esstntial to continuance of the rigid pavement design system. This conclusion stems from the theory that feedback from highway engineers will be extremely useful for guidance of future RPS-3 updating.

(3) The traffic delay cost subroutine, TDC, has been improved to realistically predict concrete overlay curing costs.

(4) The traffic study of ADT distribution throughout the complete day should be useful to other areas of the systematic approach to pavement design.

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5. "1973 Annual Report of Permanent Automatic Traffic Recorders," an annual report published by the Texas Highway Department in cooperation with the United States Department of Transportation Federal Highway Administration, 1973.
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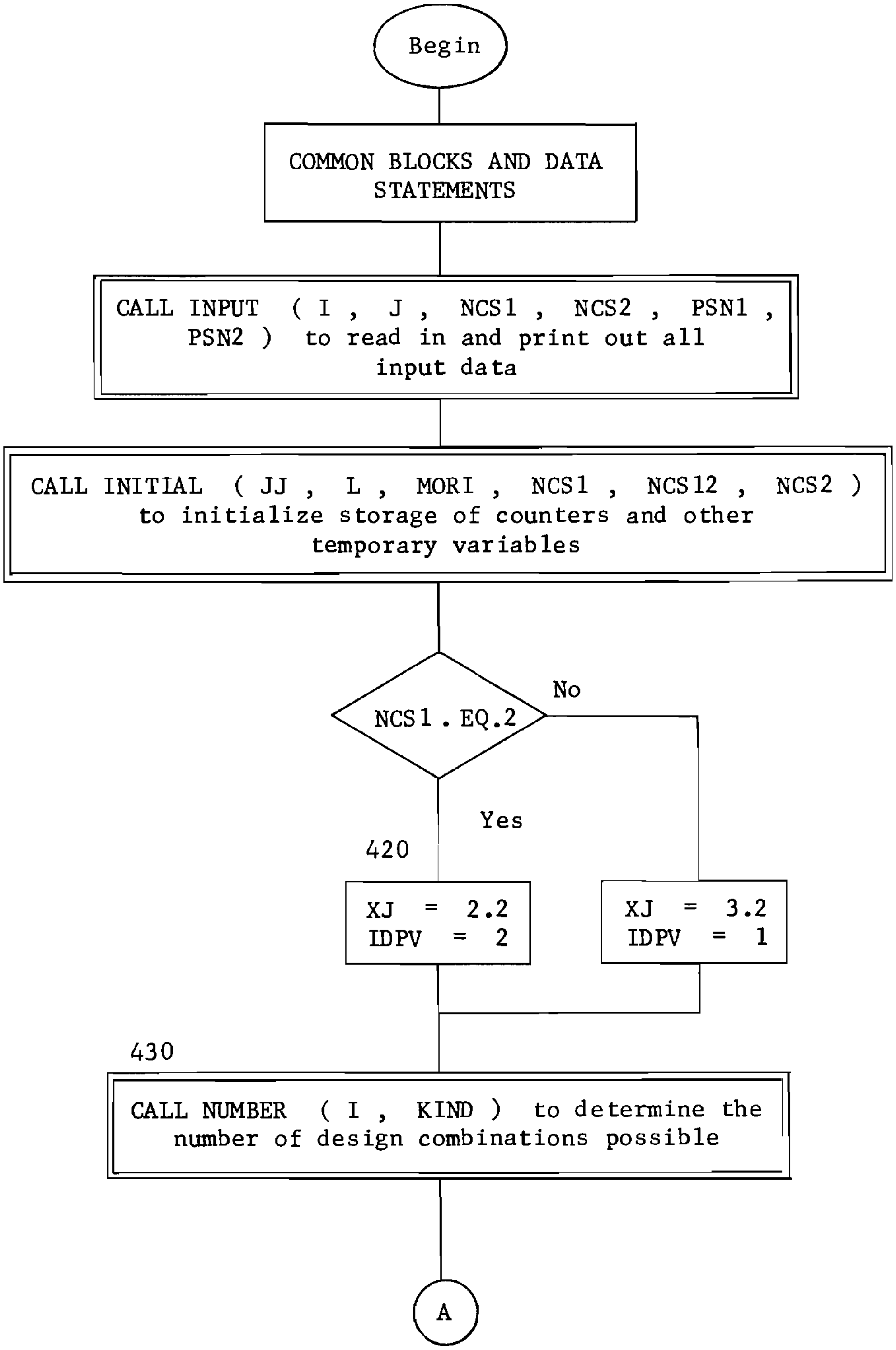
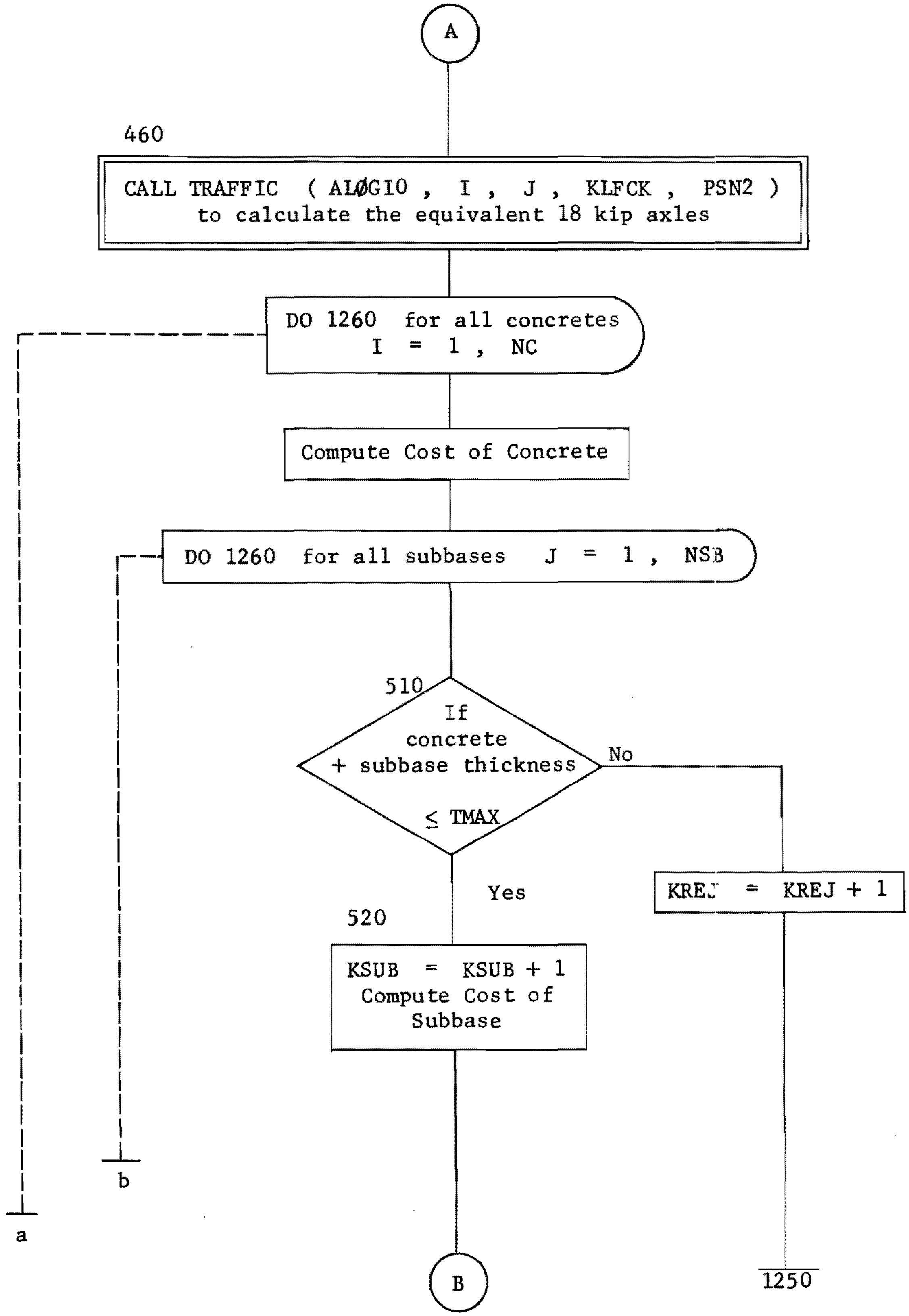
11. Treybig, H. T., B. F. McCullough and W. R. Hudson, "Sensitivity Analysis of the Extended AASHO Rigid Pavement Design Equation," Highway Research Record No. 329, Highway Research Board, 1970.

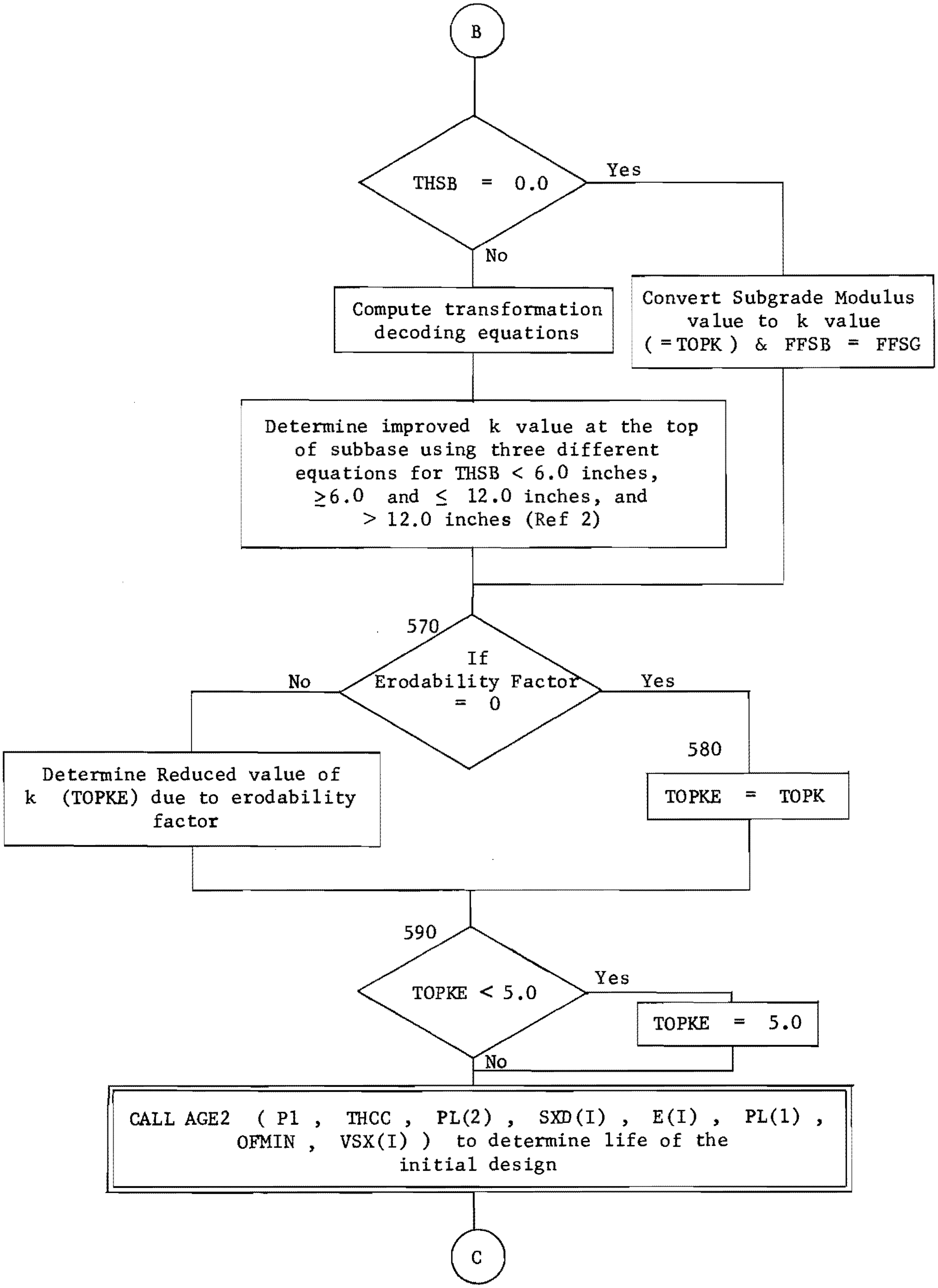
12. "Systems Approach to Pavement Design - Implementation Phase, NCHRP Report 1-10A, Highway Research Board, September 1973.

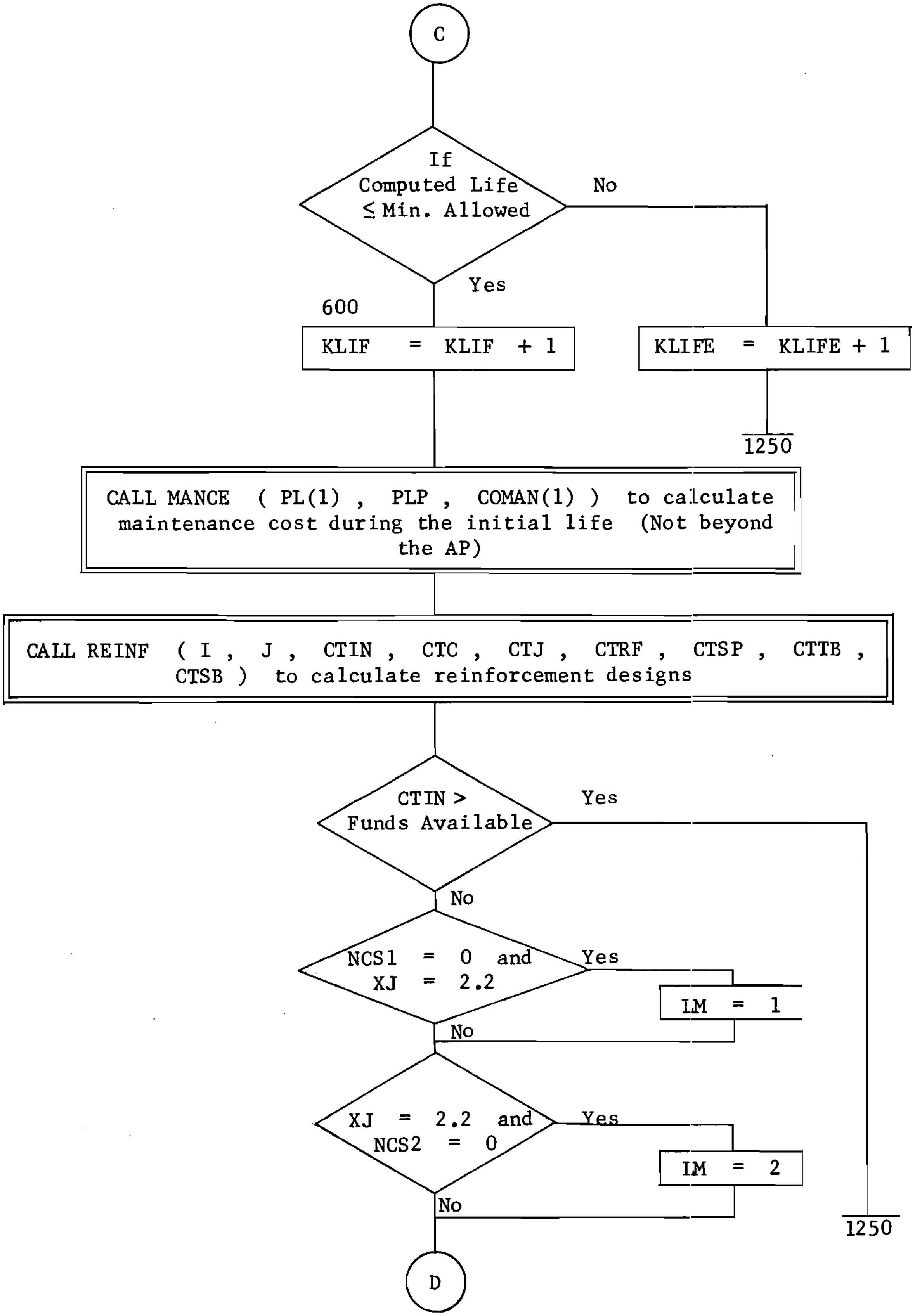
APPENDIX 1

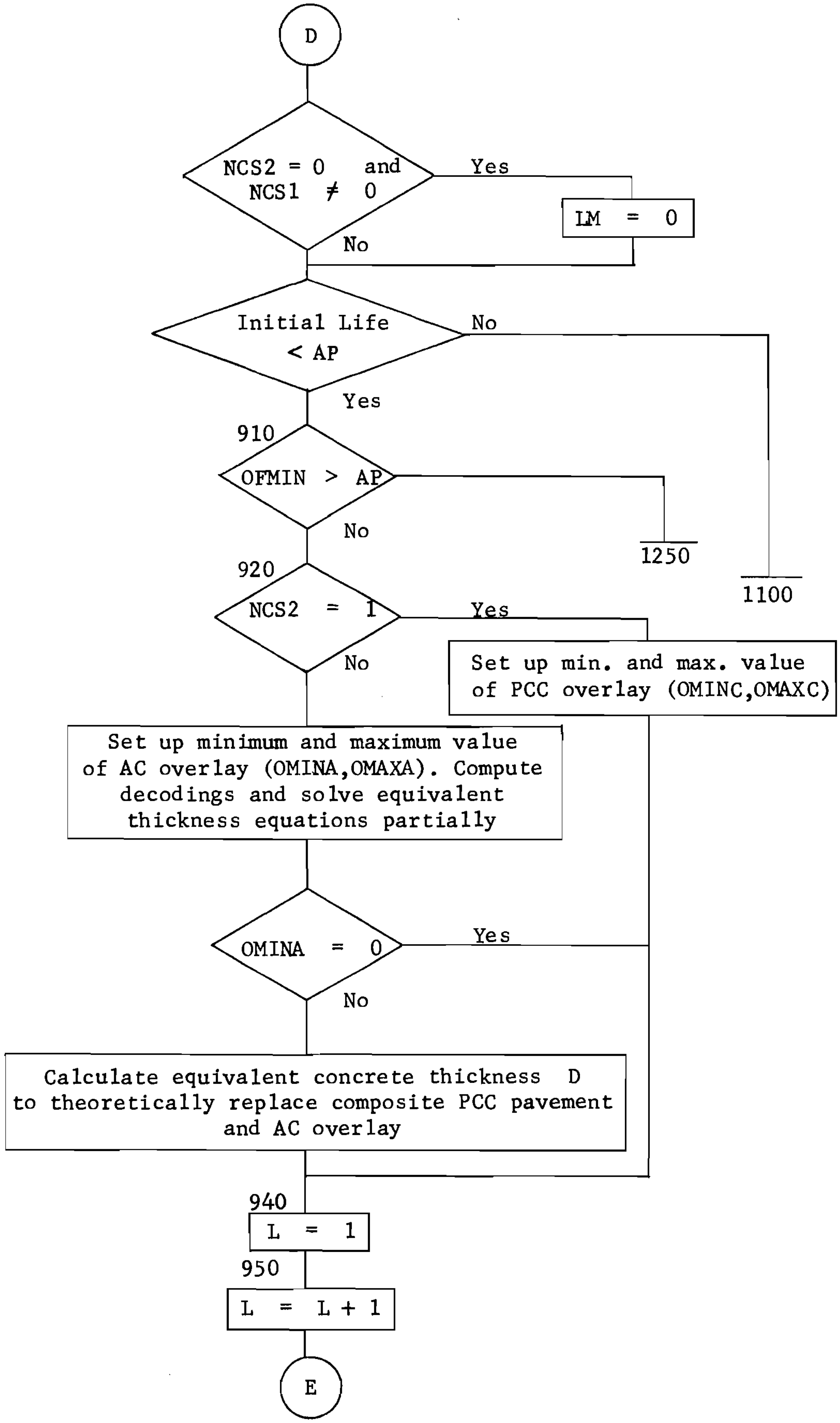
FLOW DIAGRAM FOR PROGRAM RPS-3

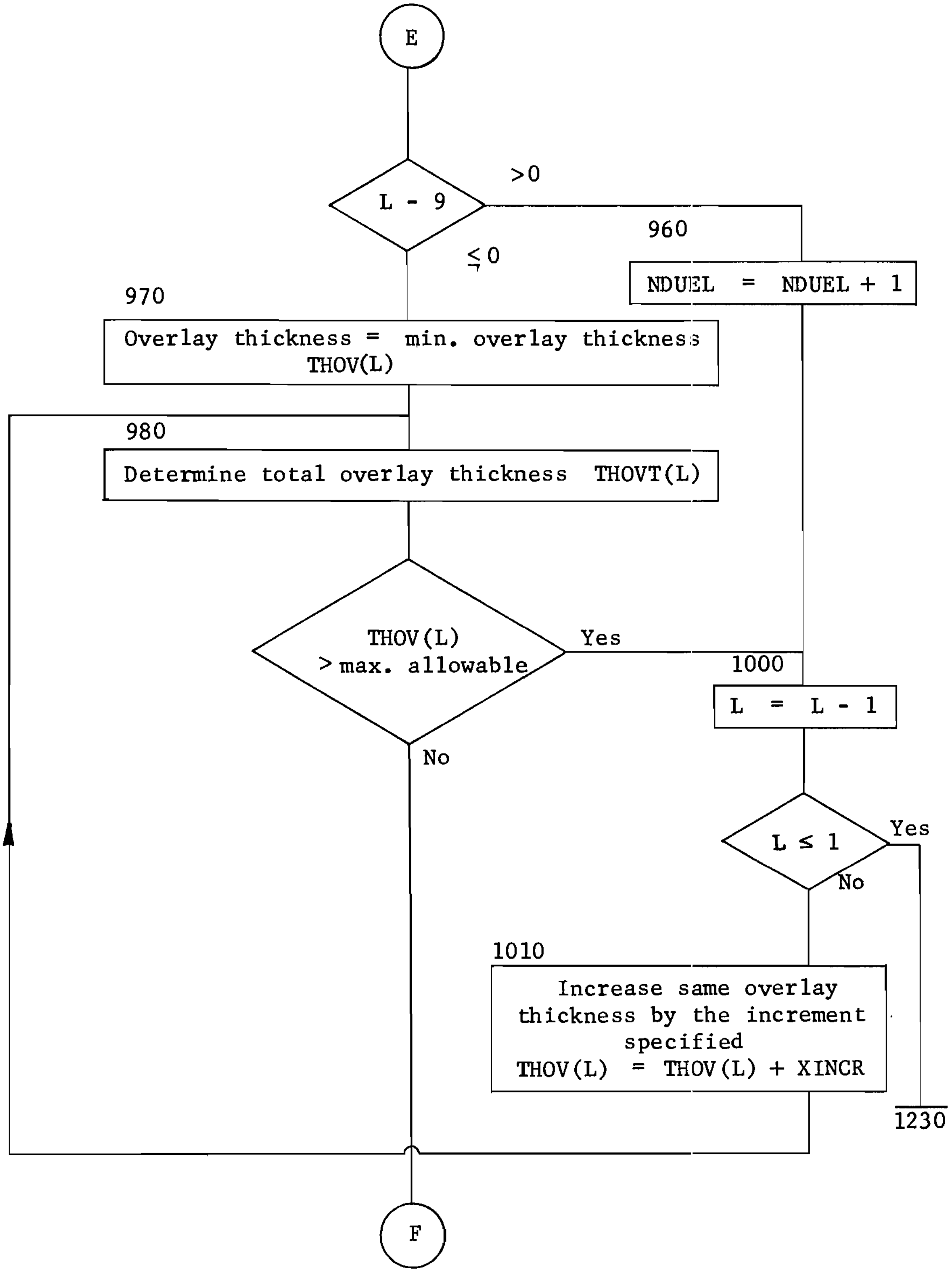

Begin
COMMON BLOCKS AND DATA STATEMENTS
CALL INPUT (I , J , NCS1 , NCS2 , PSN1 , PSN2) to read in and print out all input data
CALL INITIAL (JJ , L , MORI , NCS1 , NCS12 , NCS2) to initialize storage of counters and other temporary variables
NCS1 . EQ.2
No
Yes
420
XJ = 2.2
IDPV = 2
XJ = 3.2
IDPV = 1
430
CALL NUMBER (I , KIND) to determine the number of design combinations possible
A

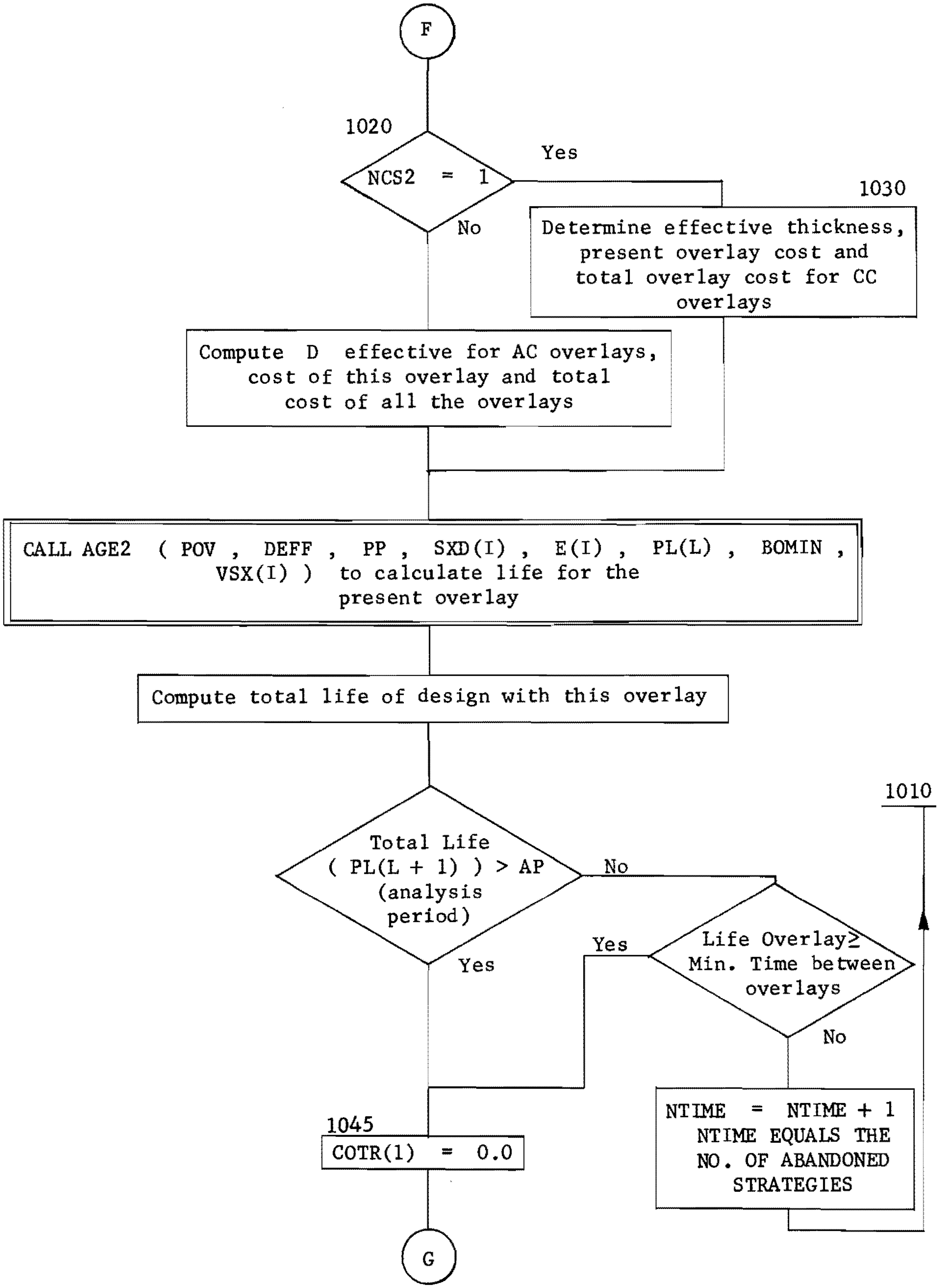

A
460
CALL TRAFFIC (ALØGIO , I , J , KLFCK , PSN2)
to calculate the equivalent 18 kip axles
DO 1260 for all concretes
I = 1 , NC
Compute Cost of Concrete
DO 1260 for all subbases J = 1 , NSB
510
If
concrete
+ subbase thickness
≤ TMAX
No
Yes
520
KSUB = KSUB + 1
Compute Cost of
Subbase
KREJ = KREJ + 1
b
a
B
1250

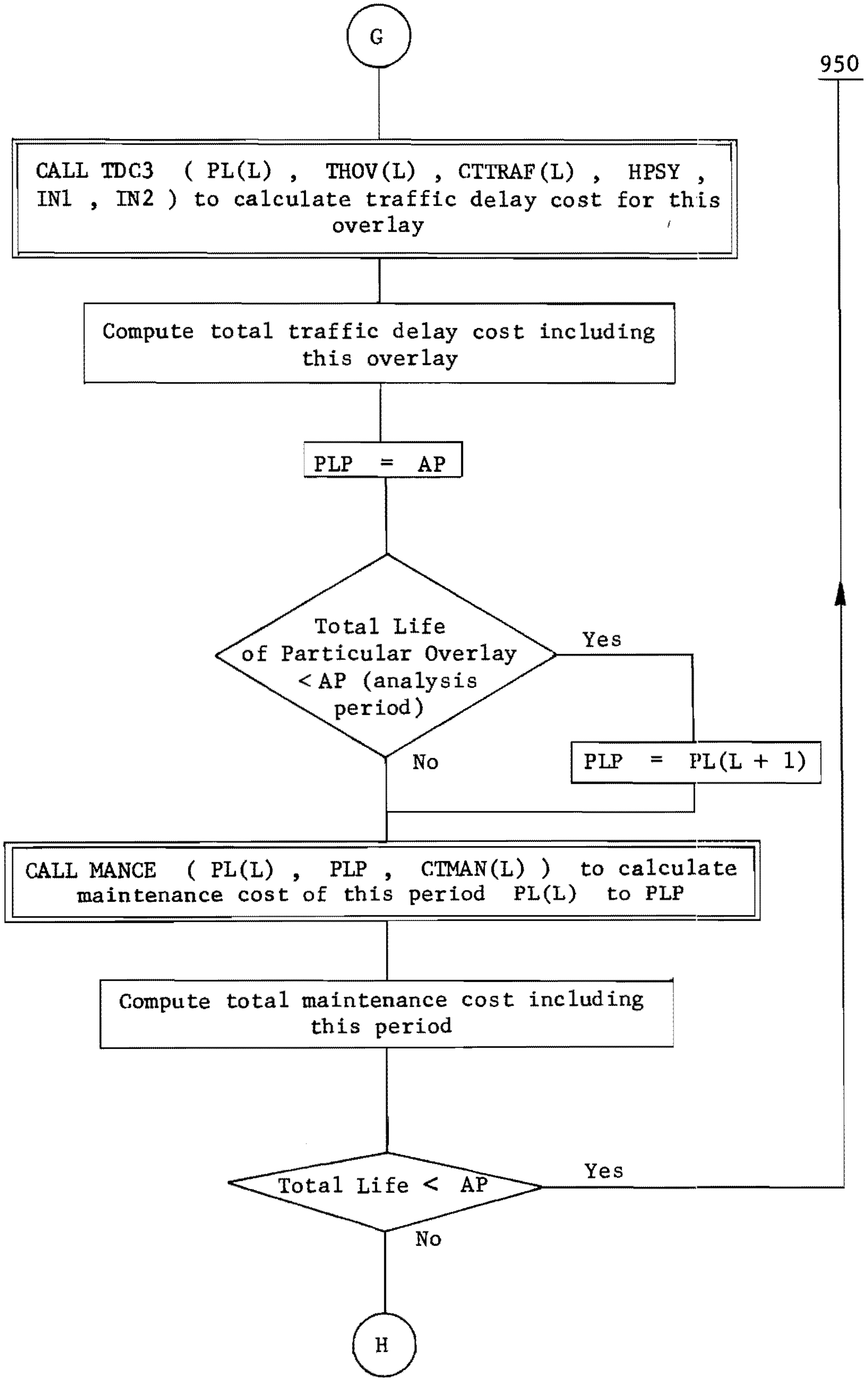

B
THSB = 0.0
Yes
No
Compute transformation decoding equations
Convert Subgrade Modulus value to k value (= TOPK) & FFSB = FFSG
Determine improved k value at the top of subbase using three different equations for THSB < 6.0 inches, ≥6.0 and ≤ 12.0 inches, and > 12.0 inches (Ref 2)
570
If Erodability Factor = 0
No
Yes
580
Determine Reduced value of k (TOPKE) due to erodability factor
TOPKE = TOPK
590
TOPKE < 5.0
Yes
TOPKE = 5.0
No
CALL AGE2 (P1 , THCC , PL(2) , SXD(I) , E(I) , PL(1) , OFMIN , VSX(I)) to determine life of the initial design
C

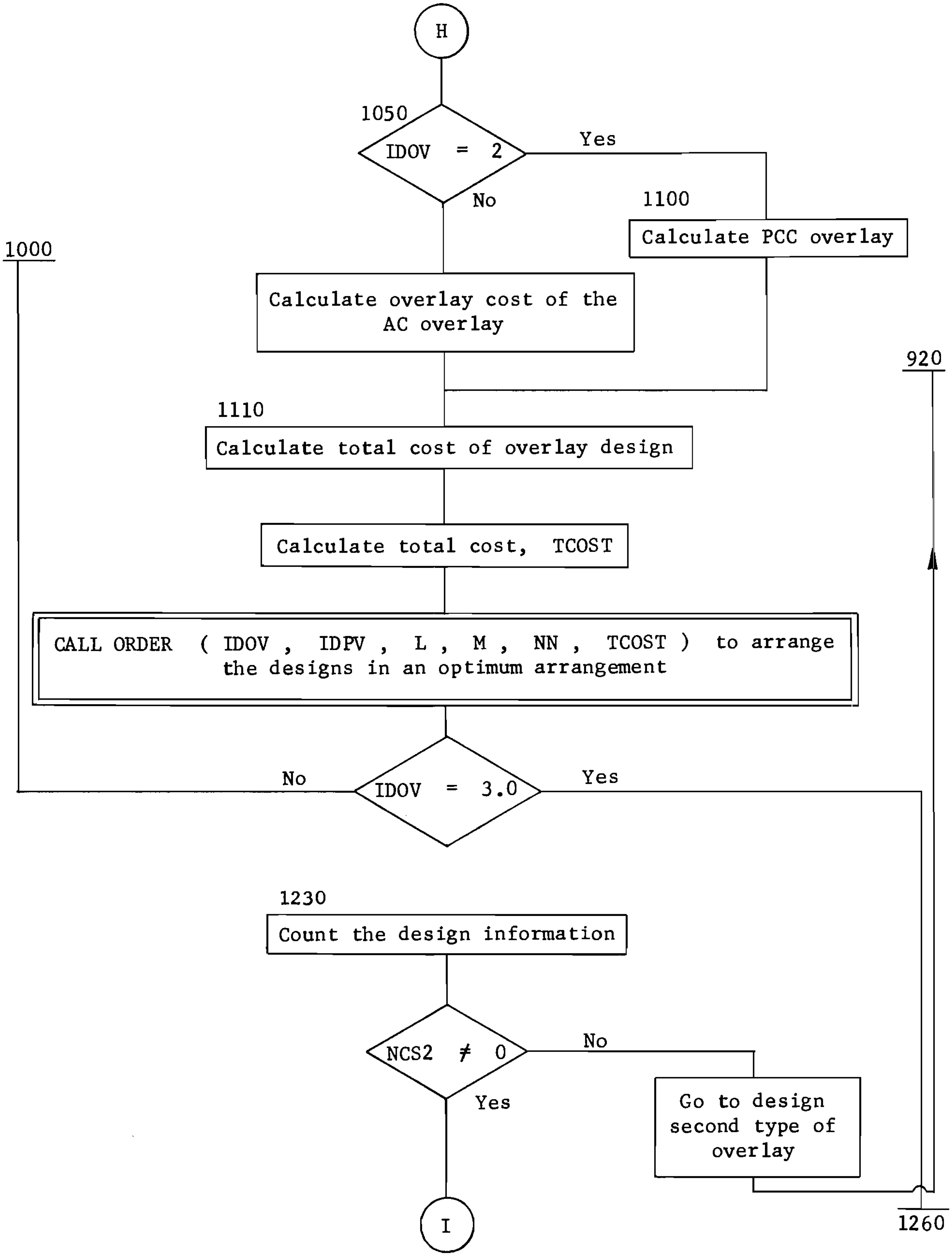

C
If
Computed Life
≤ Min. Allowed
No
Yes
600
KLIF = KLIF + 1
KLIFE = KLIFE + 1
1250
CALL MANCE (PL(1) , PLP , COMAN(1)) to calculate maintenance cost during the initial life (Not beyond the AP)
CALL REINF (I , J , CTIN , CTC , CTJ , CTRF , CTSP , CTTB , CTSB) to calculate reinforcement designs
CTIN >
Funds Available
Yes
No
NCS1 = 0 and
XJ = 2.2
Yes
IM = 1
No
XJ = 2.2 and
NCS2 = 0
Yes
IM = 2
No
1250
D

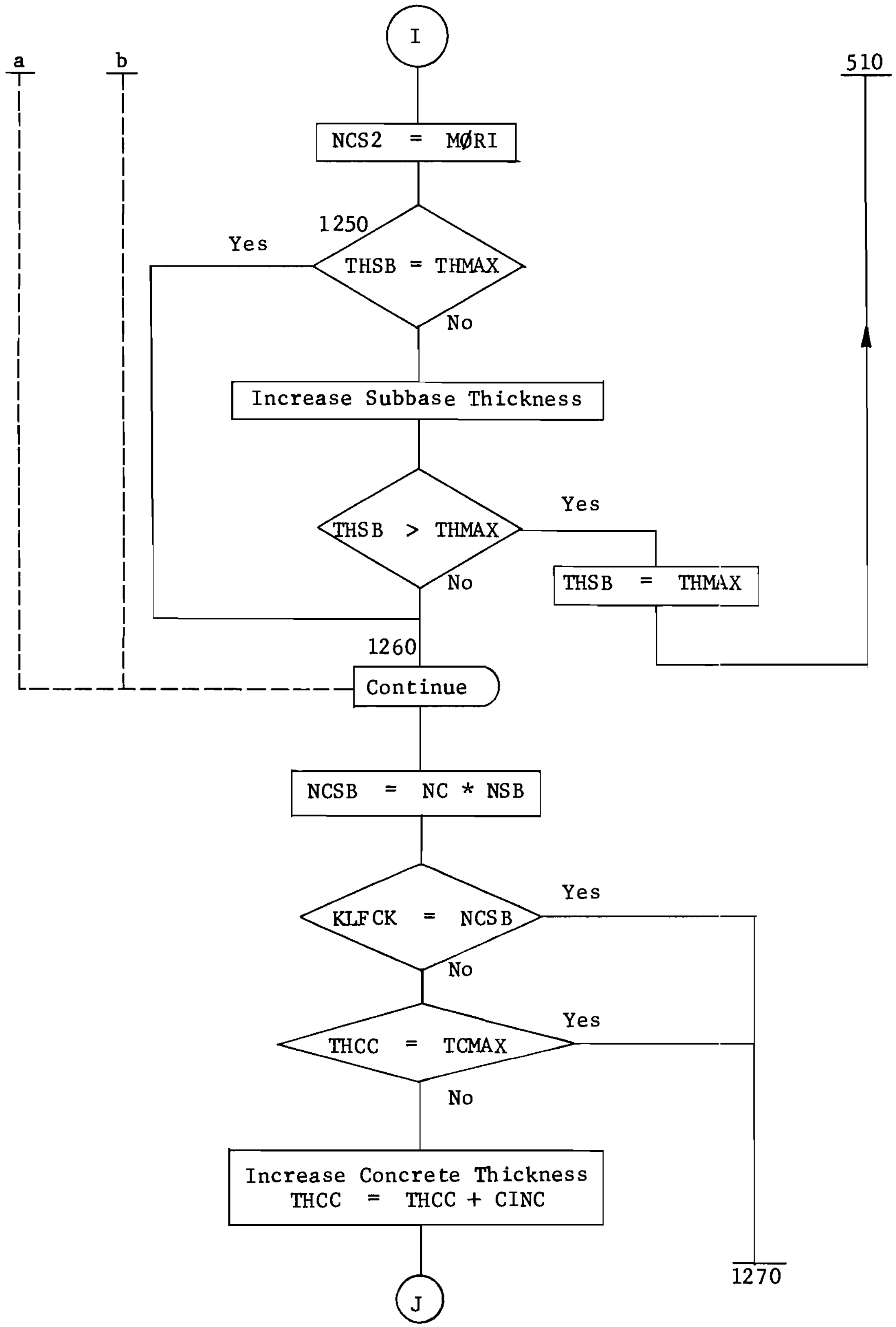

D
NCS2 = 0 and
NCS1 ≠ 0
Yes
LM = 0
No
Initial Life
< AP
No
Yes
910
OFMIN > AP
No
1250
1100
920
NCS2 = 1
Yes
No
Set up min. and max. value of PCC overlay (OMINC,OMAXC)
Set up minimum and maximum value of AC overlay (OMINA,OMAXA). Compute decodings and solve equivalent thickness equations partially
OMINA = 0
Yes
No
Calculate equivalent concrete thickness D to theoretically replace composite PCC pavement and AC overlay
940
L = 1
950
L = L + 1
E

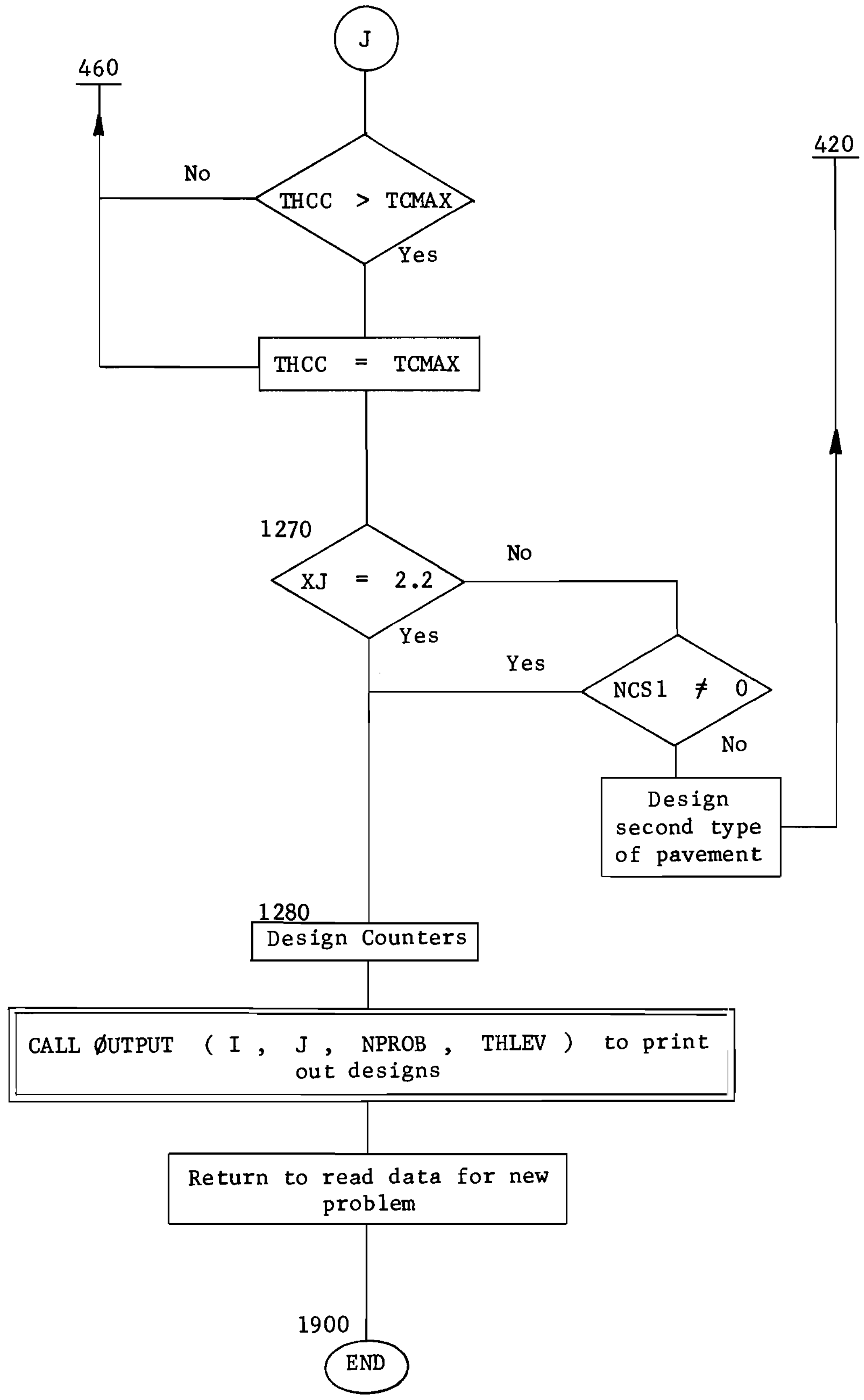

E
L - 9
>0
≤0
960
NDUEL = NDUEL + 1
970
Overlay thickness = min. overlay thickness
THOV(L)
980
Determine total overlay thickness THOVT(L)
THOV(L)
> max. allowable
Yes
No
1000
L = L - 1
L ≤ 1
Yes
No
1010
Increase same overlay thickness by the increment specified
THOV(L) = THOV(L) + XINCR
1230
F

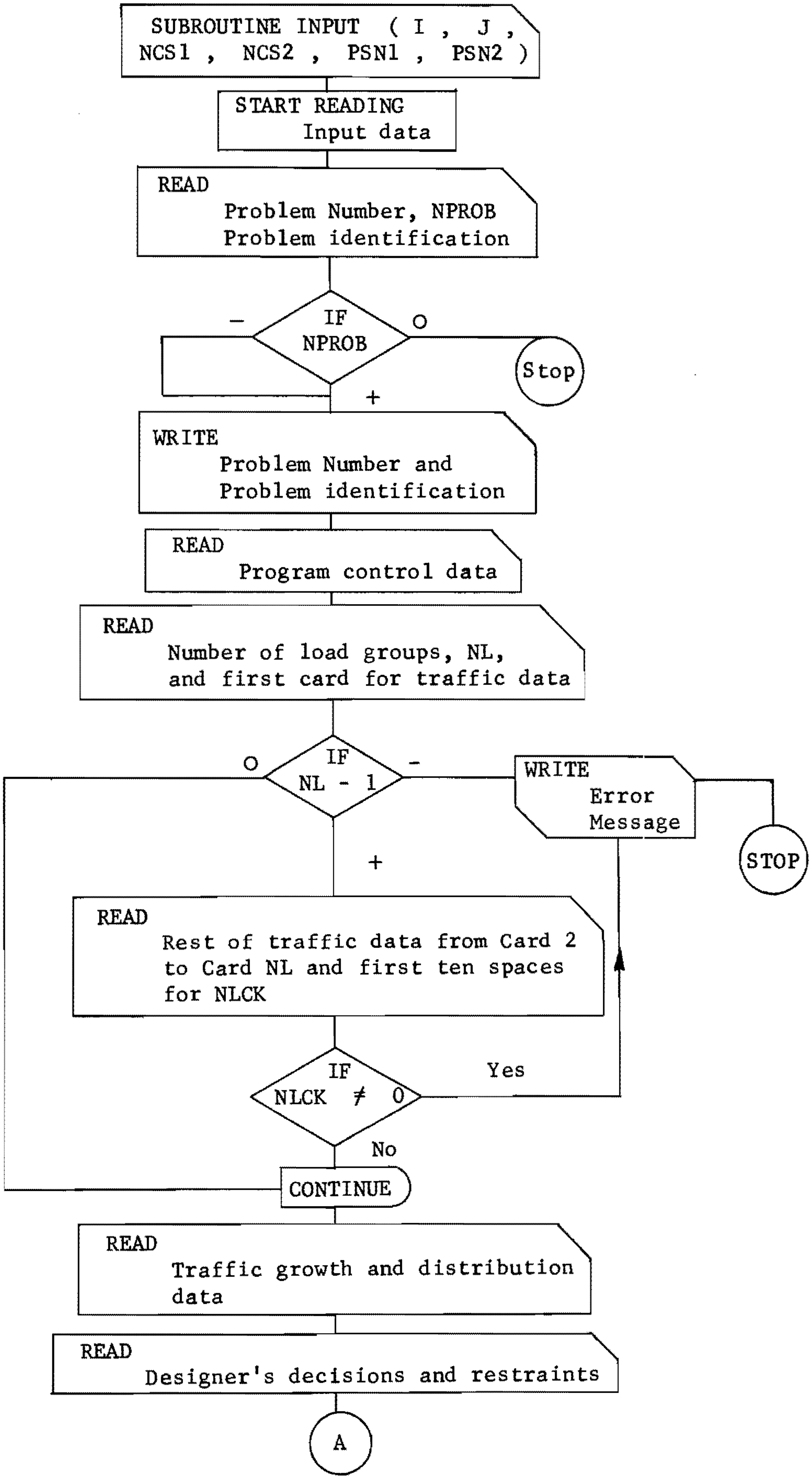

F
1020
NCS2 = 1
Yes
No
1030
Determine effective thickness, present overlay cost and total overlay cost for CC overlays
Compute D effective for AC overlays, cost of this overlay and total cost of all the overlays
CALL AGE2 (POV , DEFF , PP , SXD(I) , E(I) , PL(L) , BOMIN , VSX(I)) to calculate life for the present overlay
Compute total life of design with this overlay
1010
Total Life (PL(L + 1)) > AP (analysis period)
No
Yes
Yes
Life Overlay≥ Min. Time between overlays
No
1045
COTR(1) = 0.0
NTIME = NTIME + 1 NTIME EQUALS THE NO. OF ABANDONED STRATEGIES
G

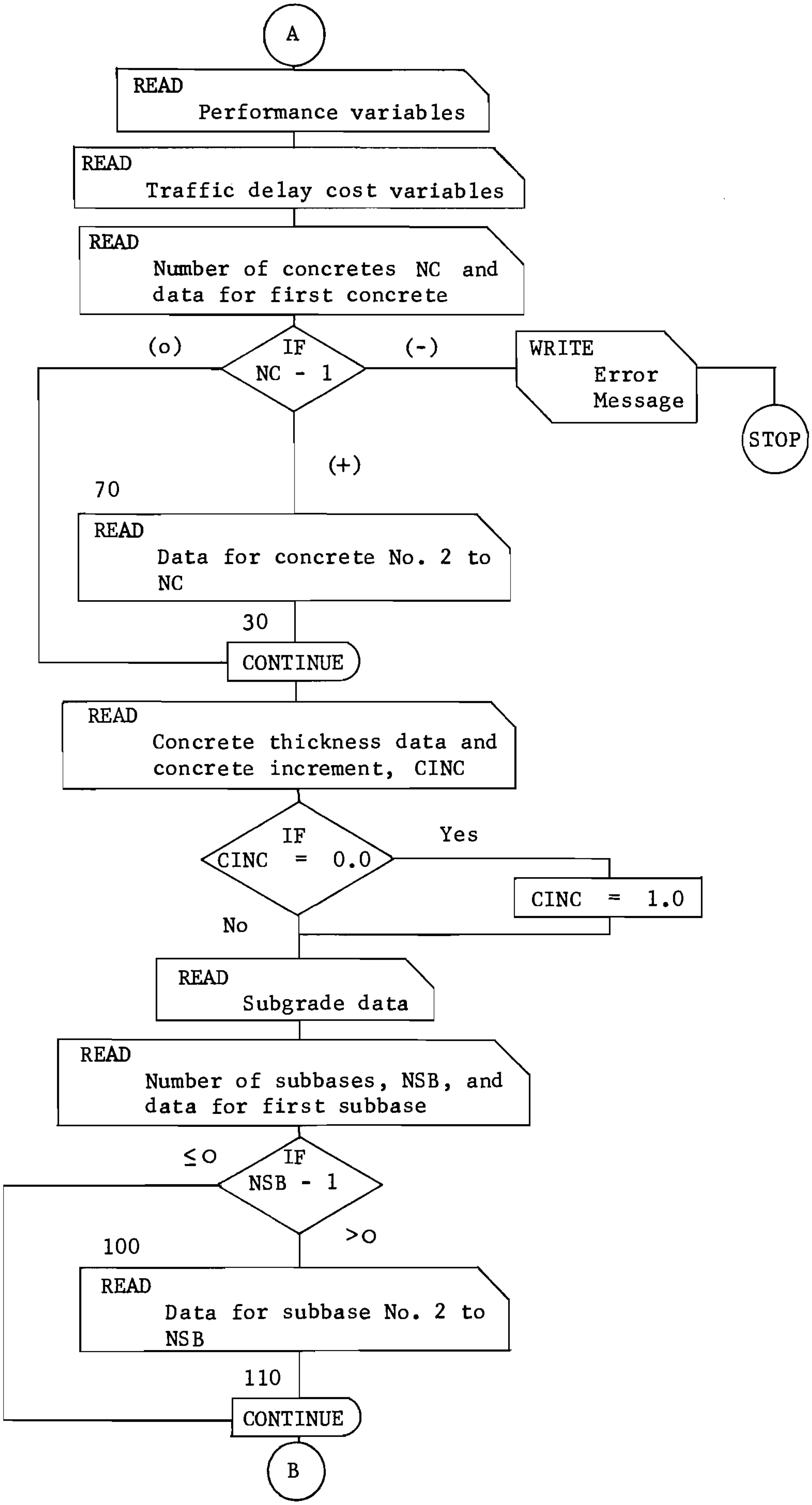

G
950
CALL TDC3 (PL(L) , THOV(L) , CTTRAF(L) , HPSY , IN1 , IN2) to calculate traffic delay cost for this overlay
Compute total traffic delay cost including this overlay
PLP = AP
Total Life of Particular Overlay < AP (analysis period)
Yes
PLP = PL(L + 1)
No
CALL MANCE (PL(L) , PLP , CTMAN(L)) to calculate maintenance cost of this period PL(L) to PLP
Compute total maintenance cost including this period
Total Life < AP
Yes
No
H

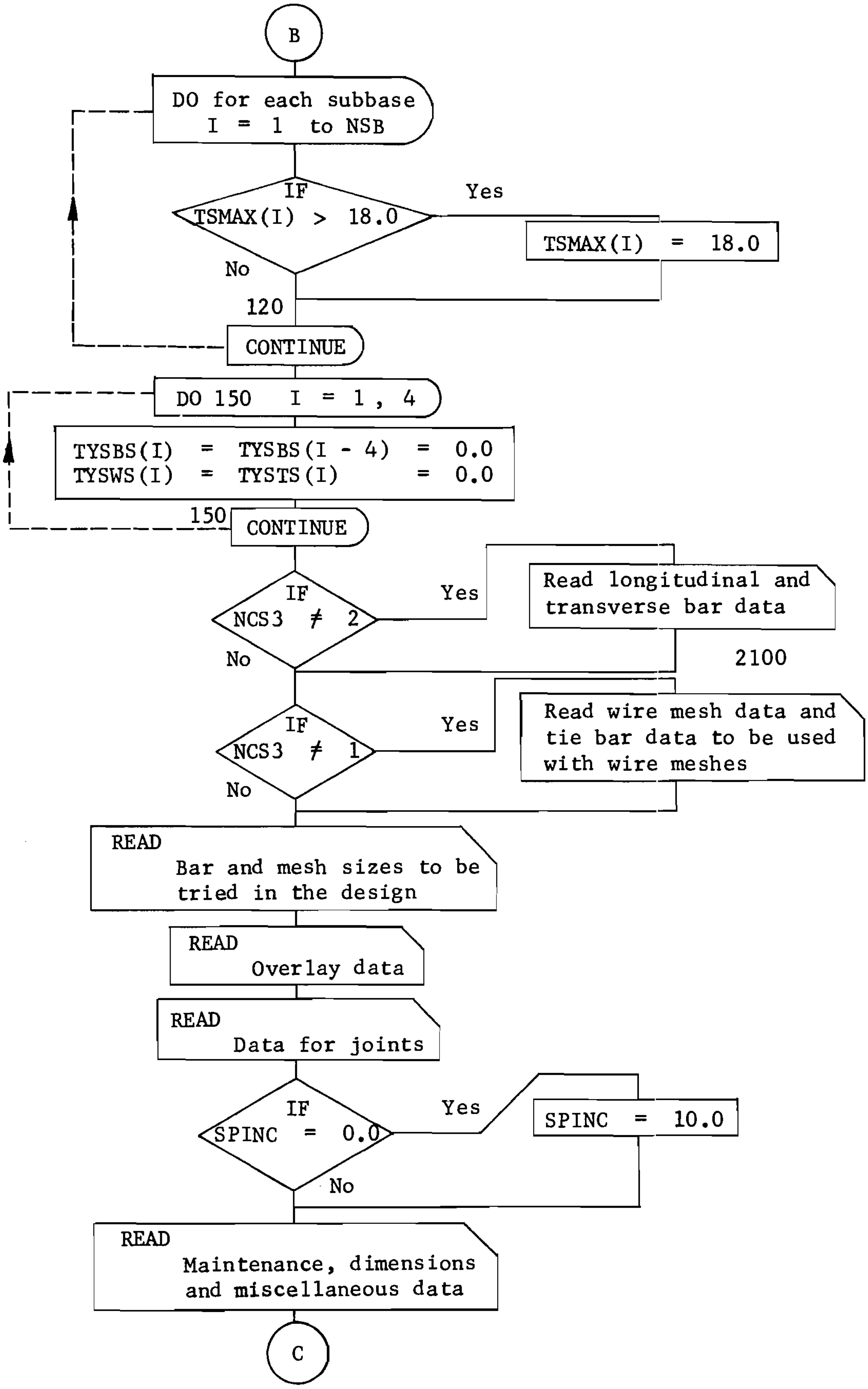

H
1050
IDOV = 2
Yes
No
1100
Calculate PCC overlay
1000
Calculate overlay cost of the AC overlay
920
1110
Calculate total cost of overlay design
Calculate total cost, TCOST
CALL ORDER (IDOV , IDPV , L , M , NN , TCOST) to arrange the designs in an optimum arrangement
No
IDOV = 3.0
Yes
1230
Count the design information
NCS2 ≠ 0
No
Yes
Go to design second type of overlay
I
1260

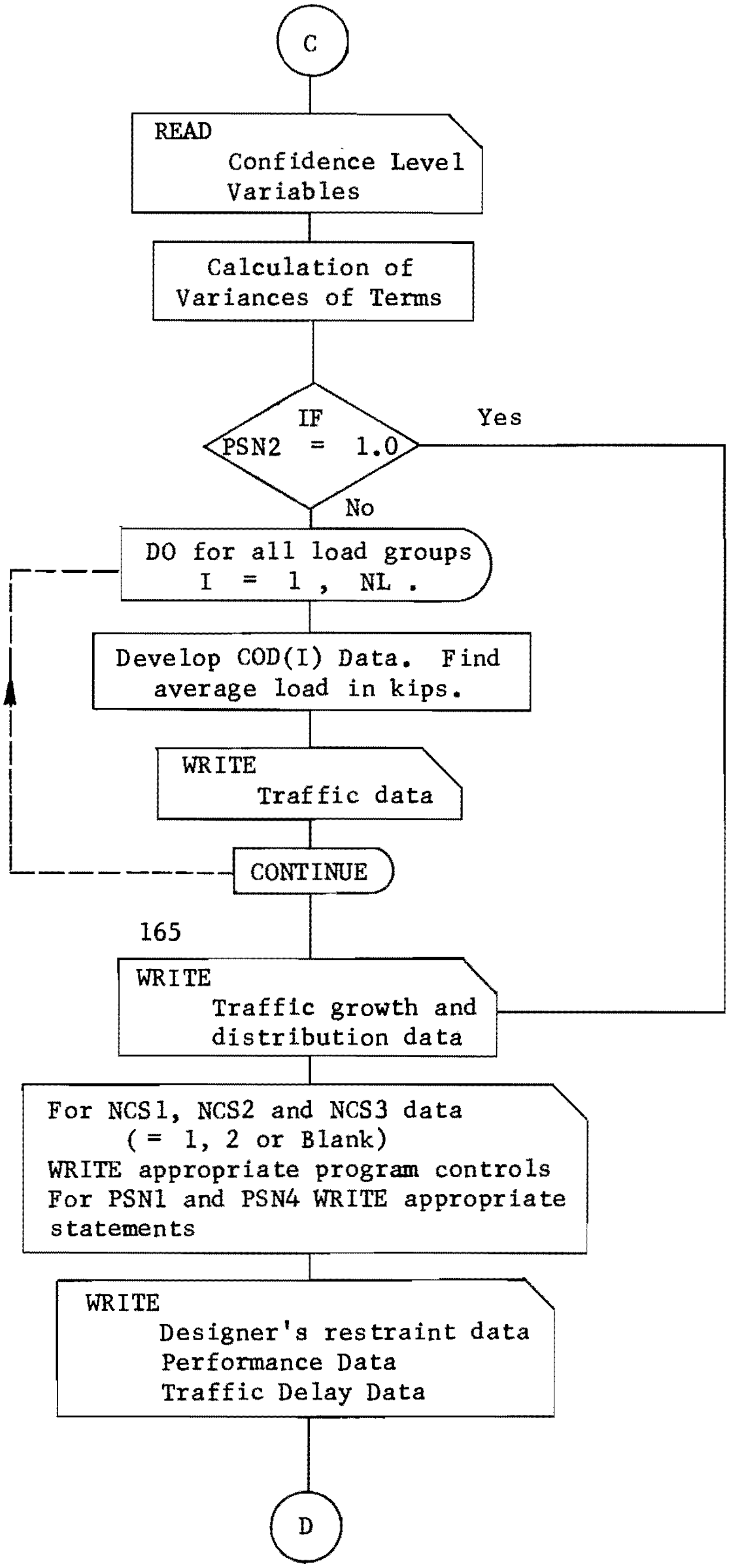

I
a
b
510
NCS2 = MØRI
1250
Yes
THSB = THMAX
No
Increase Subbase Thickness
Yes
THSB > THMAX
No
THSB = THMAX
1260
Continue
NCSB = NC * NSB
Yes
KLFCK = NCSB
No
Yes
THCC = TCMAX
No
Increase Concrete Thickness
THCC = THCC + CINC
J
1270

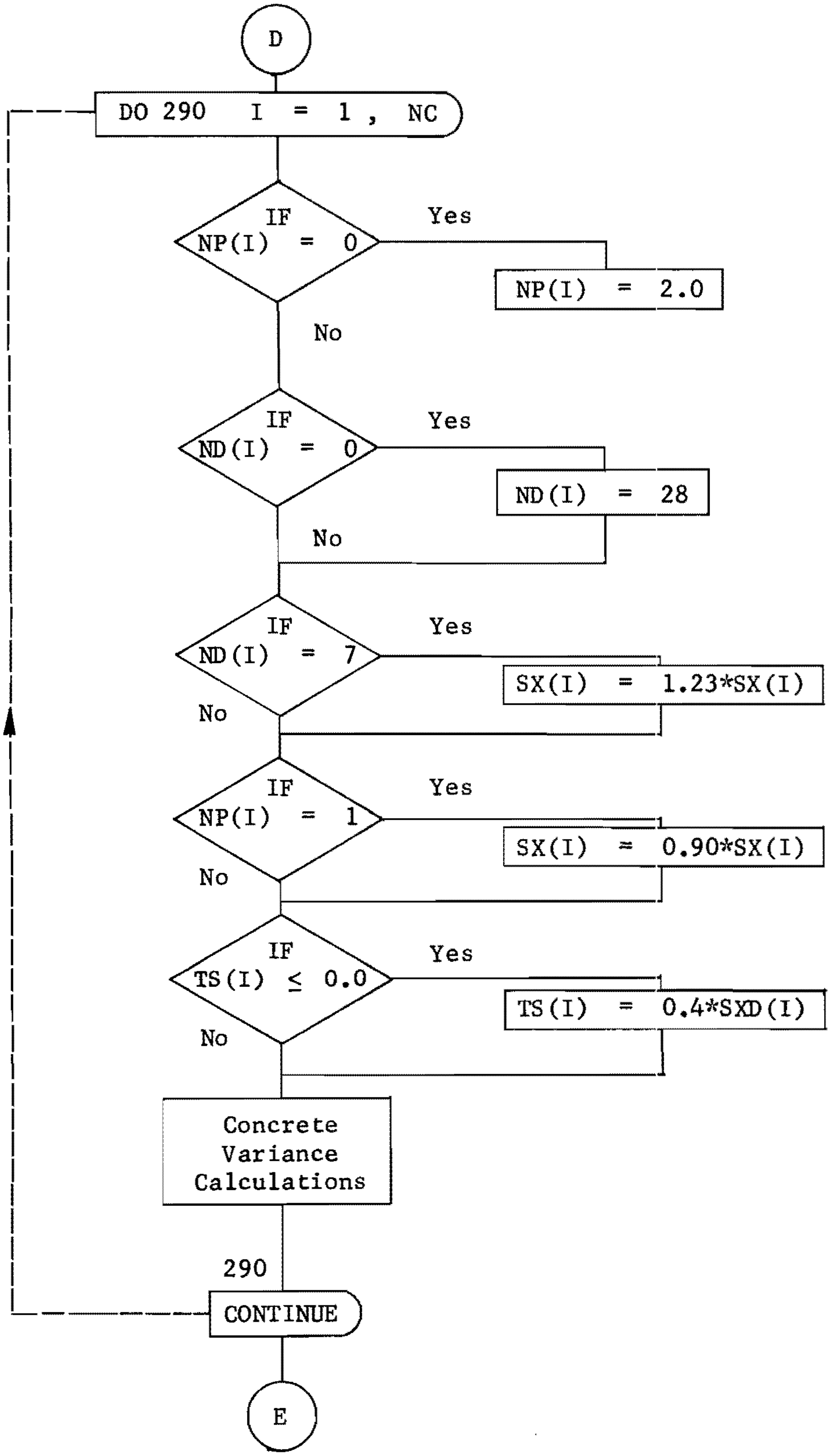

J
460
420
No
THCC > TCMAX
Yes
THCC = TCMAX
1270
XJ = 2.2
No
Yes
Yes
NCS1 ≠ 0
No
Design second type of pavement
1280
Design Counters
CALL ØUTPUT (I , J , NPROB , THLEV) to print out designs
Return to read data for new problem
1900
END

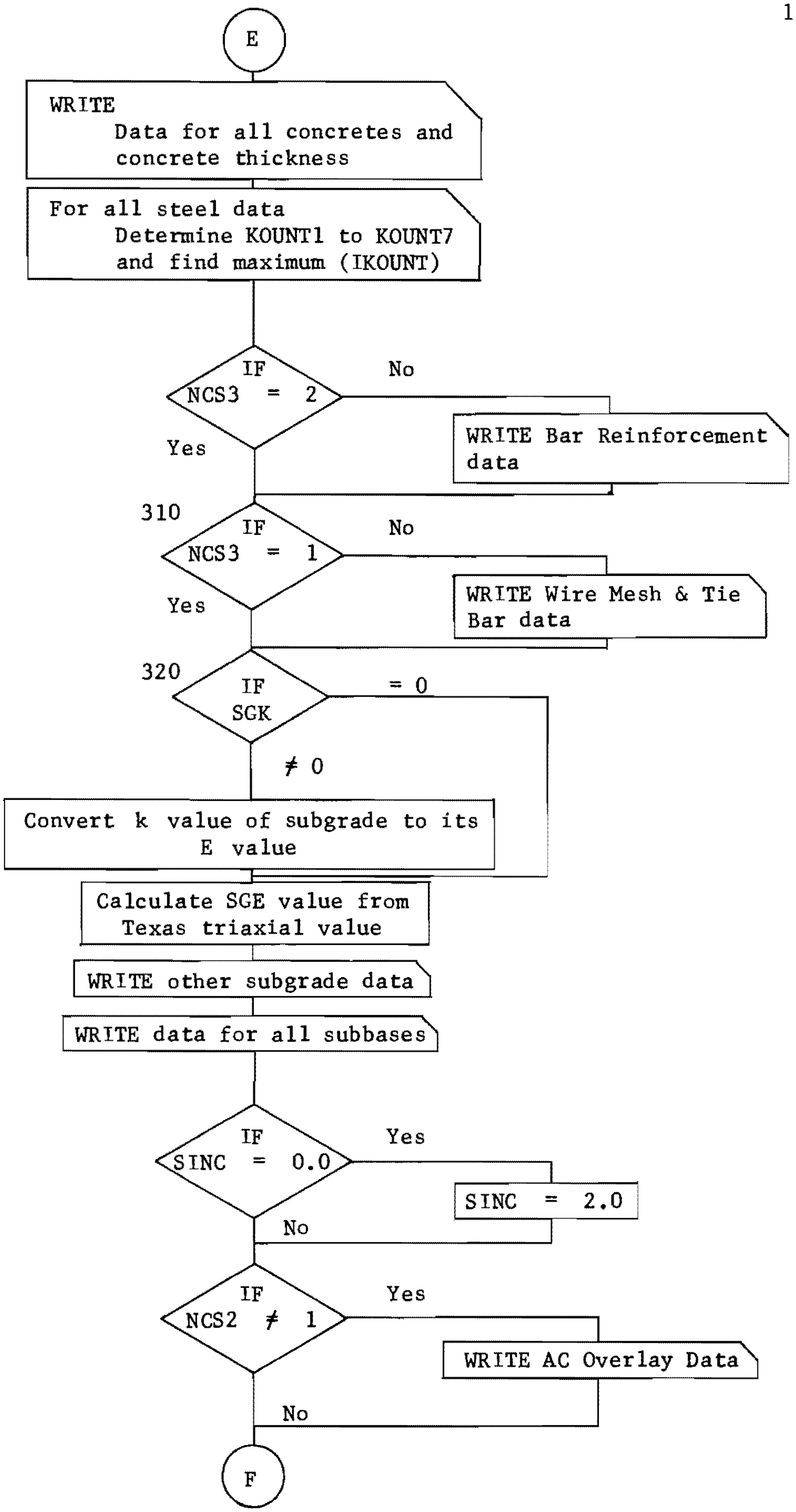

SUBROUTINE INPUT (I , J , NCS1 , NCS2 , PSN1 , PSN2)
START READING Input data
READ Problem Number, NPROB Problem identification
IF NPROB
–
O
Stop
+
WRITE Problem Number and Problem identification
READ Program control data
READ Number of load groups, NL, and first card for traffic data
IF NL - 1
O
–
WRITE Error Message
STOP
+
READ Rest of traffic data from Card 2 to Card NL and first ten spaces for NLCK
IF NLCK ≠ 0
Yes
No
CONTINUE
READ Traffic growth and distribution data
READ Designer's decisions and restraints
A

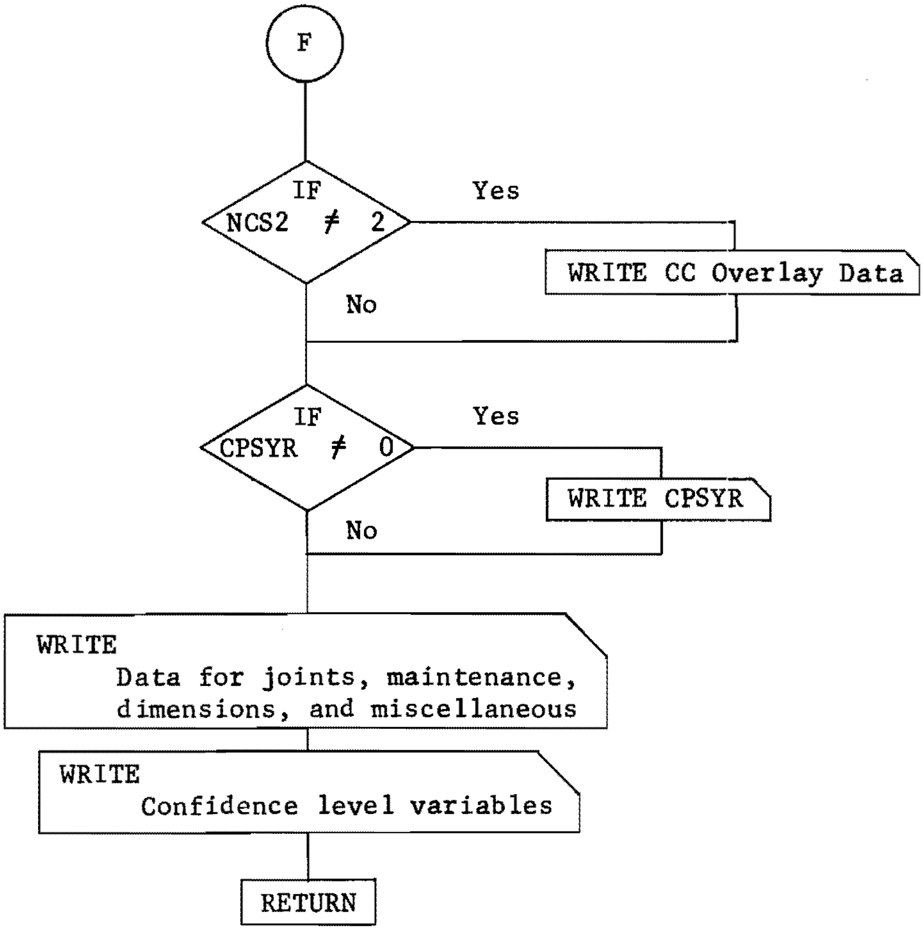

A
READ
Performance variables
READ
Traffic delay cost variables
READ
Number of concretes NC and data for first concrete
(o)
IF
NC - 1
(-)
WRITE
Error Message
STOP
(+)
70
READ
Data for concrete No. 2 to NC
30
CONTINUE
READ
Concrete thickness data and concrete increment, CINC
IF
CINC = 0.0
Yes
CINC = 1.0
No
READ
Subgrade data
READ
Number of subbases, NSB, and data for first subbase
≤0
IF
NSB - 1
>0
100
READ
Data for subbase No. 2 to NSB
110
CONTINUE
B

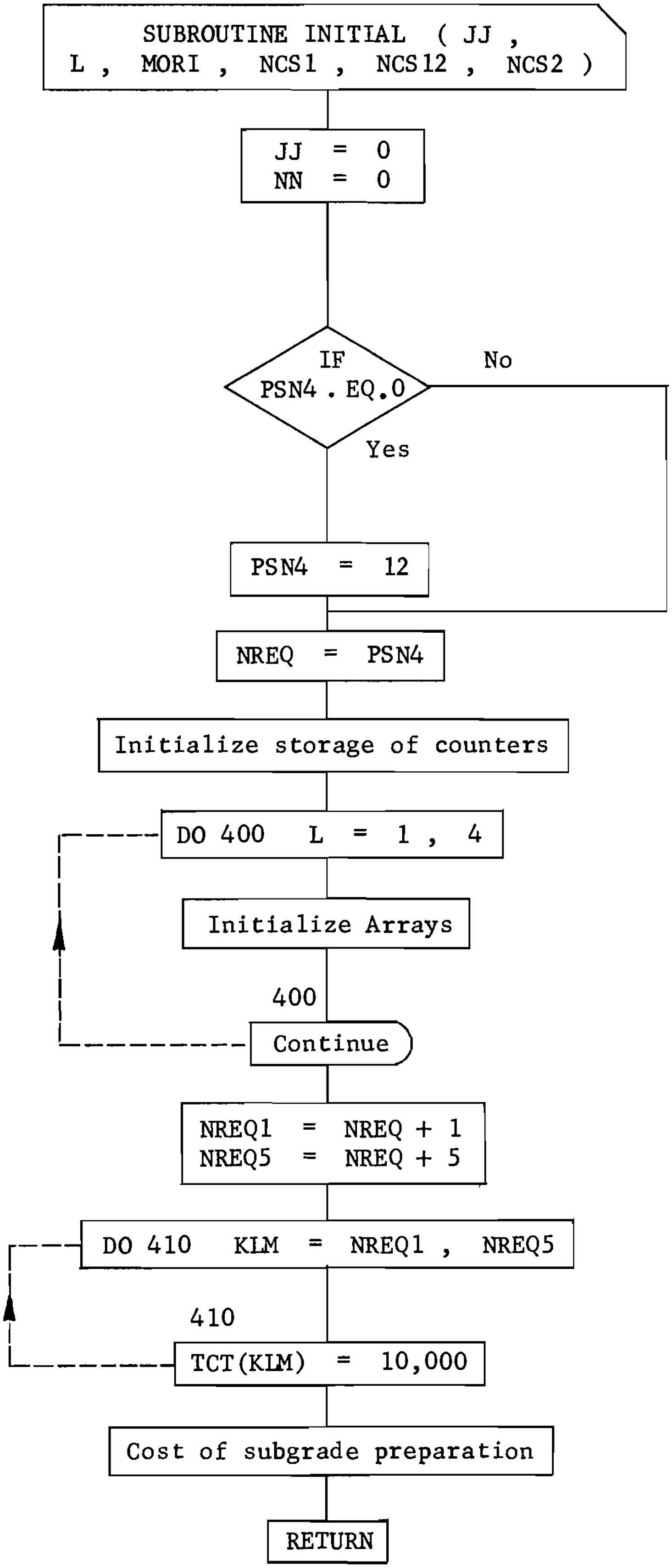

B
DO for each subbase
I = 1 to NSB
IF
TSMAX(I) > 18.0
Yes
TSMAX(I) = 18.0
No
120
CONTINUE
DO 150 I = 1 , 4
TYSBS(I) = TYSBS(I - 4) = 0.0
TYSWS(I) = TYSTS(I) = 0.0
150
CONTINUE
IF
NCS3 ≠ 2
Yes
Read longitudinal and transverse bar data
No
2100
IF
NCS3 ≠ 1
Yes
Read wire mesh data and tie bar data to be used with wire meshes
No
READ
Bar and mesh sizes to be tried in the design
READ
Overlay data
READ
Data for joints
IF
SPINC = 0.0
Yes
SPINC = 10.0
No
READ
Maintenance, dimensions and miscellaneous data
C

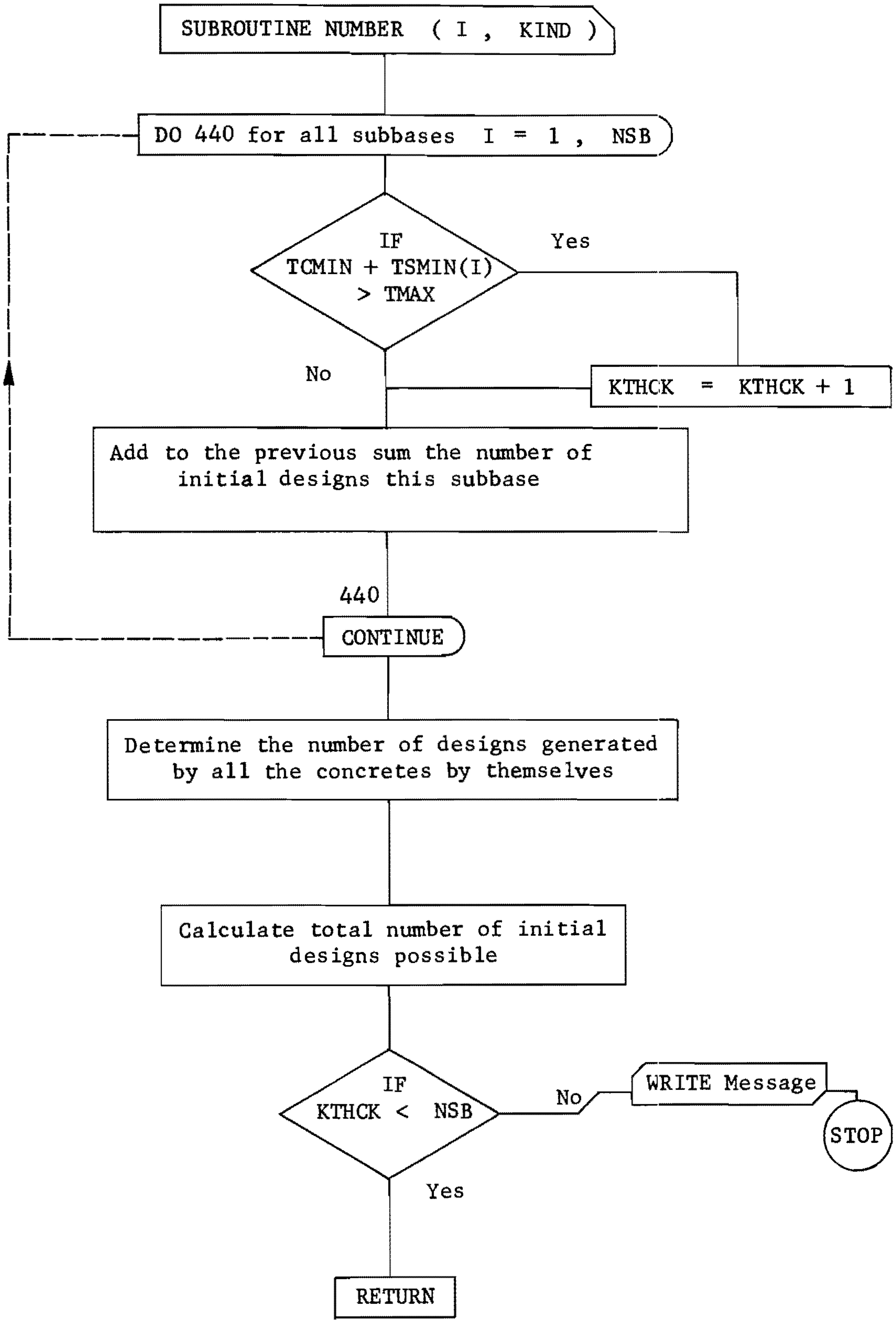

C
READ
Confidence Level
Variables
Calculation of
Variances of Terms
IF
PSN2 = 1.0
Yes
No
DO for all load groups
I = 1 , NL .
Develop COD(I) Data. Find
average load in kips.
WRITE
Traffic data
CONTINUE
165
WRITE
Traffic growth and
distribution data
For NCS1, NCS2 and NCS3 data
(= 1, 2 or Blank)
WRITE appropriate program controls
For PSN1 and PSN4 WRITE appropriate
statements
WRITE
Designer's restraint data
Performance Data
Traffic Delay Data
D

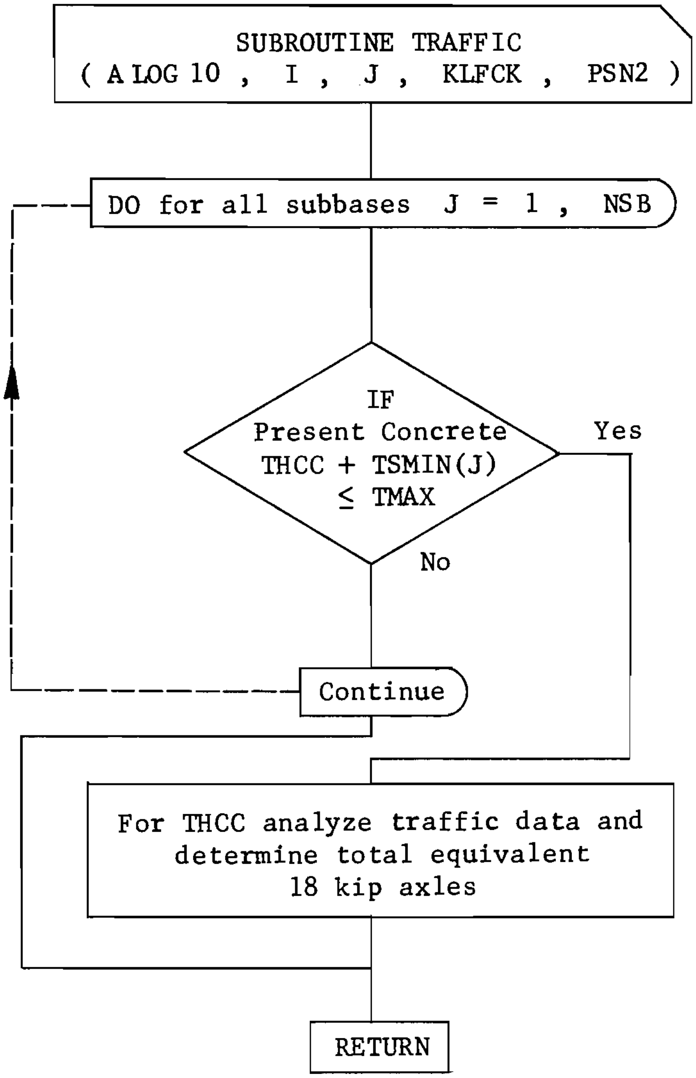

D
DO 290 I = 1 , NC
IF NP(I) = 0
Yes
NP(I) = 2.0
No
IF ND(I) = 0
Yes
ND(I) = 28
No
IF ND(I) = 7
Yes
SX(I) = 1.23*SX(I)
No
IF NP(I) = 1
Yes
SX(I) = 0.90*SX(I)
No
IF TS(I) ≤ 0.0
Yes
TS(I) = 0.4*SXD(I)
No
Concrete Variance Calculations
290
CONTINUE
E

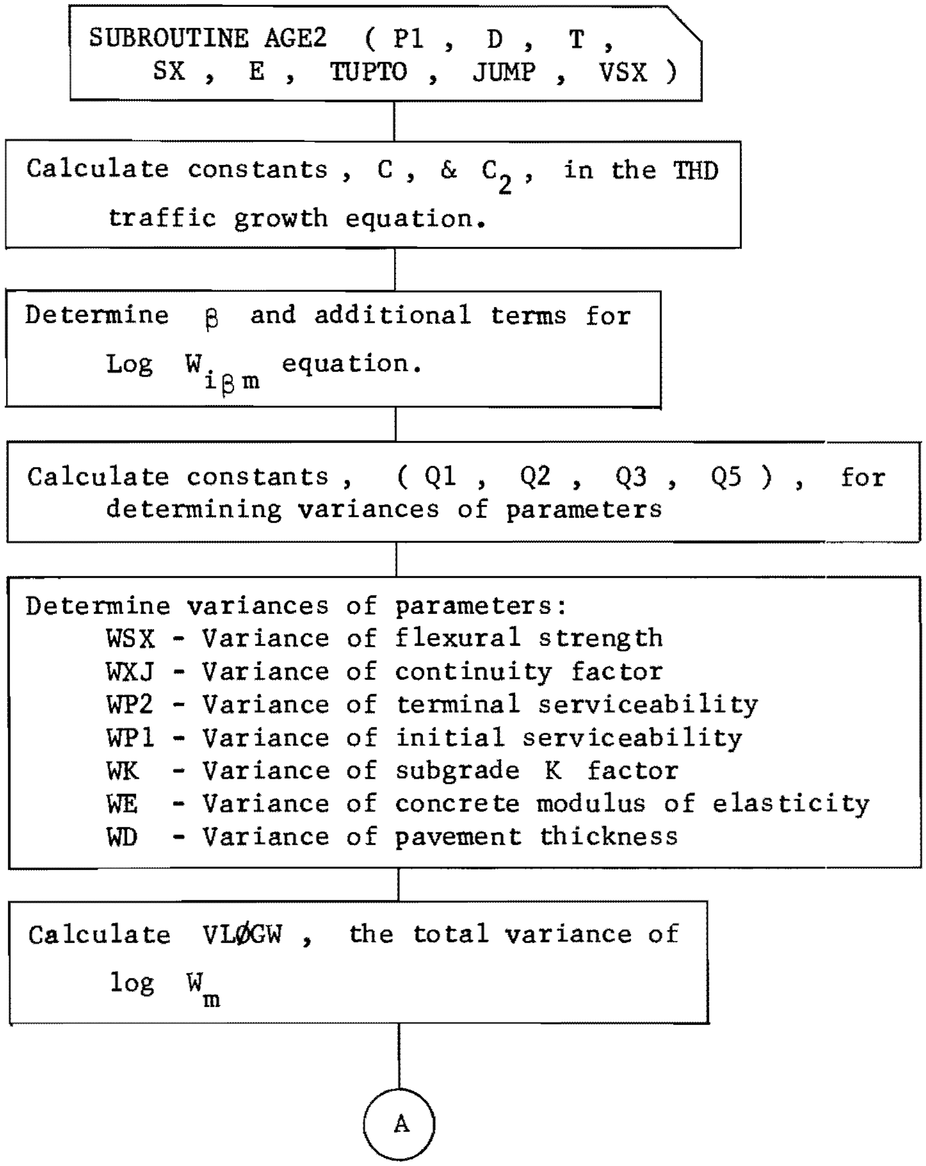

E
WRITE
Data for all concretes and concrete thickness
For all steel data
Determine KOUNT1 to KOUNT7 and find maximum (IKOUNT)
IF NCS3 = 2
No
Yes
WRITE Bar Reinforcement data
310
IF NCS3 = 1
No
Yes
WRITE Wire Mesh & Tie Bar data
320
IF SGK
= 0
≠ 0
Convert k value of subgrade to its E value
Calculate SGE value from Texas triaxial value
WRITE other subgrade data
WRITE data for all subbases
IF SINC = 0.0
Yes
SINC = 2.0
No
IF NCS2 ≠ 1
Yes
WRITE AC Overlay Data
No
F


F
IF
NCS2 ≠ 2
Yes
No
WRITE CC Overlay Data
IF
CPSYR ≠ 0
Yes
No
WRITE CPSYR
WRITE
Data for joints, maintenance, dimensions, and miscellaneous
WRITE
Confidence level variables
RETURN


SUBROUTINE INITIAL (JJ , L , MORI , NCS1 , NCS12 , NCS2)
JJ = 0
NN = 0
IF PSN4 . EQ.0
No
Yes
PSN4 = 12
NREQ = PSN4
Initialize storage of counters
DO 400 L = 1 , 4
Initialize Arrays
400
Continue
NREQ1 = NREQ + 1
NREQ5 = NREQ + 5
DO 410 KLM = NREQ1 , NREQ5
410
TCT(KLM) = 10,000
Cost of subgrade preparation
RETURN


SUBROUTINE NUMBER (I , KIND)
DO 440 for all subbases I = 1 , NSB
IF TCMIN + TSMIN(I) > TMAX
Yes
No
KTHCK = KTHCK + 1
Add to the previous sum the number of initial designs this subbase
440
CONTINUE
Determine the number of designs generated by all the concretes by themselves
Calculate total number of initial designs possible
IF KTHCK < NSB
No
WRITE Message
STOP
Yes
RETURN


SUBROUTINE TRAFFIC
(A LOG 10 , I , J , KLFCK , PSN2)
DO for all subbases J = 1 , NSB
IF
Present Concrete
THCC + TSMIN(J)
≤ TMAX
Yes
No
Continue
For THCC analyze traffic data and determine total equivalent 18 kip axles
RETURN



SUBROUTINE AGE2 (P1 , D , T , SX , E , TUPTO , JUMP , VSX)

Calculate constants , C , & C_2 , in the THD traffic growth equation.

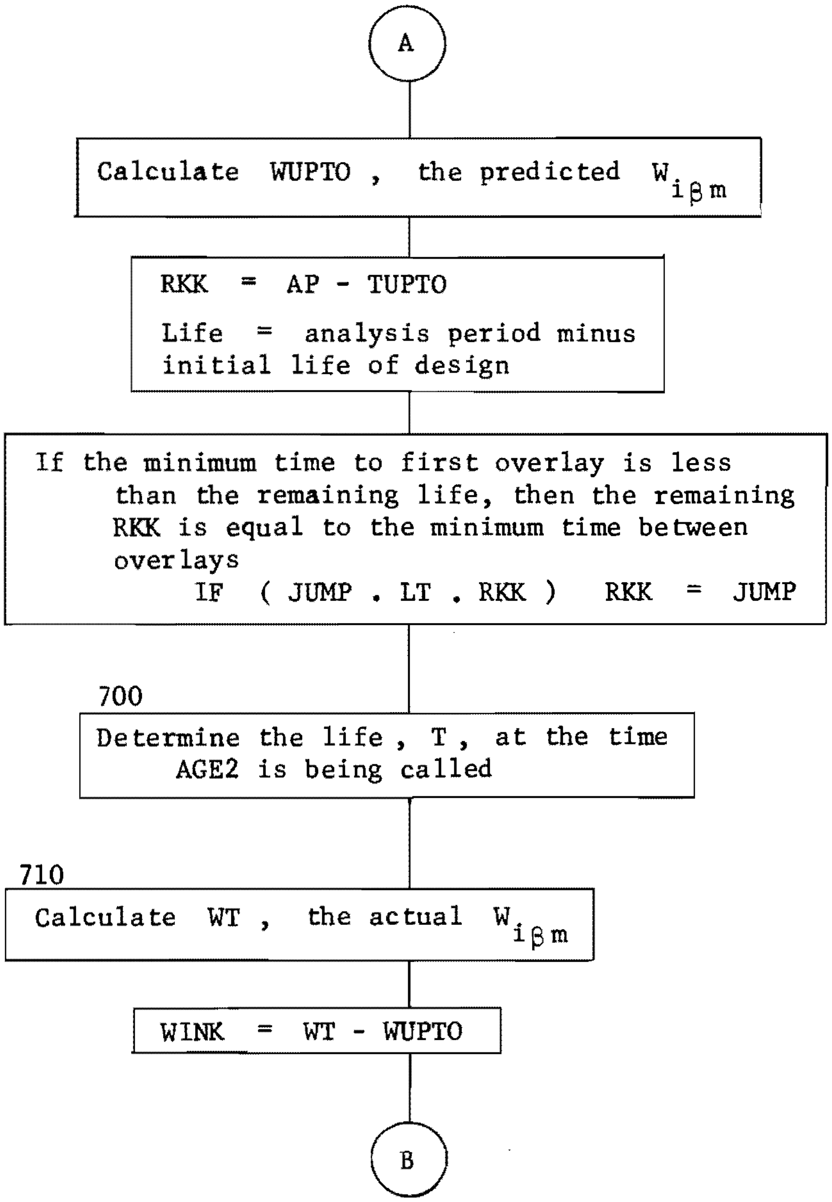
Determine β and additional terms for Log $W_{i\beta m}$ equation.

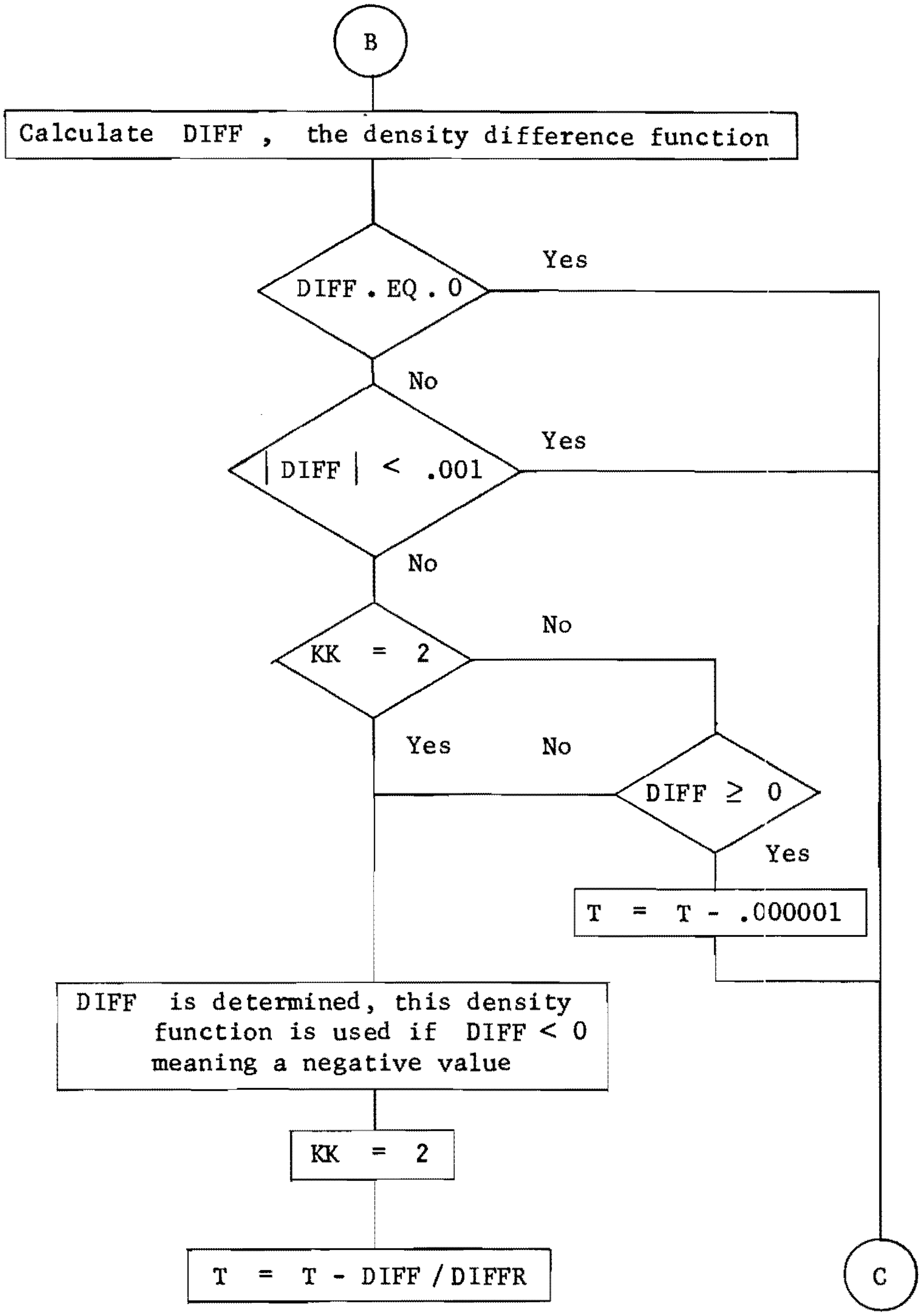
Calculate constants , (Q1 , Q2 , Q3 , Q5) , for determining variances of parameters

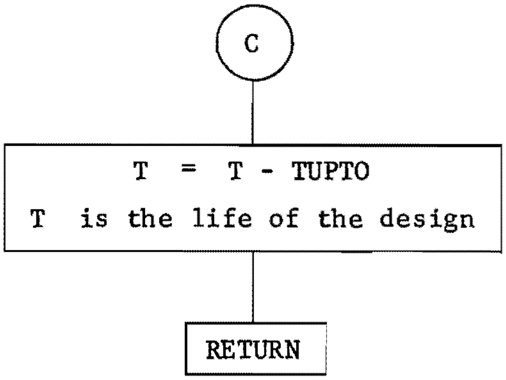
Determine variances of parameters:

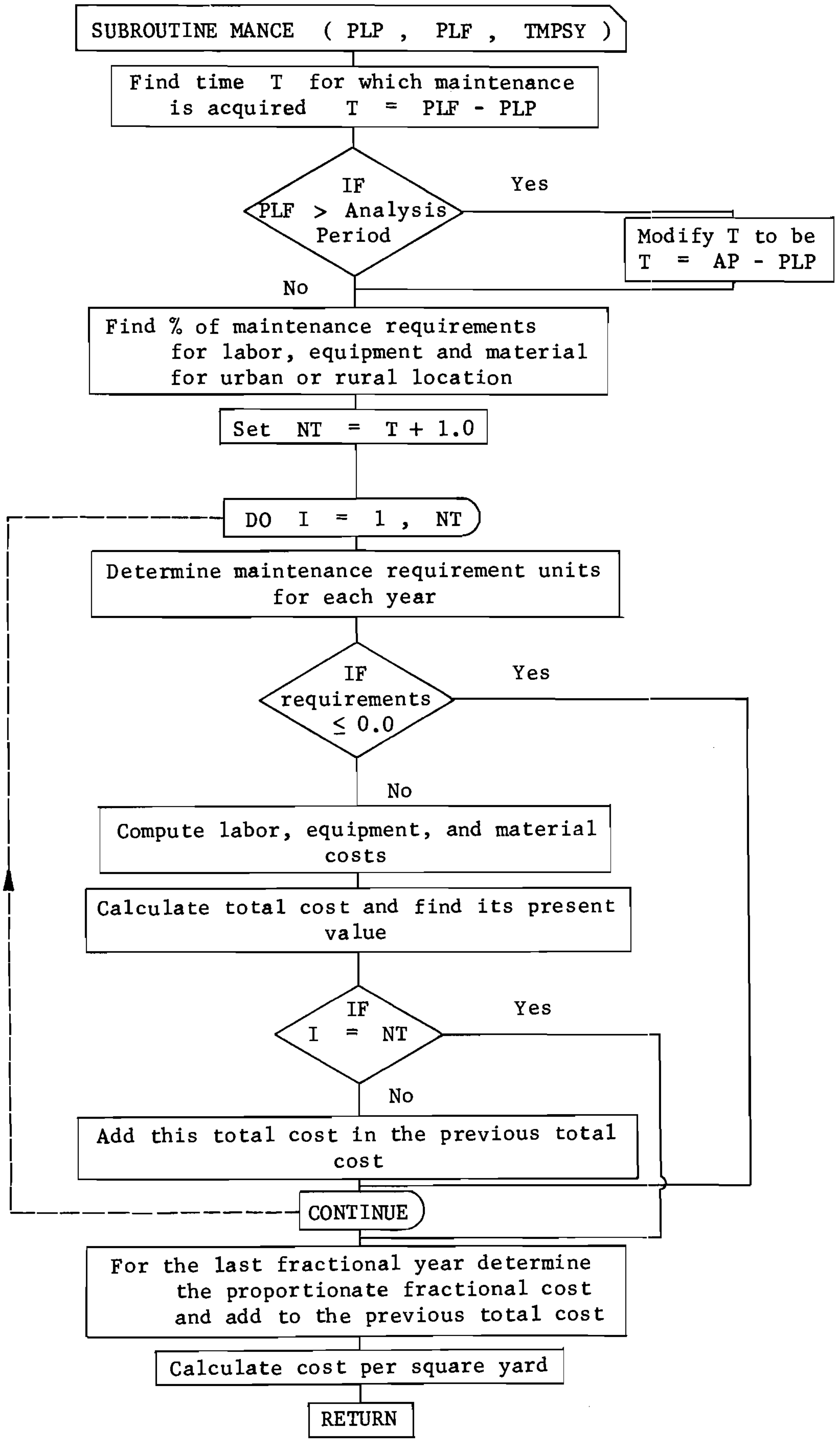
WSX - Variance of flexural strength
WXJ - Variance of continuity factor
WP2 - Variance of terminal serviceability
WP1 - Variance of initial serviceability
WK - Variance of subgrade K factor
WE - Variance of concrete modulus of elasticity
WD - Variance of pavement thickness

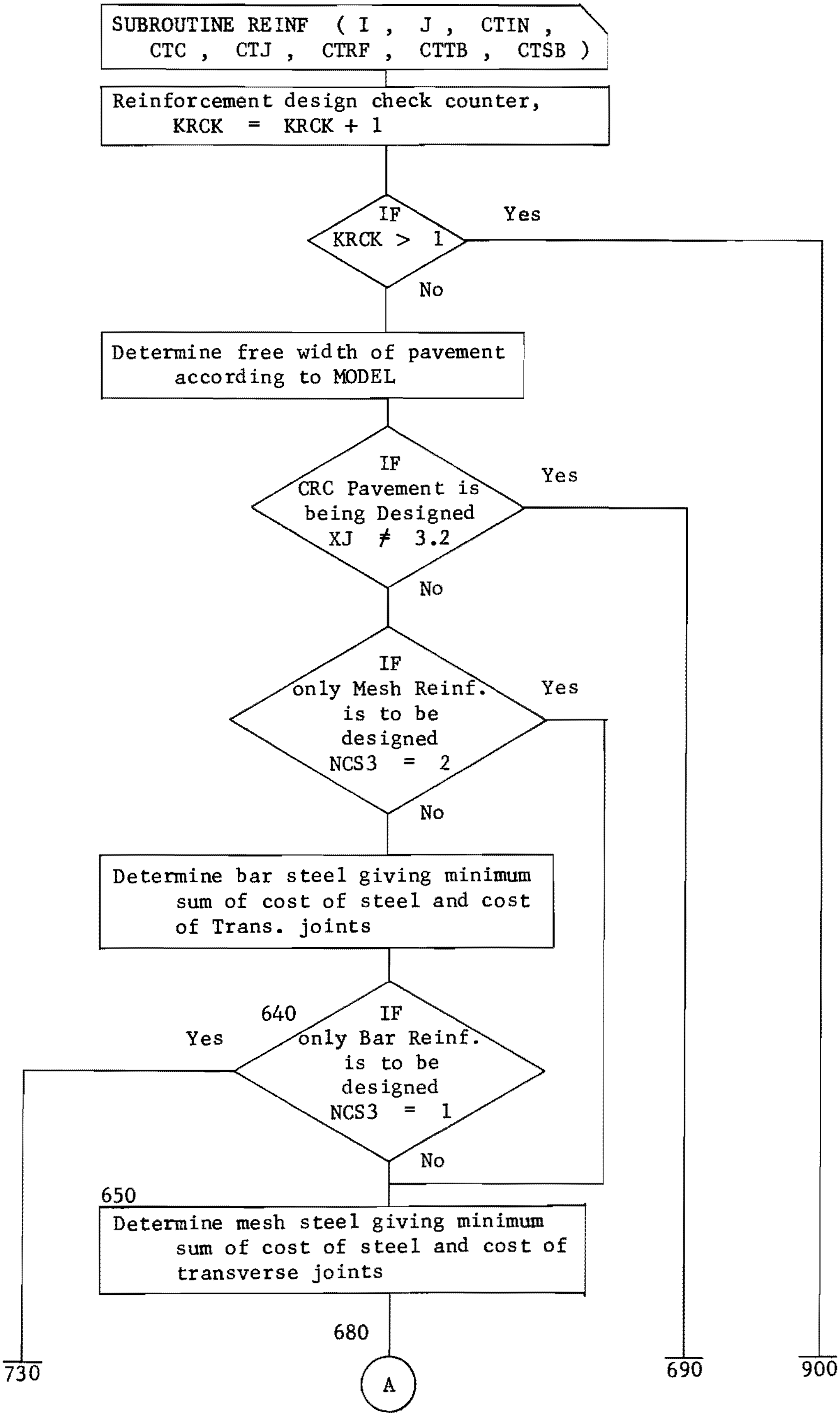
Calculate VLØGW , the total variance of log W_m

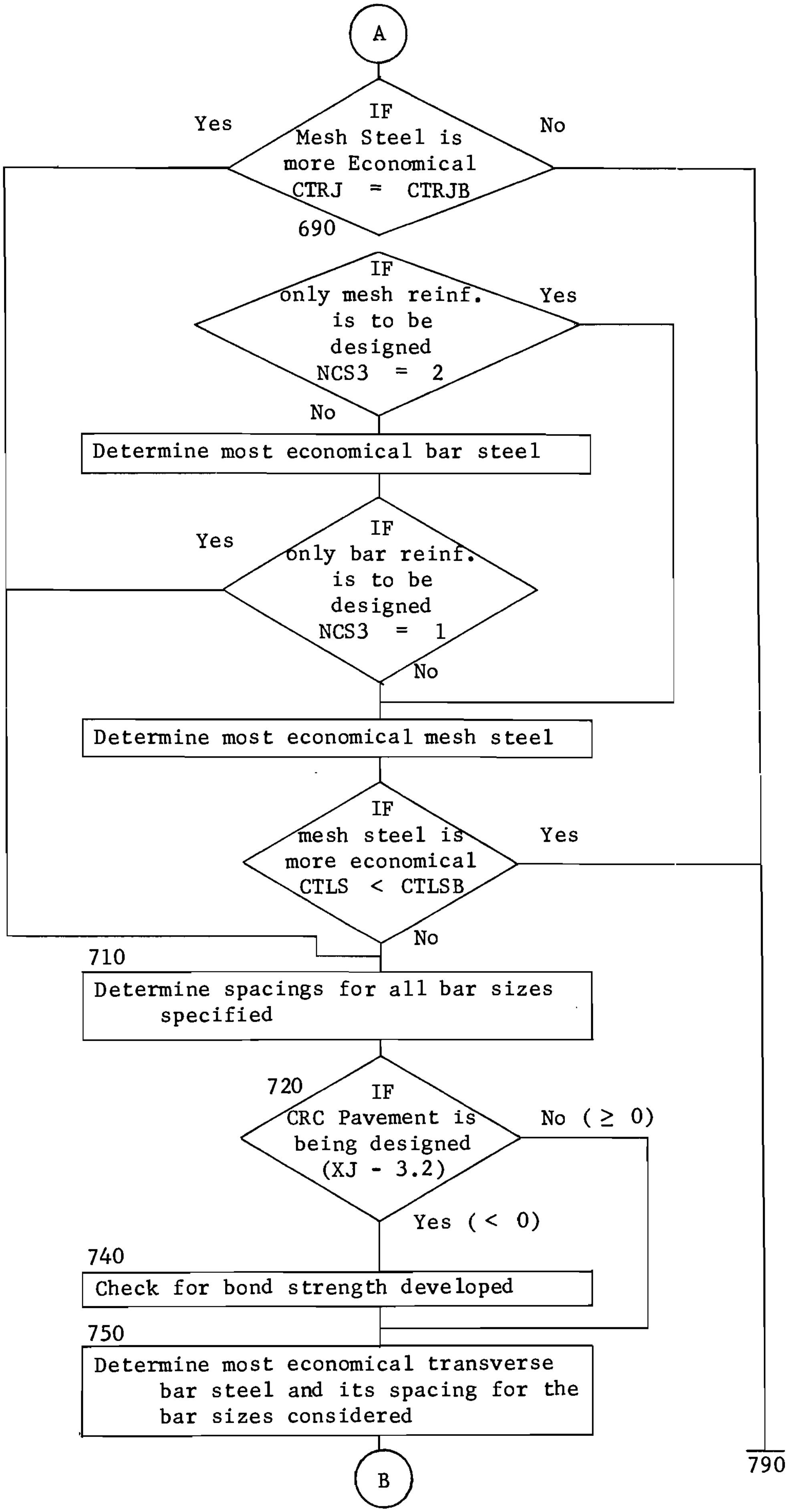

A
Calculate WUPTO , the predicted $W_{i\beta m}$
RKK = AP - TUPTO
Life = analysis period minus initial life of design
If the minimum time to first overlay is less than the remaining life, then the remaining RKK is equal to the minimum time between overlays
IF (JUMP . LT . RKK) RKK = JUMP
700
Determine the life , T , at the time AGE2 is being called
710
Calculate WT , the actual $W_{i\beta m}$
WINK = WT - WUPTO
B

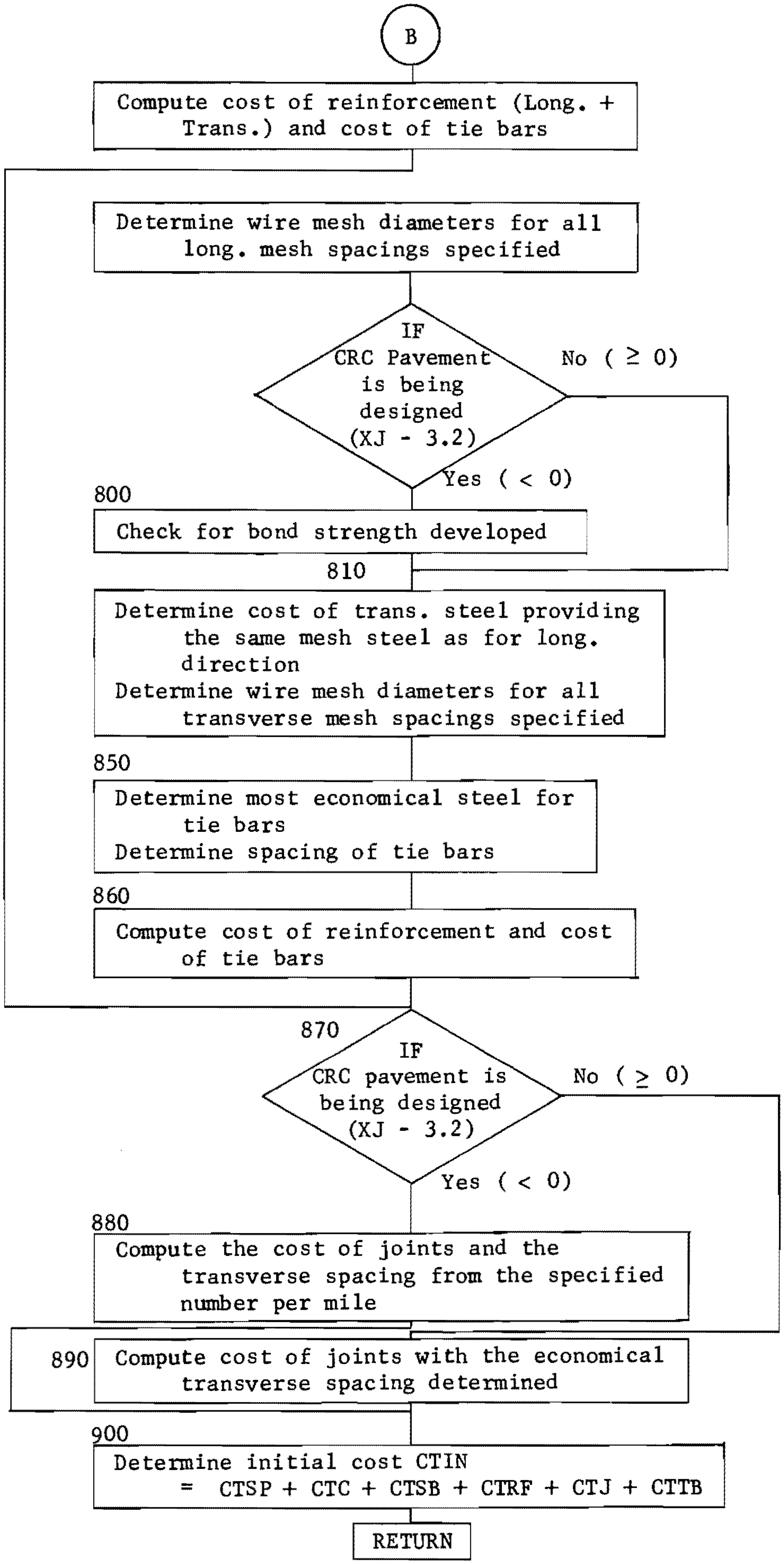

B
Calculate DIFF , the density difference function
DIFF . EQ . 0
Yes
No
| DIFF | < .001
Yes
No
KK = 2
No
Yes
No
DIFF ≥ 0
Yes
T = T - .000001
DIFF is determined, this density function is used if DIFF < 0 meaning a negative value
KK = 2
T = T - DIFF / DIFFR
C

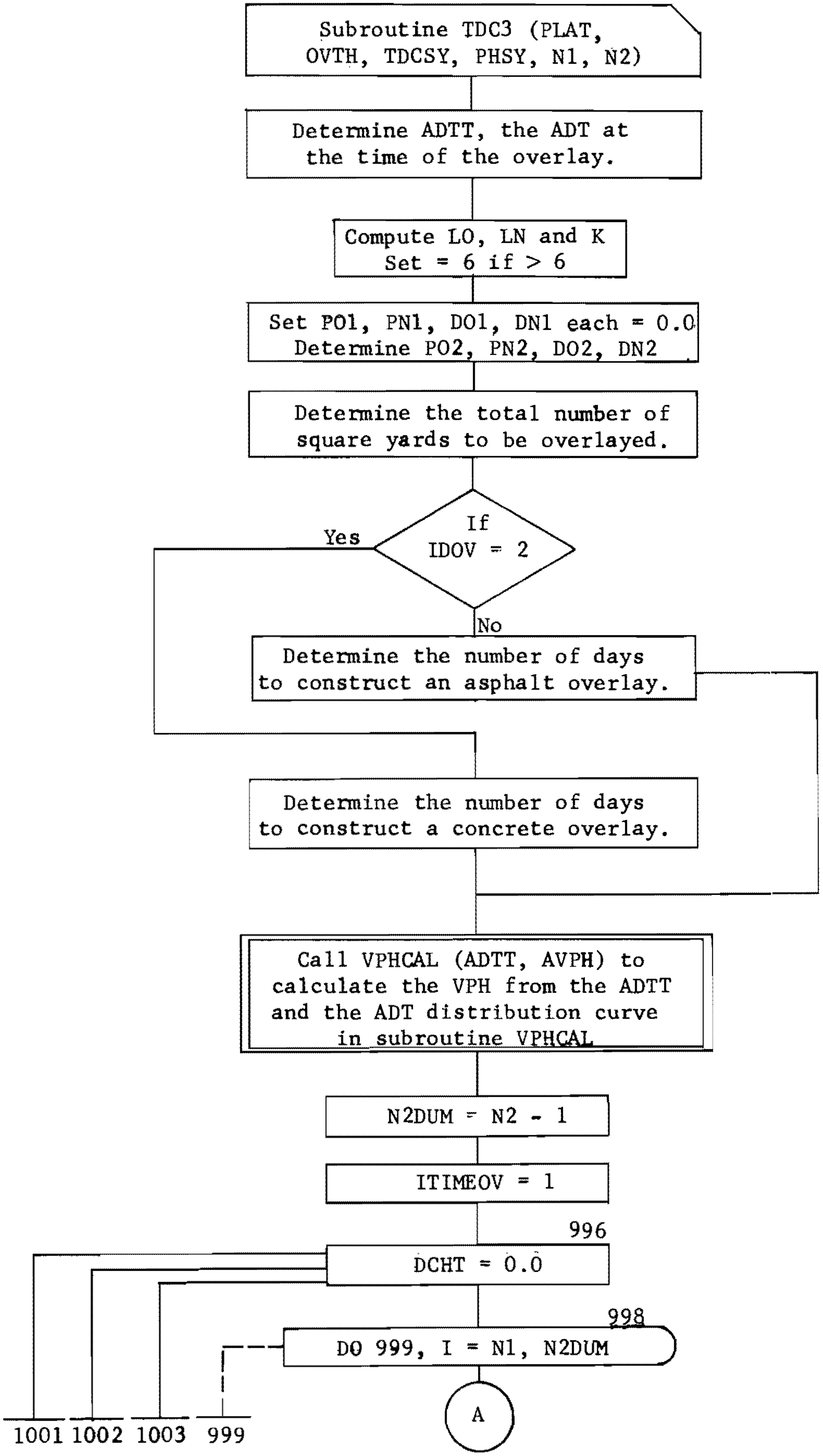

C
T = T - TUPTO
T is the life of the design
RETURN

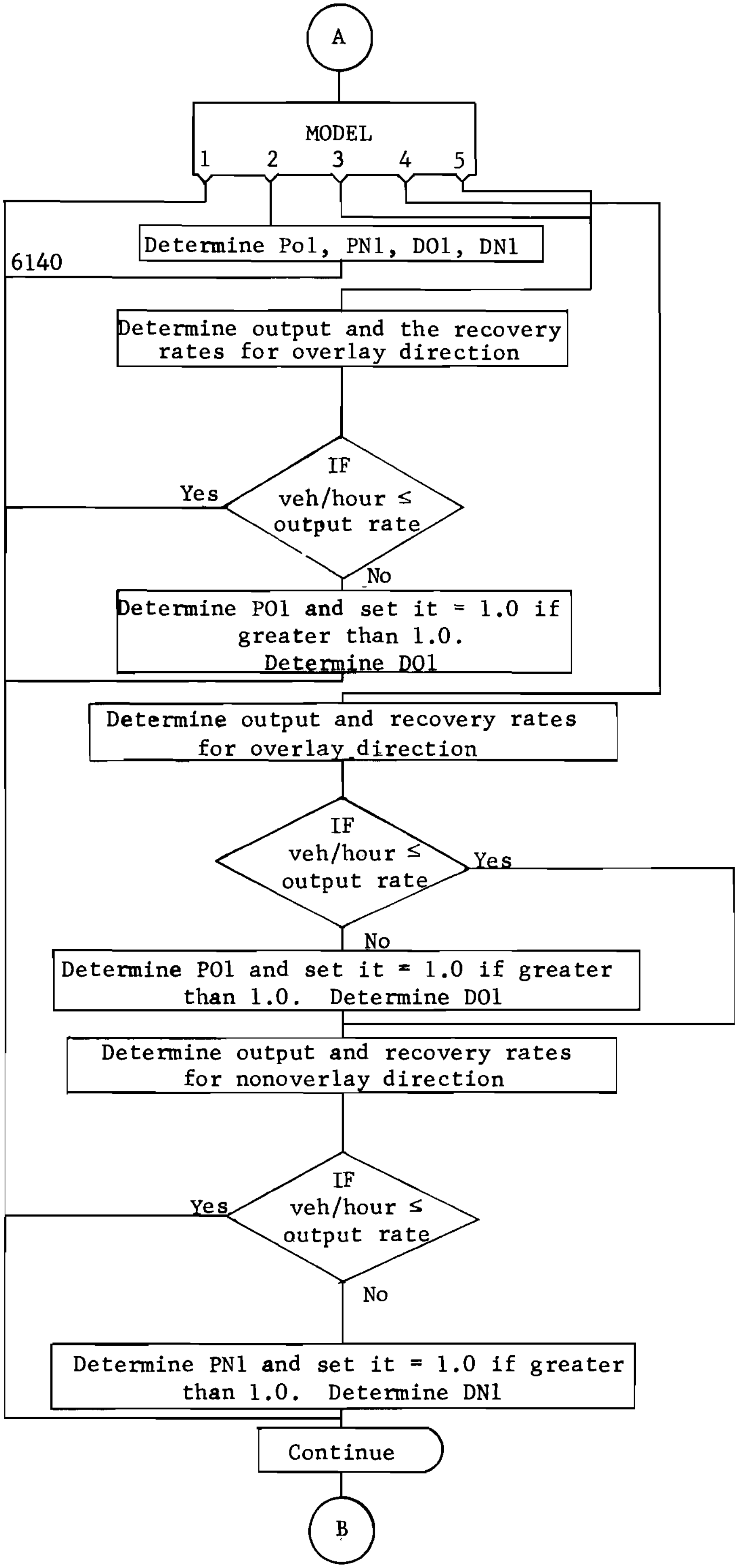

SUBROUTINE MANCE (PLP , PLF , TMPSY)
Find time T for which maintenance is acquired T = PLF - PLP
IF PLF > Analysis Period
Yes
Modify T to be T = AP - PLP
No
Find % of maintenance requirements for labor, equipment and material for urban or rural location
Set NT = T + 1.0
DO I = 1 , NT
Determine maintenance requirement units for each year
IF requirements ≤ 0.0
Yes
No
Compute labor, equipment, and material costs
Calculate total cost and find its present value
IF I = NT
Yes
No
Add this total cost in the previous total cost
CONTINUE
For the last fractional year determine the proportionate fractional cost and add to the previous total cost
Calculate cost per square yard
RETURN

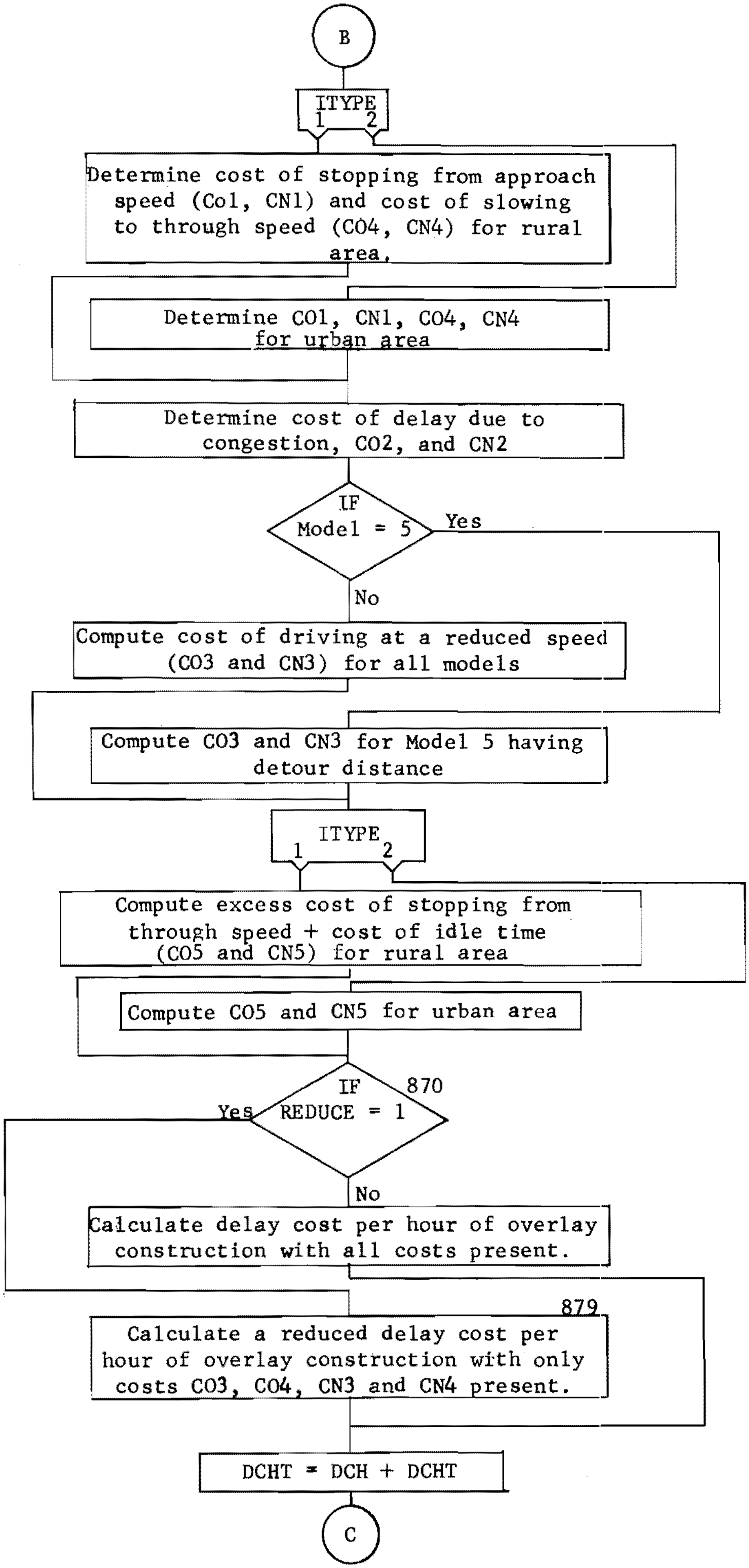

SUBROUTINE REINF (I , J , CTIN , CTC , CTJ , CTRF , CTTB , CTSB)
Reinforcement design check counter, KRCK = KRCK + 1
IF KRCK > 1
Yes
No
Determine free width of pavement according to MODEL
IF CRC Pavement is being Designed XJ ≠ 3.2
Yes
No
IF only Mesh Reinf. is to be designed NCS3 = 2
Yes
No
Determine bar steel giving minimum sum of cost of steel and cost of Trans. joints
640
IF only Bar Reinf. is to be designed NCS3 = 1
Yes
No
650
Determine mesh steel giving minimum sum of cost of steel and cost of transverse joints
680
A
730
690
900

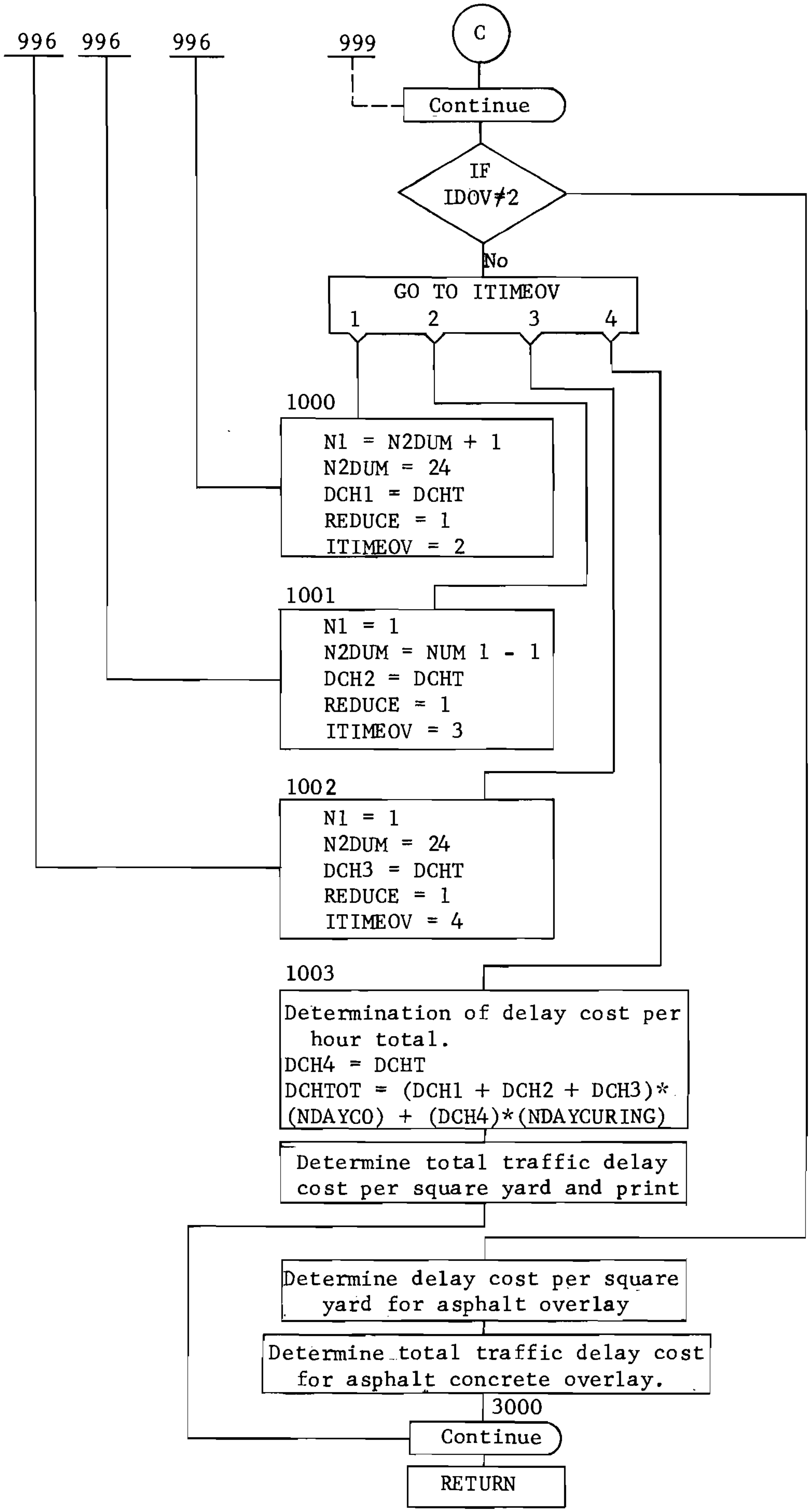

A
IF
Mesh Steel is
more Economical
CTRJ = CTRJB
Yes
No
690
IF
only mesh reinf.
is to be
designed
NCS3 = 2
Yes
No
Determine most economical bar steel
IF
only bar reinf.
is to be
designed
NCS3 = 1
Yes
No
Determine most economical mesh steel
IF
mesh steel is
more economical
CTLS < CTLSB
Yes
No
710
Determine spacings for all bar sizes
specified
720
IF
CRC Pavement is
being designed
(XJ - 3.2)
No (≥ 0)
Yes (< 0)
740
Check for bond strength developed
750
Determine most economical transverse
bar steel and its spacing for the
bar sizes considered
B
790

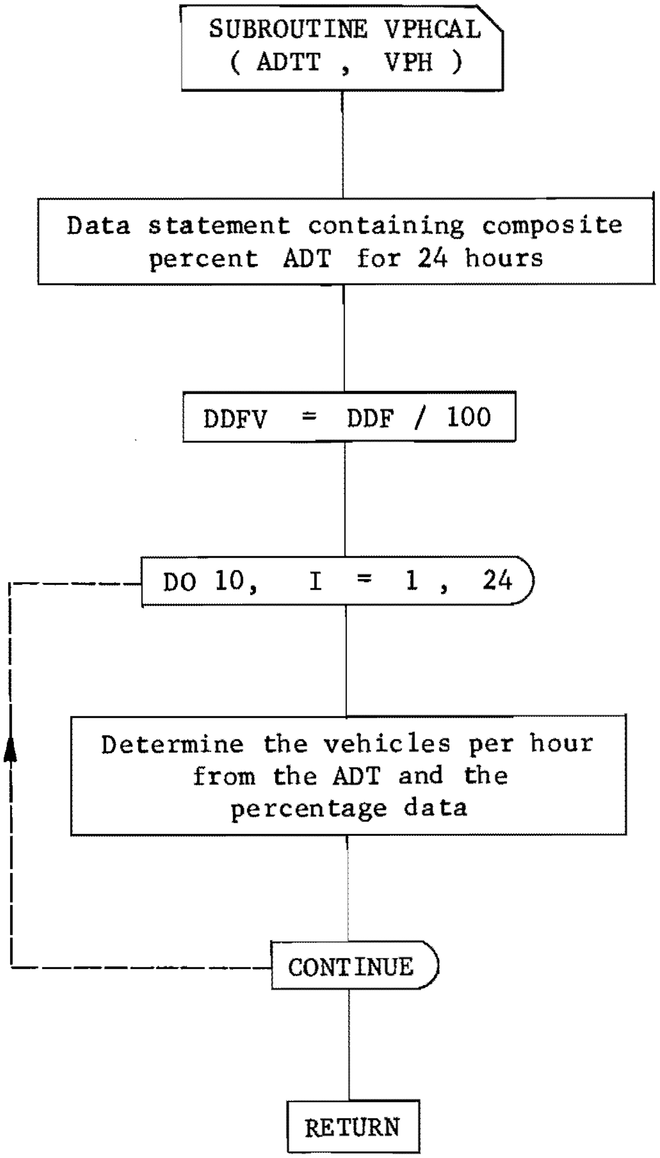

B
Compute cost of reinforcement (Long. + Trans.) and cost of tie bars
Determine wire mesh diameters for all long. mesh spacings specified
IF CRC Pavement is being designed (XJ - 3.2)
No (≥ 0)
Yes (< 0)
800
Check for bond strength developed
810
Determine cost of trans. steel providing the same mesh steel as for long. direction
Determine wire mesh diameters for all transverse mesh spacings specified
850
Determine most economical steel for tie bars
Determine spacing of tie bars
860
Compute cost of reinforcement and cost of tie bars
870
IF CRC pavement is being designed (XJ - 3.2)
No (≥ 0)
Yes (< 0)
880
Compute the cost of joints and the transverse spacing from the specified number per mile
890
Compute cost of joints with the economical transverse spacing determined
900
Determine initial cost CTIN = CTSP + CTC + CTSB + CTRF + CTJ + CTTB
RETURN

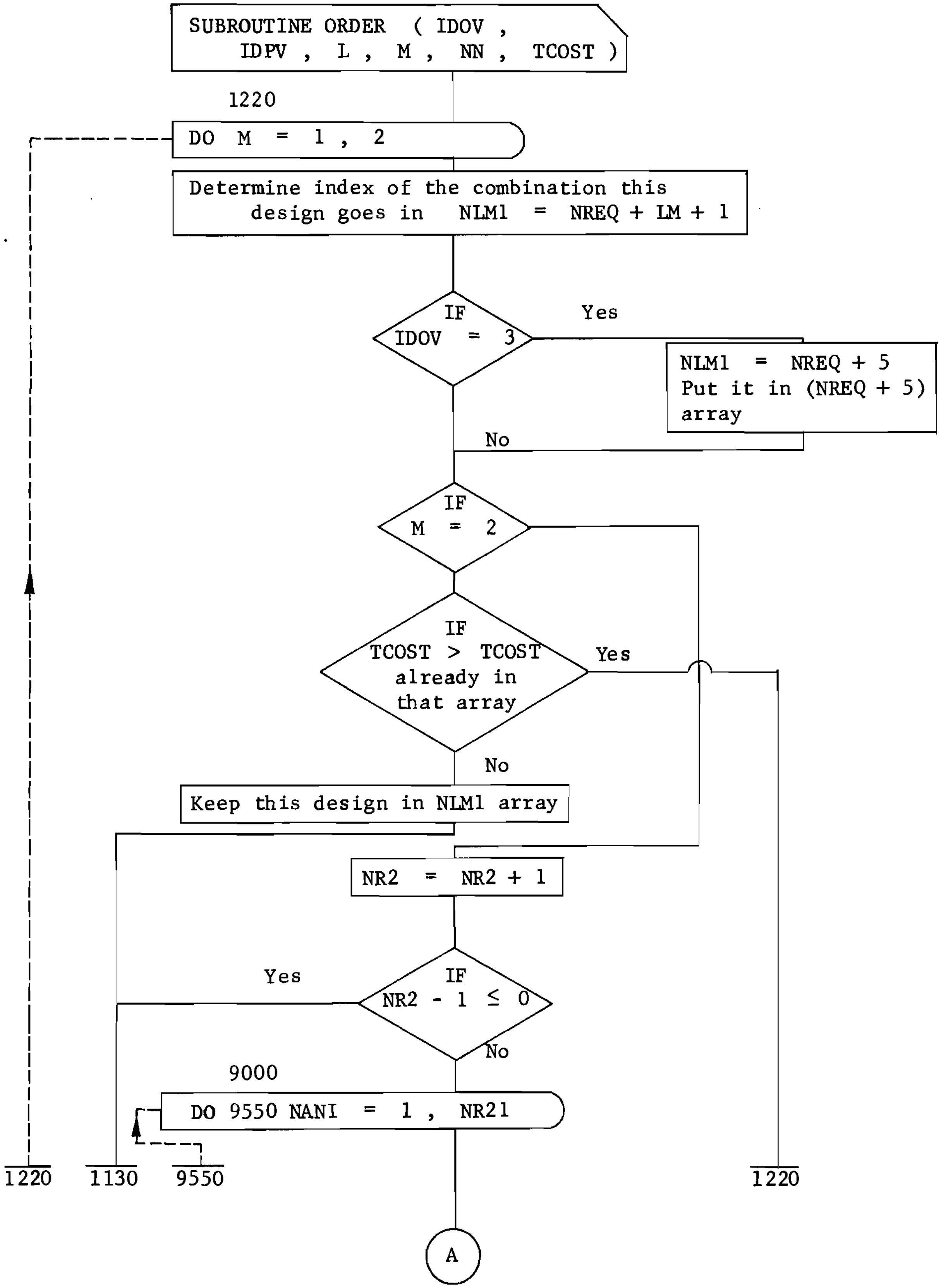

Subroutine TDC3 (PLAT, OVTH, TDCSY, PHSY, N1, N2)
Determine ADTT, the ADT at the time of the overlay.
Compute LO, LN and K Set = 6 if > 6
Set PO1, PN1, DO1, DN1 each = 0.0 Determine PO2, PN2, DO2, DN2
Determine the total number of square yards to be overlayed.
If IDOV = 2
Yes
No
Determine the number of days to construct an asphalt overlay.
Determine the number of days to construct a concrete overlay.
Call VPHCAL (ADTT, AVPH) to calculate the VPH from the ADTT and the ADT distribution curve in subroutine VPHCAL
N2DUM = N2 - 1
ITIMEOV = 1
996
DCHT = 0.0
998
DO 999, I = N1, N2DUM
A
1001
1002
1003
999

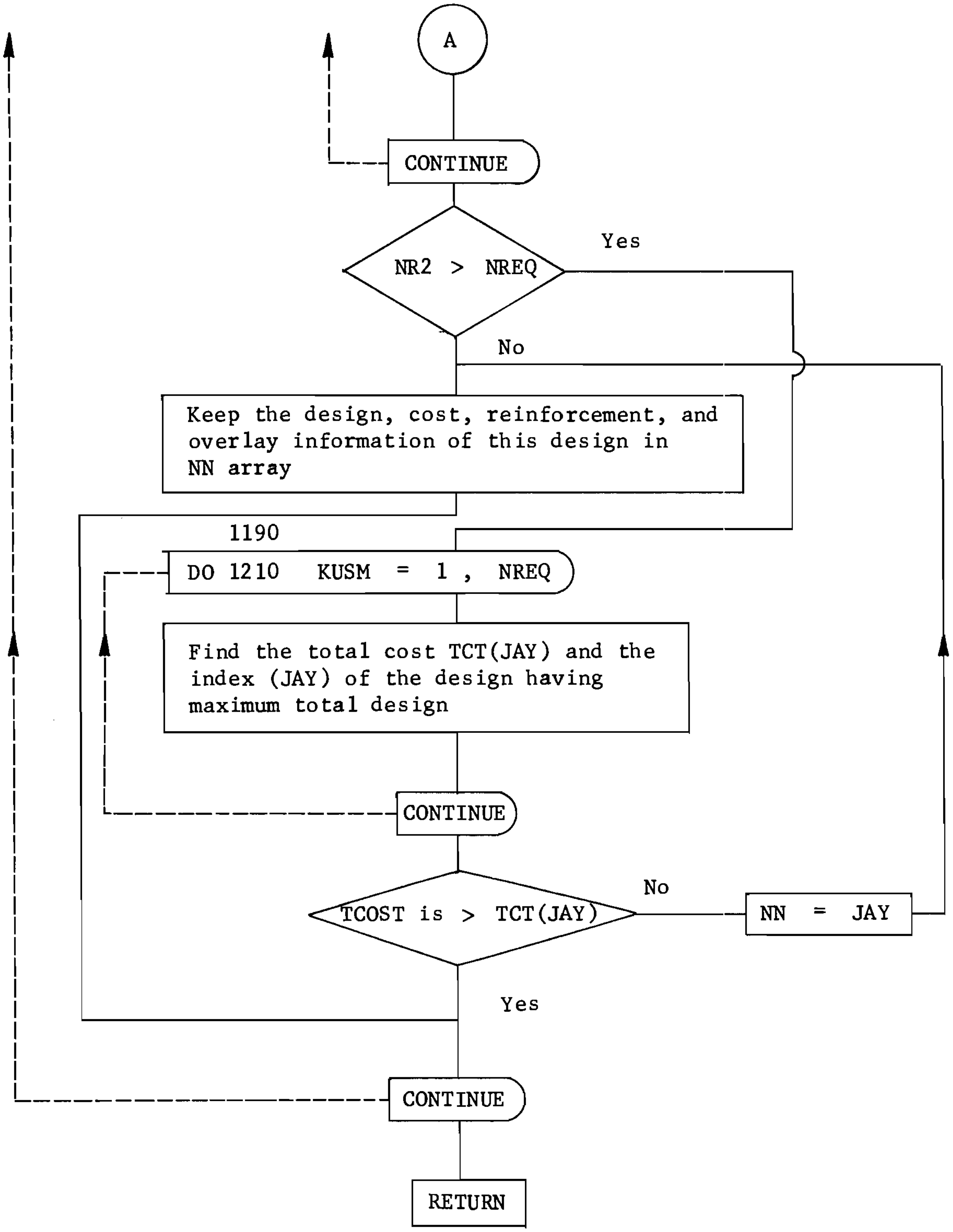

A
MODEL
1
2
3
4
5
6140
Determine Pol, PN1, DO1, DN1
Determine output and the recovery rates for overlay direction
IF veh/hour ≤ output rate
Yes
No
Determine PO1 and set it = 1.0 if greater than 1.0. Determine DO1
Determine output and recovery rates for overlay direction
IF veh/hour ≤ output rate
Yes
No
Determine PO1 and set it = 1.0 if greater than 1.0. Determine DO1
Determine output and recovery rates for nonoverlay direction
IF veh/hour ≤ output rate
Yes
No
Determine PN1 and set it = 1.0 if greater than 1.0. Determine DN1
Continue
B

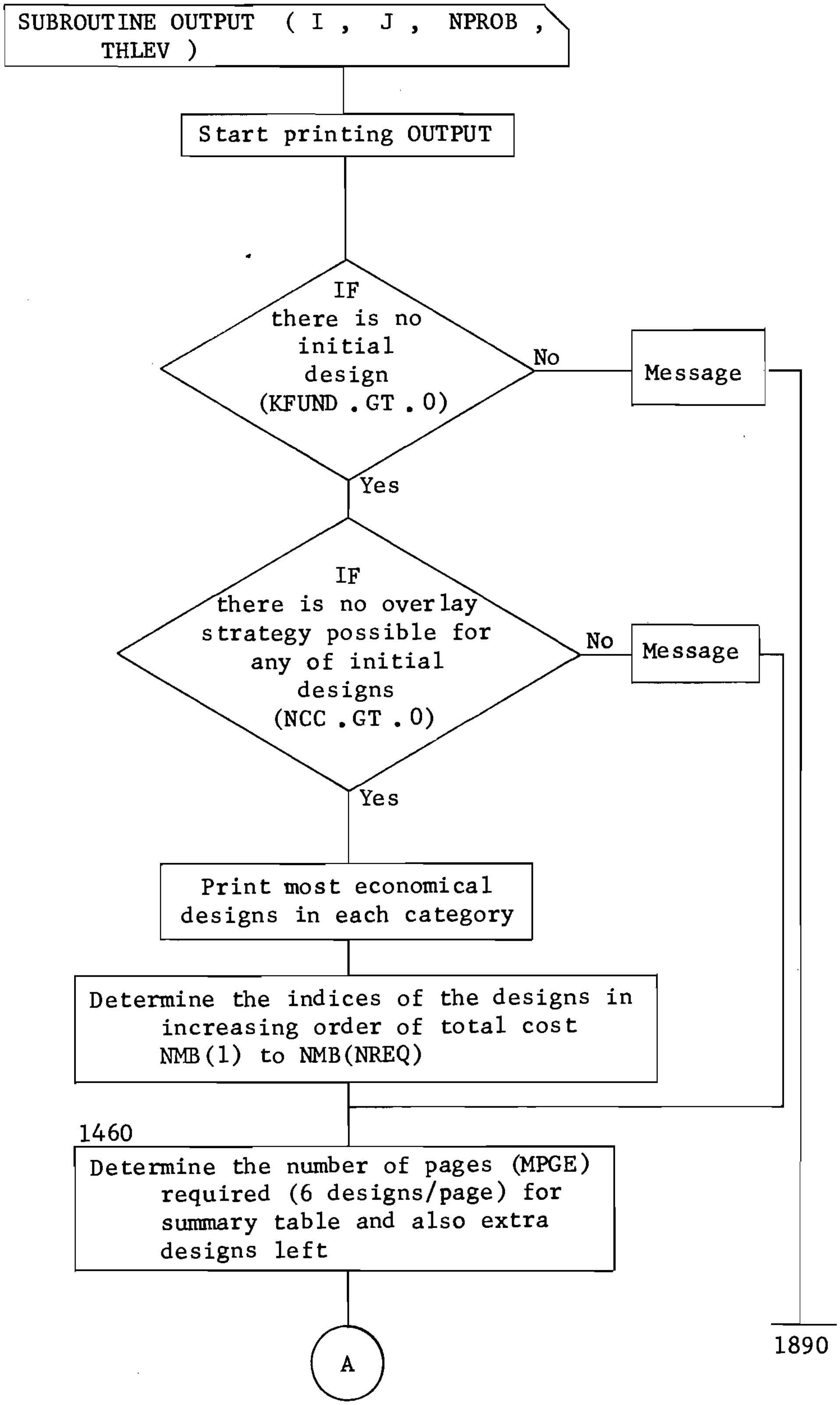

B
ITYPE
1
2
Determine cost of stopping from approach speed (Co1, CN1) and cost of slowing to through speed (C04, CN4) for rural area.
Determine C01, CN1, C04, CN4 for urban area
Determine cost of delay due to congestion, C02, and CN2
IF Model = 5
Yes
No
Compute cost of driving at a reduced speed (C03 and CN3) for all models
Compute C03 and CN3 for Model 5 having detour distance
ITYPE
1
2
Compute excess cost of stopping from through speed + cost of idle time (C05 and CN5) for rural area
Compute C05 and CN5 for urban area
IF REDUCE = 1
870
Yes
No
Calculate delay cost per hour of overlay construction with all costs present.
879
Calculate a reduced delay cost per hour of overlay construction with only costs C03, C04, CN3 and CN4 present.
DCHT = DCH + DCHT
C


996
996
996
999
C
Continue
IF
IDOV≠2
No
GO TO ITIMEOV
1
2
3
4
1000
N1 = N2DUM + 1
N2DUM = 24
DCH1 = DCHT
REDUCE = 1
ITIMEOV = 2
1001
N1 = 1
N2DUM = NUM 1 - 1
DCH2 = DCHT
REDUCE = 1
ITIMEOV = 3
1002
N1 = 1
N2DUM = 24
DCH3 = DCHT
REDUCE = 1
ITIMEOV = 4
1003
Determination of delay cost per hour total.
DCH4 = DCHT
DCHTOT = (DCH1 + DCH2 + DCH3)*(NDAYCO) + (DCH4)*(NDAYCURING)
Determine total traffic delay cost per square yard and print
Determine delay cost per square yard for asphalt overlay
Determine total traffic delay cost for asphalt concrete overlay.
3000
Continue
RETURN

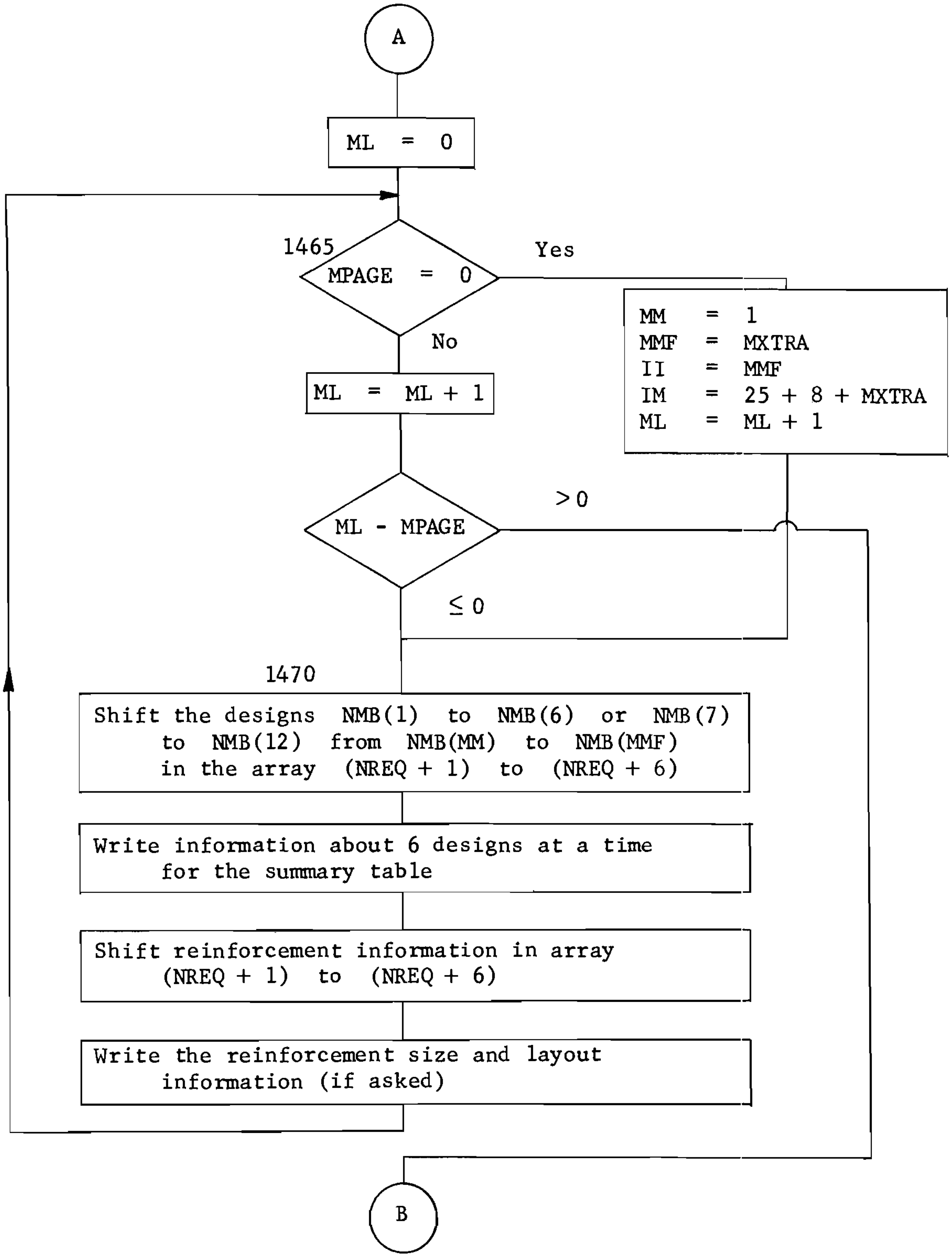

SUBROUTINE VPHCAL
(ADTT , VPH)
Data statement containing composite percent ADT for 24 hours
DDFV = DDF / 100
DO 10, I = 1 , 24
Determine the vehicles per hour from the ADT and the percentage data
CONTINUE
RETURN

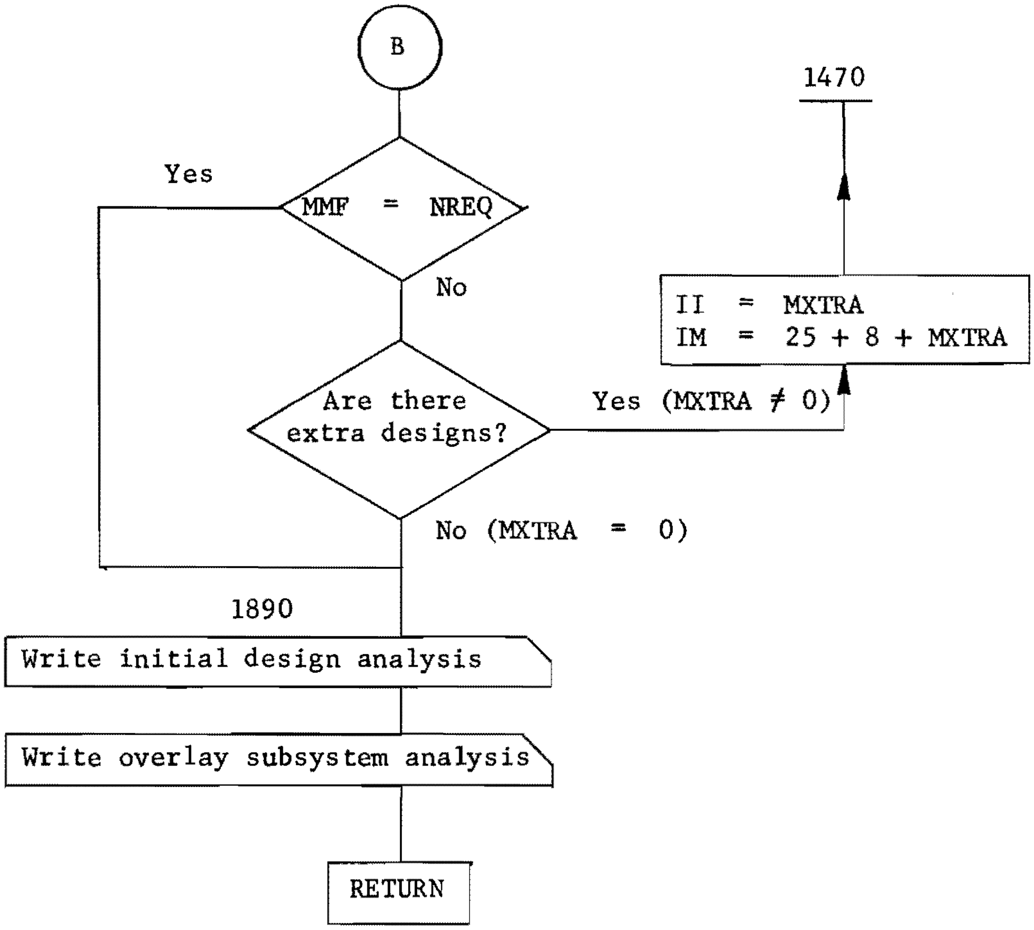

SUBROUTINE ORDER (IDOV , IDPV , L , M , NN , TCOST)
1220
DO M = 1 , 2
Determine index of the combination this design goes in NLM1 = NREQ + LM + 1
IF IDOV = 3
Yes
NLM1 = NREQ + 5 Put it in (NREQ + 5) array
No
IF M = 2
IF TCOST > TCOST already in that array
Yes
No
Keep this design in NLM1 array
NR2 = NR2 + 1
Yes
IF NR2 - 1 ≤ 0
No
9000
DO 9550 NANI = 1 , NR21
1220
1130
9550
1220
A


A
CONTINUE
NR2 > NREQ
Yes
No
Keep the design, cost, reinforcement, and overlay information of this design in NN array
1190
DO 1210 KUSM = 1 , NREQ
Find the total cost TCT(JAY) and the index (JAY) of the design having maximum total design
CONTINUE
TCOST is > TCT(JAY)
No
NN = JAY
Yes
CONTINUE
RETURN



SUBROUTINE OUTPUT (I , J , NPROB , THLEV)
Start printing OUTPUT
IF there is no initial design (KFUND . GT . 0)
No
Message
Yes
IF there is no overlay strategy possible for any of initial designs (NCC . GT . 0)
No
Message
Yes
Print most economical designs in each category
Determine the indices of the designs in increasing order of total cost NMB(1) to NMB(NREQ)
1460
Determine the number of pages (MPGE) required (6 designs/page) for summary table and also extra designs left
A
1890


A
ML = 0
1465
MPAGE = 0
Yes
No
MM = 1
MMF = MXTRA
II = MMF
IM = 25 + 8 + MXTRA
ML = ML + 1
ML = ML + 1
ML - MPAGE
> 0
≤ 0
1470
Shift the designs NMB(1) to NMB(6) or NMB(7) to NMB(12) from NMB(MM) to NMB(MMF) in the array (NREQ + 1) to (NREQ + 6)
Write information about 6 designs at a time for the summary table
Shift reinforcement information in array (NREQ + 1) to (NREQ + 6)
Write the reinforcement size and layout information (if asked)
B


B
1470
Yes
MMF = NREQ
No
II = MXTRA
IM = 25 + 8 + MXTRA
Are there extra designs?
Yes (MXTRA ≠ 0)
No (MXTRA = 0)
1890
Write initial design analysis
Write overlay subsystem analysis
RETURN

APPENDIX 2

INPUT CODING SHEETS FOR PROGRAM RPS-3
SAMPLE RUN AND SAMPLE OUTPUT

IDENTIFICATION EXAMPLE CODING SHEET RPS-3 CODED BY RFC III DATE Dec 31, 1974 PAGE 1 OF 2

```
1          TEST RUN SHOWING NEW RPS-3 VERSION RFC III
                                                           1                 23.
      2.0       3.0                50.0      60.0             20000.0   8000000.
     12.0      24.0       5.0       5.0   6.0  2.0  6.0  2.0     20.0   1.0    0
      4.4       3.0       4.5        .80       .14       1.5
      2.0       0.0       2.0       3.0      8.0     2    4                   2
      5.0       0.0        .02      0.0      60.0      40.0      55.0          3
    6 28 1500.           140.   1800000.200.     1000.      8.50     950.  60.
      28 1550.           141.   2000000.210.     1000.      8.75     950.  70.
      28 1600.           142.   2200000.220.     1000.      9.00     950.  70.
      28 1650.           145.   2400000.230.     1000.      9.10     950.  70.
      28 1700.           148.   2600000.240.     1000.      9.15     950.  75.
      28 1750.           150.   2800000.250.     1000.      9.25     950.  75.
                8.0      12.0       2.0
    150.0                                                     .90 2.0    1500.00
    4 GRANULAR  1.0  1.5          20000.   2000.        3.0030.  10.  12.0  2.0
```

IDENTIFICATION EXAMPLE CODING SHEET RPS-3 CODED BY RFC III DATE Dec. 31, 1974 PAGE 2 OF 2

```
      CENT STAB  0.01.8         1000000.   2000.        5.0040.  10.   12.0  2.0
      ASP STAB   0.51.7          800000.   2000.        4.5040.  10.   12.0  2.0
      LIMSTN     1.51.5           25000.   2000.        3.5030.  10.   12.0  2.0
A-615,GR7570000  .13A-432     60000  .10A-812,GR6565000  .12A-777,GR8075000  .11
A-15STR   33000  .07A-15INT   40000  .08A-15 STR  35000  .07A-15 INT  38000  .09
ASTM.A-49 70000  .10ASTM,A-50 75000  .11ASTM,A-51 60000  .08ASTM,A-52 65000  .09
A-615,GR4040000  .08A-15 STR  33000  .07A-615,GR4537000  .07A-615,GR4638000 .078
   3.   4.   5.   6. 4.0 12.0  5.0 14.0  6.0 16.0  7.0 18.0   3.    4.   5.   6.
   1000.        10.0     40.0    300000.    175.        40.0       1.0       5.0
         9        17        13         1         2
      1.4        1.2               15.0       90.0      15.0          2
     10.0       2.50      3.00      1.00      8.00               12.00         8
               19.70   820000.      35.0       0.0       .30       .30       .30
```

```
RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION RFC III


                               TRAFFIC GROWTH AND DISTRIBUTION


AXLE GROWTH FACTOR, PERCENT PER YEAR                                          2.00
ADT GROWTH RATE, PERCENT PER YEAR                                             3.00
DIRECTIONAL DISTRIBUTION FACTOR, PERCENT                                     50.00
DESIGN LANE DISTRIBUTION FACTOR, PERCENT                                     60.00
INITIAL AVERAGE DAILY TRAFFIC, ONE DIRECTION                              28000.00
TOTAL 18 KIP AXLES FOR ANALYSIS PERIOD, BOTH DIRECTIONS                    8000000
```

```
RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION RFC III


                              PROGRAM CONTROLS
                  DESIGNER SPECIFIES

BOTH CRCP AND JCP PAVEMENTS TO BE TRIED
BOTH CC AND AC OVERLAYS TO BE TRIED
BOTH DEFORMED BAR AND WIRE MESH REINFORCEMENT TO BE TRIED
PRINT LONG FORM OF OUTPUT
PRINT FIRST 23 DESIGNS IN INCREASING ORDER OF TOTAL COST


                              DESIGNERS  DECISIONS OR RESTRAINTS

MAXIMUM INITIAL FUNDS AVAILABLE, DOLLARS PER SQ. YD.                    12.00
MAX INITIAL THICKNESS, SLAB PLUS SUBBASE, INCHES                        24.00
MIN TIME TO FIRST OVERLAY, YEARS                                         5.00
MIN TIME BETWEEN OVERLAYS, YEARS                                         5.00
MAX TOTAL AC OVERLAY THICKNESS,INCHES                                    6.00
MIN AC OVERLAY THICKNESS AT ONE TIME, INCHES                             2.00
MAX TOTAL CONC OVERLAY THICKNESS, INCHES                                 6.00
MIN CONC OVERLAY THICKNESS AT ONE TIME, INCHES                           2.00
AVERAGE LEVEL UP THICKNESS, INCHES                                       1.00
LENGTH OF ANALYSIS PERIOD, YEARS                                        20.00
CONFIDENCE LEVEL(C), PERCENT                                            95.000


                           PERFORMANCE VARIABLES

INITIAL SERVICEABILITY INDEX, EXPECTED                                   4.40
TERMINAL SERVICEABILITY INDEX, ACCEPTED                                  3.00
SERVICEABILITY INDEX AFTER AN OVERLAY, EXPECTED                          4.50
PROBABILITY OF CONJUNCTION OF BAD SOIL AND SITE, PERCENT                  .80
SWELLING RATE CONSTANT                                                    .14
SWELLING ACTIVITY, ESTIMATED DIFFERENTIAL MOVEMENT, INCHES               1.50


                          TRAFFIC DELAY COST VARIABLES

DISTANCE OVER WHICH TRAFFIC IS SLOWED, MILES, OV.DIRECTION               2.00
                                         NON.OV.DIRECTION                0.00
NO. OF OPEN LANES IN RESTRICTED ZONE, MILES,  OV.DIRECTION                  2
                                         NON.OV.DIRECTION                   4
PERCENT VEHICLES STOPPED BY ROAD EQUIPMENT,   OV.DIRECTION               5.00
                                         NON.OV.DIRECTION                0.00
AVG DELAY CAUSED BY ROAD EQUIP, HOURS ,       OV.DIRECTION                .02
                                         NON.OV.DIRECTION                0.00
AVG SPEED THROUGH OVERLAY ZONE, MPH           OV.DIRECTION              40.00
                                         NON.OV.DIRECTION               55.00
AVERAGE APPROACH SPEED TO OVERLAY AREA, MPH                             60.00
DETOUR DISTANCE AROUND OVERLAY ZONE, MILES                               2.00
NO. OF HOURS/DAY OVERLAY CONSTRUCTION OCCURS                             8.00
TRAFFIC MODEL USED IN THE ANALYSIS                                          3
ROAD LOCATION                                                           URBAN
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     RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974     RFC III  I-----TRYM
     PROB 1          TEST RUN SHOWING NEW RPS-3 VERSION RFC III


                                  MATERIALS, CONCRETE

 CONCRETE MIX DESIGN NUMBER                                  1          2          3          4          5          6
 AGE OF TESTING CONCRETE, DAYS                              28         28         28         28         28         28
 MEASURING POINT                                        CENTER     CENTER     CENTER     CENTER     CENTER     CENTER
 FLEXURAL STRENGTH, PSI                                 500.00     550.00     600.00     650.00     700.00     750.00
 TENSILE STRENGTH, PSI                                  200.00     210.00     220.00     230.00     240.00     250.00
 ELASTIC MODULUS, PSI                                  1800000    2000000    2200000    2400000    2600000    2800000
 UNIT WEIGHT, PCF                                       140.00     141.00     142.00     145.00     148.00     150.00
 CONSTRUCTION EQUIPMENT COST, PER LANE MILE            1000.00    1000.00    1000.00    1000.00    1000.00    1000.00
 COST PER CUBIC YARD OF CONCRETE, DOLLARS                 8.50       8.75       9.00       9.10       9.15       9.25
 COST OF SURFACING CONCRETE, DOLLARS/PER LANE MILE      950.00     950.00     950.00     950.00     950.00     950.00
 SALVAGE VALUE OF CONCRETE, PERCENT                      60.00      70.00      70.00      70.00      75.00      75.00


 MINIMUM ALLOWABLE CONCRETE THICKNESS, INCHES                      8.00
 MAXIMUM ALLOWABLE CONCRETE THICKNESS, INCHES                     12.00
 PRACTICAL INCREMENT FOR POURING CONCRETE, INCHES                  2.00


                                  MATERIALS, STEEL

                                            1            2            3            4
      BARS
         LONGITUDINAL
           BAR STEEL ASTM DESIG   A-615,GR75   A-432        A-812,GR65   A-777,GR80
           TENSILE STRENGTH,PSI     70000.00     60000.00     65000.00     75000.00
           COST/LB, DOLLARS             .130         .100         .120         .110
         TRANSVERSE
           BAR STEEL ASTM DESIG   A-15STR      A-15INT      A-15 STR      A-15 INT
           TENSILE STRENGTH,PSI     33000.00     40000.00     35000.00     38000.00
           COST/LB, DOLLARS             .070         .080         .070         .090
         BAR NOS. TO BE TRIED              3            4            5            6

      WIRE MESHES
           WIRE MESH ASTM DESIG   ASTM, A-49   ASTM,A-50    ASTM,A-51    ASTM, A-52
           TENSILE STRENGTH,PSI     70000.00     75000.00     60000.00     65000.00
           COST/LB, DOLLARS             .100         .110         .080         .090
         MESH SIZES TO BE TRIED
          LONG. WIRE SPACING,FT         4.00         5.00         6.00         7.00
          TRAN. WIRE SPACING,FT        12.00        14.00        16.00        18.00

      TIE BARS USED WITH W. MESH
           TIE BAR ASTM  DESIG.   A-615,GR40   A-15 STR     A-615,GR45   A-615,GR46
           TENSILE STRENGTH,PSI     40000.00     33000.00     37000.00     38000.00
           COST/LB, DOLLARS         .080         .070         .075         .078
         TIE BAR NOS TO BE TRIED           3            4            5            6
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974     RFC III  I-----
PROB 1          TEST RUN SHOWING NEW RPS-3 VERSION RFC III


                          MATERIALS, SUBGRADE

SUBGRADE K, PCI                                                      150.00
SUBGRADE FRICTION FACTOR                                                .90
SUBGRADE ERODABILITY FACTOR                                            2.00
COST PER LANE MILE OF SUBGRADE PREPARATION, DOLLARS                 1500.00

                          MATERIALS, SUBBASE

SUBBASE TYPE                                        GRANULAR  CEMT STAB ASP STAB  LIMSTN
ERODABILITY FACTOR                                     1.00      0.00      .50      1.50
FRICTION FACTOR                                        1.50      1.80     1.70      1.50
ELASTIC MODULUS, PSI                                  20000   1000000   800000     25000
CONSTRUCTION EQUIPMENT COST, DOLLARS/LANE MILE      2000.00   2000.00  2000.00   2000.00
COST PER COMPACTED CU YD , DOLLARS                     3.00      5.00     4.50      3.50
SALVAGE PERCENT VALUE, PERCENT                        30.00     40.00    40.00     30.00
MIN ALLOWED THICKNESS, INCHES                         10.00     10.00    10.00     10.00
MAX ALLOWED THICKNESS, INCHES                         12.00     12.00    12.00     12.00
INCREMENT FOR SUBBASE, INCHES                          2.00      2.00     2.00      2.00

                          OVERLAY

INITIAL COST PER LANE MILE OF EQUIPMENT FOR OVERLAYS, DOLLARS       1000.00
COST / CU YD OF IN PLACE COMPACTED ASPHALT CONCRETE, DOLLARS          10.00
SALVAGE VALUE OF ASPHALT CONCRETE, PERCENT                            40.00
ASPHALT CONCRETE MODULUS VALUE, PSI                                  300000
PRODUCTION RATE OF COMPACTED ASPHALT CONCRETE, CU YD / HR            175.00
CONCRETE PRODUTION RATE, CU YD /HR                                    40.00
CONCRETE COEFFICIENT                                                   1.00
RANDOM ADDITIONAL COST / SQ YD FOR ANYTHING                            5.00

                          JOINTS

COST/FT OF TRANS. JOINT,  SAWING, DOWELS, AND/OR SEALING, DOLLARS         1.40
COST/FT OF LONG. JOINT, SEALING, DOLLARS                                  1.20
RANGE OF SPACING FOR TRANSVERSE JOINTS, LOWER VALUE, FT                  15.00
                                        UPPER VALUE, FT                  90.00
INCREMENT OF SPACING TO BE TRIED FOR TRANSVERSE JOINTS, FT               15.00
NO. OF TRANS. CONST. OR WRAPPING JOINTS/MILE FOR CRCP                        2


   MAINTENANCE, DIMENTIONS AND MISCELLANEOUS

DAYS OF FREEZING TEMPERATURE PER YEAR                                  10.00
COMPOSITE LABOR WAGE FOR MAINTENANCE OPERATIONS, DOLLARS/HR             2.50
COMPOSITE EQUIPMENT RENTAL RATE FOR MAINT. OPERATION, DOLLARS           3.00
COST OF MATERIALS FOR MAINTENANCE OPERATIONS, DOLLARS                   1.00
WIDTH OF EACH LANE, FEET                                               12.00
TOTAL NUMBER OF LANES IN BOTH DIRECTIONS                                   8
RATE OF INTEREST OR TIME VALUE OF MONEY, PERCENT                        8.00
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      REC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION REC III


                    CONFIDENCE LEVEL VARIABLES

             PERCENT COEFF. OF VARIATION OF FLEXURAL
                    STRENGTH OF CONCRETE                              19.70

             STD. DEV. OF ELASTIC MODULUS OF CONCRETE (PSI)       820000.00

             STD. DEV. OF SUBGRADE K VALUE                            35.00
             STD. DEV. OF CONTINUITY FACTOR (J)                        0.00
             STD. DEV. OF INITIAL SERVICABILITY INDEX (P1)              .30

             STD. DEV. OF TERMINAL SERVICABILITY INDEX (P2)             .30

             STD. DEV. OF THICKNESS OF CONCRETE                         .30

             STD. DEV. OF FLEXURAL STRENGTH OF DESIGN WITH:
                                 MIX     1                            98.50
                                 MIX     2                           108.35
                                 MIX     3                           118.20
                                 MIX     4                           128.05
                                 MIX     5                           137.90
                                 MIX     6                           147.75


                    OVERLAY CONSTRUCTION VARIABLES


MILITARY HOUR OF THE DAY WHEN OVERLAY CONSTRUCTION BEGINS                 9
MILITARY HOUR OF THE DAY WHEN OVERLAY CONSTRUCTION ENDS                  17
NUMBER OF DAYS CONCRETE MUST CURE                                        13
TOTAL NUMBER OF LANES TO BE OVERLAID                                      1
TOTAL OVERLAY LENGTH IN ONE LANE                                          2
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION RFC III

    MOST ECONOMICAL  ICP PAVEMENT DESIGN WITH  AC OVERLAY.

INITIAL CONSTRUCTION.   LIFE IS   5.708 YEARS

   MATERIALS                                                    DESCRIPTION
                                                            MATERIAL    MATERIAL
                                                             NUMBER       NAME

   CONCRETE          8.00 INCHES                                6
   SURBASE          10.00 INCHES                                1
   LONG.REINF.MESH SPACING   4.0    5.0    6.0    7.0           3       ASTM.A-51
            MESH DIAMETER    .21    .23    .25    .27
   TRAN.REINF.MESH SPACING  12.0   14.0   16.0   18.0           3       ASTM.A-51
            MESH DIAMETER    .32    .34    .37    .39
   TIE BARS       BAR NUMBER   3      4      5      6           1       A-615,GR40
                  SPACING   11.0   19.6   30.7   44.2

               TRANSVERSE JOINT SPACING                        60 FEET
               LONGITUDINAL JOINT SPACING                      12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER   5.708 YEARS
   2  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER  13.529 YEARS

      EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

     TOTAL OVERLAY THICKNESS   4.00 INCHES    TOTAL LIFE  24.022 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
     INITIAL CONSTRUCTION
        COST OF SUBGRADE PREPARATION                        .213
        COST OF CONCRETE                                   2.333
        COST OF SUBBASE                                    1.117
        COST OF REINFORCEMENT                               .441
        COST OF JOINTS                                      .885
        COST OF TIE BARS                                    .034

     TOTAL INITIAL CONSTRUCTION COST                       5.023
     TOTAL OVERLAY CONSTRUCTION COST                        .973
     TOTAL T.D. COST DURING OV. CONSTRUCTION                .049
     TOTAL MAINTENANCE COST                                 .146
     SALVAGE RETURNS                                       -.480
     ANY ADDITIONAL COST SPECIFIED                         5.000

    TOTAL OVERALL COST                               .    10.712

DESIGN ANALYSIS
   TOTAL 144 INITIAL DESIGNS WERE EXAMINED. OUT OF WHICH.
          78 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          66 REMAINING INITIAL DESIGNS PRODUCED  141 OVERLAY STRATEGIES
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION RFC III

    MOST ECONOMICAL  ICP PAVEMENT DESIGN WITH  CC OVERLAY.

INITIAL CONSTRUCTION.   LIFE IS  12.322 YEARS

   MATERIALS                                                    DESCRIPTION
                                                            MATERIAL    MATERIAL
                                                             NUMBER       NAME

   CONCRETE          8.00 INCHES                                6
   SUBBASE          10.00 INCHES                                1
   LONG.REINF.MESH SPACING   4.0    5.0    6.0    7.0           3       ASTM.A-51
            MESH DIAMETER    .22    .25    .27    .29
   TRAN.REINF.MESH SPACING  12.0   14.0   16.0   18.0           3       ASTM.A-51
            MESH DIAMETER    .34    .37    .39    .42
   TIE BARS       BAR NUMBER   3      4      5      6           1       A-615,GR40
                  SPACING    9.7   17.3   27.1   39.0

               TRANSVERSE JOINT SPACING                        60 FEET
               LONGITUDINAL JOINT SPACING                      12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   CC AFTER  12.322 YEARS

      EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

     TOTAL OVERLAY THICKNESS   2.00 INCHES    TOTAL LIFE  31.839 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
     INITIAL CONSTRUCTION
        COST OF SUBGRADE PREPARATION                        .213
        COST OF CONCRETE                                   2.333
        COST OF SUBBASE                                    1.534
        COST OF REINFORCEMENT                               .500
        COST OF JOINTS                                      .885
        COST OF TIE BARS                                    .039

     TOTAL INITIAL CONSTRUCTION COST                       5.504
     TOTAL OVERLAY CONSTRUCTION COST                        .406
     TOTAL T.D. COST DURING OV. CONSTRUCTION                .622
     TOTAL MAINTENANCE COST                                 .472
     SALVAGE RETURNS                                       -.521
     ANY ADDITIONAL COST SPECIFIED                         5.000

    TOTAL OVERALL COST                                    11.483

DESIGN ANALYSIS
   TOTAL 144 INITIAL DESIGNS WERE EXAMINED, OUT OF WHICH,
          78 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          66 REMAINING INITIAL DESIGNS PRODUCED  114 OVERLAY STRATEGIES
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      REC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION REC III

    MOST ECONOMICAL CRC PAVEMENT DESIGN WITH  AC OVERLAY.

INITIAL CONSTRUCTION.   LIFE IS   9.359 YEARS

  MATERIALS                                                  DESCRIPTION
                                                         MATERIAL    MATERIAL
                                                          NUMBER       NAME

  CONCRETE          8.00 INCHES                             3
  SUBBASE          10.00 INCHES                             1
  LONG.REINF.MESH SPACING   4.0    5.0    6.0    7.0        3       ASTM,A-51
             MESH DIAMETER  .45    .50    .55    .59
  TRAN.REINF.MESH SPACING  12.0   14.0   16.0   18.0        3       ASTM,A-51
             MESH DIAMETER  .31    .34    .36    .38
  TIE BARS       BAR NUMBER   3      4      5      6        1       A-615,GR40
                    SPACING  11.7   20.7   32.4   46.7

              TRANSVERSE CONSTRUCTION JOINT SPACING   2640 FEET
              LONGITUDINAL JOINT SPACING                12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER   9.359 YEARS

      EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

     TOTAL OVERLAY THICKNESS   2.00 INCHES    TOTAL LIFE  22.354 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
     INITIAL CONSTRUCTION
        COST OF SUBGRADE PREPARATION                    .213
        COST OF CONCRETE                               2.277
        COST OF SUBBASE                                1.117
        COST OF REINFORCEMENT                          1.335
        COST OF JOINTS                                  .680
        COST OF TIE BARS                                .033

     TOTAL INITIAL CONSTRUCTION COST                   5.655
     TOTAL OVERLAY CONSTRUCTION COST                    .475
     TOTAL T.D. COST DURING OV. CONSTRUCTION            .025
     TOTAL MAINTENANCE COST                             .346
     SALVAGE RETURNS                                   -.402
     ANY ADDITIONAL COST SPECIFIED                     5.000

    TOTAL OVERALL COST                                11.099

DESIGN ANALYSIS
   TOTAL 144 INITIAL DESIGNS WERE EXAMINED. OUT OF WHICH.
         112 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          32 REMAINING INITIAL DESIGNS PRODUCED   63 OVERLAY STRATEGIES
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      REC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION REC III

    MOST ECONOMICAL CRC PAVEMENT DESIGN WITH  CC OVERLAY.

INITIAL CONSTRUCTION.   LIFE IS  11.525 YEARS

  MATERIALS                                                  DESCRIPTION
                                                         MATERIAL    MATERIAL
                                                          NUMBER       NAME

  CONCRETE          8.00 INCHES                             4
  SUBBASE          10.00 INCHES                             1
  LONG.REINF.MESH SPACING   4.0    5.0    6.0    7.0        3       ASTM,A-51
             MESH DIAMETER  .46    .51    .56    .60
  TRAN.REINF.MESH SPACING  12.0   14.0   16.0   18.0        3       ASTM,A-51
             MESH DIAMETER  .31    .34    .36    .39
  TIE BARS       BAR NUMBER   3      4      5      6        1       A-615,GR40
                    SPACING  11.4   20.3   31.7   45.7

              TRANSVERSE CONSTRUCTION JOINT SPACING   2640 FEET
              LONGITUDINAL JOINT SPACING                12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   CC AFTER  11.525 YEARS

      EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

     TOTAL OVERLAY THICKNESS   2.00 INCHES    TOTAL LIFE  31.434 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
     INITIAL CONSTRUCTION
        COST OF SUBGRADE PREPARATION                    .213
        COST OF CONCRETE                               2.299
        COST OF SUBBASE                                1.117
        COST OF REINFORCEMENT                          1.392
        COST OF JOINTS                                  .680
        COST OF TIE BARS                                .033

     TOTAL INITIAL CONSTRUCTION COST                   5.734
     TOTAL OVERLAY CONSTRUCTION COST                    .426
     TOTAL T.D. COST DURING OV. CONSTRUCTION            .651
     TOTAL MAINTENANCE COST                             .423
     SALVAGE RETURNS                                   -.433
     ANY ADDITIONAL COST SPECIFIED                     5.000

    TOTAL OVERALL COST                                11.801

DESIGN ANALYSIS
   TOTAL 144 INITIAL DESIGNS WERE EXAMINED, OUT OF WHICH,
         112 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          32 REMAINING INITIAL DESIGNS PRODUCED   43 OVERLAY STRATEGIES
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      REC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION REC III

    MOST ECONOMICAL INITIAL DESIGN LASTING THE ANALYSIS PERIOD

  PAVEMENT TYPE IS JCP

                                                     MATERIAL
                                                      NUMBER
  CONCRETE        10.00 INCHES                          5
  SUBBASE         10.00 INCHES                          3

              TRANSVERSE JOINT SPACING                        45 FEET
              LONGITUDINAL JOINT SPACING                      12 FEET


  LIFE OF THE DESIGN IS  27.210 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
    INITIAL CONSTRUCTION
       COST OF SUBGRADE PREPARATION                         .213
       COST OF CONCRETE                                    2.819
       COST OF SUBBASE                                     1.534
       COST OF REINFORCEMENT                                .531
       COST OF JOINTS                                       .955
       COST OF TIE BARS                                     .048

    TOTAL INITIAL CONSTRUCTION COST                        6.100
    TOTAL MAINTENANCE COST                                 1.307
    SALVAGE RETURNS                                        -.516
    ANY ADDITIONAL COST SPECIFIED                          5.000

   TOTAL OVERALL COST                                     11.89[illegible]

DESIGN ANALYSIS
         THIS IS THE MOST OPTIMAL DESIGN
         OUT OF   85 ACCEPTABLE DESIGNS
         OF THIS KIND
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      REC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION REC III


         SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER                 1       2       3       4       5       6
***********************************************************************
PAVEMENT TYPE               JCP     JCP     JCP     JCP     JCP     JCP
OVERLAY  TYPE                AC      AC      AC      AC      AC      AC
REINFORCEMENT TYPE         MESH    MESH    MESH    MESH    MESH    MESH

CONCRETE TYPE                 6       5       4       3       6       2
SUBBASE  TYPE                 1       3       3       1       1       3
***********************************************************************

SLAB THICKNESS             8.00    8.00    8.00   10.00    8.00    8.00
SUBBASE THICKNESS         10.00   10.00   10.00   10.00   12.00   10.00

OVERLAY + LEVEL UP 1       3.00    3.00    3.00    3.00    3.50    3.00
OVERLAY + LEVEL UP 2       3.00                            3.00    3.00

INITIAL LIFE               5.71   10.49    8.82    9.79    5.86    5.95

PERFORMANCE LIFE 1        13.53   25.82   21.63   22.89   14.63   14.63
PERFORMANCE LIFE 2        24.02                           26.52   26.37

TOTAL PERFORMANCE LIFE    24.02   25.82   21.63   22.89   26.52   26.37


SPACING TRANS. JOINTS     60.00   60.00   60.00   45.00   60.00   60.00
SPACING LONG. JOINTS      12.00   12.00   12.00   12.00   12.00   12.00
***********************************************************************

COST OF SUBG. PREPARATION  .213    .213    .213    .213    .213    .213
COST OF CONCRETE          2.333   2.310   2.299   2.777   2.333   2.221
COST OF SUBBASE           1.117   1.534   1.534   1.117   1.284   1.534
COST OF REINFORCEMENT      .441    .493    .483    .449    .441    .470
COST OF JOINTS             .885    .885    .885    .955    .885    .885
COST OF TIE BARS           .034    .039    .038    .041    .034    .037

INITIAL CONST. COST       5.023   5.474   5.452   5.553   5.190   5.360
OVERLAY CONST. COST        .973    .435    .495    .459   1.026    .939
TRAFFIC DELAY COST         .049    .023    .025    .024    .053    .048
MAINTENANCE COST           .146    .376    .341    .354    .168    .161
SALVAGE RETURNS           -.480   -.482   -.459   -.477   -.502   -.495
ANY ADDITIONAL COST       5.000   5.000   5.000   5.000   5.000   5.000

***********************************************************************
TOTAL COST PER SQ YARD   10.712  10.826  10.854  10.913  10.934  11.013
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION RFC III

                            REINFORCEMENT DESIGN
 DESIGN     REINFORCEMENT DESCRIPTION                           MATERIAL   MATERIAL
 NUMBER                                                          NUMBER      NAME


   1    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM.A-51
                  MESH DIAMETER    .21    .23    .25    .27
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM.A-51
                  MESH DIAMETER    .32    .34    .37    .39
        TIE BAR       BAR NUMBER     3      4      5      6      1      A-615.GR40
                         SPACING  11.0   19.6   30.7   44.2

   2    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM.A-51
                  MESH DIAMETER    .22    .24    .27    .29
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM.A-51
                  MESH DIAMETER    .34    .36    .39    .41
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615.GR40
                         SPACING   9.9   17.6   27.4   39.5

   3    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM.A-51
                  MESH DIAMETER    .22    .24    .26    .29
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM.A-51
                  MESH DIAMETER    .33    .36    .39    .41
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615.GR40
                         SPACING  10.1   17.9   28.0   40.3

   4    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM.A-51
                  MESH DIAMETER    .19    .22    .24    .26
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM.A-51
                  MESH DIAMETER    .35    .37    .40    .43
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615.GR40
                         SPACING   9.3   16.6   25.9   37.3

   5    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM.A-51
                  MESH DIAMETER    .21    .23    .25    .27
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM.A-51
                  MESH DIAMETER    .32    .34    .37    .39
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615.GR40
                         SPACING  11.0   19.6   30.7   44.2

   6    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM.A-51
                  MESH DIAMETER    .21    .24    .26    .28
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM.A-51
                  MESH DIAMETER    .33    .36    .38    .40
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615.GR40
                         SPACING  10.4   18.4   28.8   41.5
```

```
RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION RFC III


          SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER                    7        8        9       10       11       12
*******************************************************************************
PAVEMENT TYPE                  JCP      JCP      JCP      JCP      JCP      CRC
OVERLAY  TYPE                   AC       AC       AC       AC       AC       AC
REINFORCEMENT TYPE            MESH     MESH     MESH     MESH     MESH     MESH

CONCRETE TYPE                    3        3        2        4        5        1
SUBBASE  TYPE                    3        3        1        4        4        .
*******************************************************************************

SLAB THICKNESS                8.00     8.00    10.00    10.00     8.00     8.00
SUBBASE THICKNESS            12.00    10.00    10.00    10.00    12.00    10.00

OVERLAY + LEVEL UP 1          3.00     4.00     3.00     3.00     3.00     3.00
OVERLAY + LEVEL UP 2                            3.00              3.00

INITIAL LIFE                  9.04     7.31     7.78    10.80     5.09     9.36

PERFORMANCE LIFE 1           22.33    20.34    18.13    25.29    12.15    22.35
PERFORMANCE LIFE 2                             30.57             21.73

TOTAL PERFORMANCE LIFE       22.33    20.34    30.57    25.29    21.73    22.35


SPACING TRANS. JOINTS        60.00    60.00    45.00    45.00    60.00  2640.00
SPACING LONG. JOINTS         12.00    12.00    12.00    12.00    12.00    12.00
*******************************************************************************

COST OF SUBG. PREPARATION     .213     .213     .213     .213     .213     .213
COST OF CONCRETE             2.277    2.277    2.708    2.805    2.333    2.277
COST OF SUBBASE              1.784    1.534    1.117    1.256    1.451    1.117
COST OF REINFORCEMENT         .473     .473     .446     .459     .441    1.335
COST OF JOINTS                .885     .885     .955     .955     .885     .680
COST OF TIE BARS              .037     .037     .040     .042     .034     .033

INITIAL CONST. COST          5.669    5.419    5.480    5.730    5.357    5.655
OVERLAY CONST. COST           .487     .714     .778     .425    1.042     .475
TRAFFIC DELAY COST            .025     .036     .042     .023     .052     .025
MAINTENANCE COST              .341     .361     .280     .388     .136     .346
SALVAGE RETURNS              -.477    -.479    -.514    -.490    -.501    -.402
ANY ADDITIONAL COST          5.000    5.000    5.000    5.000    5.000    5.000

*******************************************************************************
TOTAL COST PER SQ YARD      11.045   11.052   11.065   11.075   11.0 6   11.099
*******************************************************************************
```

```
RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974     RFC III
PROB 1             TEST RUN SHOWING NEW RPS-3 VERSION RFC III

                          REINFORCEMENT DESIGN
 DESIGN     REINFORCEMENT DESCRIPTION                          MATERIAL  MATERIAL
 NUMBER                                                         NUMBER     NAME


   7    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM,A-51
                 MESH DIAMETER    .21    .24    .26    .28
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM,A-51
                 MESH DIAMETER    .33    .36    .38    .40
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615,GR40
                         SPACING  10.3   18.3   28.6   41.2

   8    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM,A-51
                 MESH DIAMETER    .21    .24    .26    .28
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM,A-51
                 MESH DIAMETER    .33    .36    .38    .40
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615,GR40
                         SPACING  10.3   18.3   28.6   41.2

   9    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM,A-51
                 MESH DIAMETER    .19    .22    .24    .26
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM,A-51
                 MESH DIAMETER    .35    .37    .40    .42
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615,GR4
                         SPACING   9.4   16.7   26.1   37.6

  10    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM,A-51
                 MESH DIAMETER    .20    .22    .24    .26
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM,A-51
                 MESH DIAMETER    .35    .38    .41    .43
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615,GR40
                         SPACING   9.1   16.2   25.4   36.6

  11    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM,A-51
                 MESH DIAMETER    .21    .23    .25    .27
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM,A-51
                 MESH DIAMETER    .32    .34    .37    .39
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615,GR40
                         SPACING  11.0   19.6   30.7   44.2

  12    LONG.REINF.MESH SPACING    4.0    5.0    6.0    7.0      3      ASTM,A-51
                 MESH DIAMETER    .45    .50    .55    .59
        TRAN.REINF.MESH SPACING   12.0   14.0   16.0   18.0      3      ASTM,A-51
                 MESH DIAMETER    .31    .34    .36    .38
        TIE BARS      BAR NUMBER     3      4      5      6      1      A-615,GR40
                         SPACING  11.7   20.7   32.4   46.7
```

```
RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974     RFC III
PROB 1             TEST RUN SHOWING NEW RPS-3 VERSION RFC III


        SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER                    13       14       15       16       17       18
*******************************************************************************
PAVEMENT TYPE                   JCP      JCP      JCP      JCP      CRC      JCP
OVERLAY  TYPE                    AC       AC       AC       AC       AC       AC
REINFORCEMENT TYPE             MESH     MESH     MESH     MESH     MESH     MESH

CONCRETE TYPE                     2        6        4        3        2        2
SUBBASE  TYPE                     1        2        1        3        1        1
*******************************************************************************

SLAB THICKNESS                10.00     8.00    10.00     8.00     8.00    10.00
SUBBASE THICKNESS             10.00    10.00    12.00    10.00    10.00    12.00

OVERLAY + LEVEL UP 1           4.50     3.00     3.00     3.50     3.00     4.00
OVERLAY + LEVEL UP 2                                      3.00     3.00

INITIAL LIFE                   7.78    14.10    12.37     7.31     7.47     7.96

PERFORMANCE LIFE 1            20.72    34.92    28.95    19.00    17.76    20.24
PERFORMANCE LIFE 2                                       35.20    31.16

TOTAL PERFORMANCE LIFE        20.72    34.92    28.95    35.20    31.16    20.24


SPACING TRANS. JOINTS         45.00    45.00    45.00    60.00  2640.00    45.00
SPACING LONG. JOINTS          12.00    12.00    12.00    12.00    12.00    12.00
*******************************************************************************

COST OF SUBG. PREPARATION      .213     .213     .213     .213     .213     .213
COST OF CONCRETE              2.708    2.333    2.805    2.277    2.221    2.706
COST OF SUBBASE               1.117    1.673    1.284    1.534    1.117    1.284
COST OF REINFORCEMENT          .446     .456     .459     .473    1.282     .446
COST OF JOINTS                 .955     .955     .955     .885     .680     .955
COST OF TIE BARS               .040     .041     .042     .037     .032     .040

INITIAL CONST. COST           5.480    5.671    5.757    5.419    5.546    5.646
OVERLAY CONST. COST            .765     .330     .376     .861     .798     .679
TRAFFIC DELAY COST             .040     .019     .021     .046     .043     .035
MAINTENANCE COST               .349     .613     .475     .344     .255     .345
SALVAGE RETURNS               -.502    -.498    -.492    -.515    -.441    -.501
ANY ADDITIONAL COST           5.000    5.000    5.000    5.000    5.000    5.000

*******************************************************************************
TOTAL COST PER SQ YARD       11.132   11.135   11.138   11.155   11.201   11.204
*******************************************************************************
```

```
RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974     RFC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION RFC III

                        REINFORCEMENT DESIGN
 DESIGN      REINFORCEMENT DESCRIPTION                              MATERIAL   MATERIAL
 NUMBER                                                              NUMBER      NAME


  13    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0      3      ASTM,A-51
                  MESH DIAMETER     .19    .22    .24    .26
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0      3      ASTM,A-51
                  MESH DIAMETER     .35    .37    .40    .42
        TIE BARS      BAR NUMBER      3      4      5      6      1      A-615,GR40
                         SPACING    9.4   16.7   26.1   37.6

  14    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0      3      ASTM,A-51
                  MESH DIAMETER     .20    .22    .24    .26
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0      3      ASTM,A-51
                  MESH DIAMETER     .35    .38    .40    .43
        TIE BARS      BAR NUMBER      3      4      5      6      1      A-615,GR40
                         SPACING    9.2   16.4   25.6   36.8

  15    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0      3      ASTM,A-51
                  MESH DIAMETER     .20    .22    .24    .26
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0      3      ASTM,A-51
                  MESH DIAMETER     .35    .38    .41    .43
        TIE BARS      BAR NUMBER      3      4      5      6      1      A-615,GR40
                         SPACING    9.1   16.2   25.4   36.6

  16    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0      3      ASTM,A-51
                  MESH DIAMETER     .21    .24    .26    .28
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0      3      ASTM,A-51
                  MESH DIAMETER     .33    .36    .38    .40
        TIE BARS      BAR NUMBER      3      4      5      6      1      A-615,GR40
                         SPACING   10.3   18.3   28.6   41.2

  17    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0      3      ASTM,A-51
                  MESH DIAMETER     .44    .49    .53    .58
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0      3      ASTM,A-51
                  MESH DIAMETER     .31    .33    .36    .38
        TIE BARS      BAR NUMBER      3      4      5      6             A-615,GR40
                         SPACING   11.7   20.9   32.6   47.0

  18    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0      3      ASTM,A-51
                  MESH DIAMETER     .19    .22    .24    .26
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0      3      ASTM,A-51
                  MESH DIAMETER     .35    .37    .40    .42
        TIE BARS      BAR NUMBER      3      4      5      6      1      A-615,GR40
                         SPACING    9.4   16.7   26.1   37.6
```

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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974     RFC III
PROB 1           TEST RUN SHOWING NEW RPS-3 VERSION RFC III


          SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER                      19      20      21      22      23
*******************************************************************
PAVEMENT TYPE                     JCP     JCP     JCP     JCP     JCP
OVERLAY  TYPE                      AC      AC      AC      AC      AC
REINFORCEMENT TYPE               MESH    MESH    MESH    MESH    MESH

CONCRETE TYPE                       2       1       3       6       2
SUBBASE  TYPE                       3       3       4       1       2
*******************************************************************

SLAB THICKNESS                   8.00    8.00   10.00    8.00    8.00
SUBBASE THICKNESS               12.00   12.00   12.00   10.00   10.00

OVERLAY + LEVEL UP 1             4.00    3.00    3.00    6.50    4.50
OVERLAY + LEVEL UP 2                     3.00

INITIAL LIFE                     7.38    5.87    8.88    5.71    6.88

PERFORMANCE LIFE 1              20.78   14.36   20.75   21.50   20.74
PERFORMANCE LIFE 2                      26.48

TOTAL PERFORMANCE LIFE          20.78   26.48   20.75   21.50   20.74


SPACING TRANS. JOINTS           60.00   60.00   45.00   60.00   60.00
SPACING LONG. JOINTS            12.00   12.00   12.00   12.00   12.00
*******************************************************************

COST OF SUBG. PREPARATION        .213    .213    .213    .213    .213
COST OF CONCRETE                2.221   2.166   2.777   2.333   2.221
COST OF SUBBASE                 1.784   1.784   1.451   1.117   1.673
COST OF REINFORCEMENT            .470    .466    .449    .441    .497
COST OF JOINTS                   .885    .885    .955    .885    .885
COST OF TIE BARS                 .037    .036    .041    .034    .039

INITIAL CONST. COST             5.610   5.551   5.886   5.023   5.529
OVERLAY CONST. COST              .710    .944    .492   1.255    .820
TRAFFIC DELAY COST               .036    .048    .025    .064    .042
MAINTENANCE COST                 .359    .161    .341    .442    .376
SALVAGE RETURNS                 -.492   -.467   -.498   -.516   -.495
ANY ADDITIONAL COST             5.000   5.000   5.000   5.000   5.000

*******************************************************************
TOTAL COST PER SQ YARD         11.224  11.237  11.246  11.269  11.272
*******************************************************************
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION RFC III

                            REINFORCEMENT DESIGN
 DESIGN     REINFORCEMENT DESCRIPTION                            MATERIAL   MATERIAL
 NUMBER                                                           NUMBER      NAME


  19    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0       3       ASTM.A-51
                  MESH DIAMETER     .21    .24    .26    .28
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0       3       ASTM.A-51
                  MESH DIAMETER     .33    .36    .38    .40
        TIE BARS      BAR NUMBER      3      4      5      6       1       A-615.GR40
                         SPACING   10.4   18.4   28.8   41.5

  20    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0       3       ASTM.A-51
                  MESH DIAMETER     .21    .24    .26    .28
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0       3       ASTM.A-51
                  MESH DIAMETER     .33    .35    .38    .40
        TIE BARS      BAR NUMBER      3      4      5      6       1       A-615.GR40
                         SPACING   10.4   18.6   29.0   41.8

  21    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0       3       ASTM.A-51
                  MESH DIAMETER     .19    .22    .24    .26
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0       3       ASTM.A-51
                  MESH DIAMETER     .35    .37    .40    .43
        TIE BARS      BAR NUMBER      3      4      5      6       1       A-615.GR40
                         SPACING    9.3   16.6   25.9   37.3

  22    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0       3       ASTM.A-51
                  MESH DIAMETER     .21    .23    .25    .27
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0       3       ASTM.A-51
                  MESH DIAMETER     .32    .34    .37    .39
        TIE BARS      BAR NUMBER      3      4      5      6       1       A-615.GR40
                         SPACING   11.0   19.6   30.7   44.2

  23    LONG.REINF.MESH SPACING     4.0    5.0    6.0    7.0       3       ASTM.A-51
                  MESH DIAMETER     .22    .24    .27    .29
        TRAN.REINF.MESH SPACING    12.0   14.0   16.0   18.0       3       ASTM.A-51
                  MESH DIAMETER     .34    .37    .39    .42
        TIE BARS      BAR NUMBER      3      4      5      6       1       A-615.GR40
                         SPACING    9.8   17.4   27.2   39.2
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RIGID  PAVEMENT  SYSTEM  3   CENTER FOR HIGHWAY RESEARCH  DEC 1974      RFC III
PROB 1            TEST RUN SHOWING NEW RPS-3 VERSION RFC III



                        INITIAL DESIGN ANALYSIS

      OUT OF A TOTAL OF  288 INITIAL POSSIBLE DESIGNS.
                0 WERE REJECTED DUE TO MAX. INITIAL THICKNESS RESTRAINT
      OUT OF 288 DESIGNS THUS LEFT
               82 DESIGNS WERE REJECTED SINCE THEY ARE OVERDESIGNS OF
                  INITIAL DESIGNS WHICH LAST THE ANALYSIS PERIOD
      OUT OF 206 DESIGNS THUS LEFT.
               23 DESIGNS WERE REJECTED DUE  TO THEIR LIVES BEING LESS
                  THAN THE MINIMUM ALLOWABLE TIME  TO THE FIRST OVERLAY
      OUT OF 183 DESIGNS THUS LEFT.
                0 DESIGNS WERE REJECTED DUE TO THE RESTRAINT OF MAXIMUM
                  INITIAL FUNDS AVAILABLE
      OUT OF 183 DESIGNS THUS LEFT.
               85 DESIGNS WERE ACCEPTABLE  INITIAL DESIGNS WITH LIVES
                  MORE THAN THE ANALYSIS PERIOD
      AND THUS      98 DESIGNS WERE PASSED TO THE OVERLAY SUBSYSTEM  TO
                       FORMULATE THE POSSIBLE OVERLAY STRATEGIES



                        OVERLAY SUBSYSTEM ANALYSIS

  DESIGN COMBINATION NUMBER                                     1     2     3     4

  NUMBER WHEN MAX. OV. THICKNESS RESTRAINT WAS HIT             21     0     5     0
  NUMBER WHEN MIN TIME BETWEEN OV RESTRAINT WAS HIT             0     0     0     0
  NUMBER WHEN OVERLAYS NEEDED WERE MORE THAN EIGHT              0     0     0     0
  NUMBER OF TIMES  SUBROUTINE * AGE *  WAS  CALLED            237   162    99    54
  NUMBER OF TIMES  SUBROUTINE *MANCE*  WAS  CALLED            237   162    99    54
  NUMBER OF TIMES  SUBROUTINE * TDC *  WAS  CALLED            237   162    99    54
  NUMBER OF  POSSIBLE OVERLAY STRATEGIES  OBTAINED             51    86    49    43
  NUMBER OF OVERDESIGNS OBTAINED                               90    28    14     0

  OUT OF A TOTAL OF                                           162   114    68    43



             THUS FOR THE ENTIRE DESIGN SYSTEM
             OUT OF AN OVERALL TOTAL OF   387 OVERLAY STRATEGIES
                    26 WERE REJECTED DUE TO DIFFERENT RESTRAINTS
             AND   361 WERE CONSIDERED FOR  OPTIMIZATION PROCESS
```

APPENDIX 3

USER'S MANUAL

TEXAS HIGHWAY DEPARTMENT

RIGID PAVEMENT DESIGN SYSTEM

PROGRAM RPS-3

PROBLEM IDENTIFICATION
CARD NO. 1

1.1 Problem Number

1	2	3	4

(Any combination of letters and/or numbers)

1.2 Problem Description

11	12	13	14	15	16	17	18

19		70

(Any combination of letters and/or numbers)

PROGRAM CONTROLS
CARD NO. 2

2.1 Type of Pavement ________________ ☐ 10

= 1 for jointed concrete pavement to be designed only

= 2 for continuously reinforced concrete pavement to be designed only

= blank for jointed concrete pavement and continuously reinforced concrete pavement to both be designed

2.2 Type of Overlay ________________ ☐ 20

= 1 for portland cement concrete overlay only

= 2 for asphaltic concrete overlay only

= blank for portland cement concrete and asphaltic concrete overlays to be tried

2.3 Type of Reinforcement ________________ ☐ 30

= 1 for deformed bar reinforcement only

= 2 for welded wire mesh reinforcement only

= blank for deformed bars and wire mesh to be tried

2.4 Form of Output ________________ ☐ 50

= 1 for short form of output (no steel layout or seal coat schedule)

= blank for long form of output

2.5 Number of Designs for the Output (< 24) ________________

☐	☐	●
78	79	80

= blank for twelve designs (six per page)

TRAFFIC GROWTH AND DISTRIBUTION DATA
CARD NO. 3

3.1 Axle Growth Factor (percent per year of linear growth of number of axles)

							●		
1	2	3	4	5	6	7	8	9	10

3.2 ADT Growth Rate (percent per year of linear growth in average daily traffic)

							●		
11	12	13	14	15	16	17	18	19	20

3.3 Directional Distribution Factor (percent)

							●		
31	32	33	34	35	36	37	38	39	40

3.4 Lane Distribution Factor (percent)

							●		
41	42	43	44	45	46	47	48	49	50

3.5* Initial ADT Expected, One Direction (vehicles per day)

							●		
61	62	63	64	65	66	67	68	69	70

3.6** Total 18-kip Axles for Analysis Period in Both Directions

									●
71	72	73	74	75	76	77	78	79	80

* The initial ADT expected in one direction should not be large enough so as to exceed the practical capacity of 1500 veh/hr/lane. This data may be obtained from D-10

** These inputs may be obtained from D-10 of the Texas Highway Department

DESIGNER'S RESTRAINTS
CARD NO. 4

4.1 Maximum Funds Available for Initial Construction (dollars/sq. yd)

							●		
1	2	3	4	5	6	7	8	9	10

4.2 Maximum Allowable Thickness, Slab Plus Subbase (inches)

							●		
11	12	13	14	15	16	17	18	19	20

4.3* Minimum Allowable Time to the First Overlay (years)

							●		
21	22	23	24	25	26	27	28	29	30

4.4* Minimum Allowable Time Between Overlays (years)

							●		
31	32	33	34	35	36	37	38	39	40

4.5* Maximum Total Asphalt Concrete Overlay Thickness (inches)

			●	
41	42	43	44	45

4.6* Minimum Total Asphalt Concrete Overlay at one time Thickness (inches)

			●	
46	47	48	49	50

4.7* Maximum Total Portland Cement Concrete Overlay Thickness (inches)

			●	
51	52	53	54	55

4.8* Minimum Total Portland Cement Concrete at one time Overlay Thickness (inches)

			●	
56	57	58	59	60

4.9 Length of Analysis Period (years)

							●		
61	62	63	64	65	66	67	68	69	70

* See explanation following completion of this card.

4.10** Average Level Up Thickness (inches)

			●	
71	72	73	74	75

4.11 Confidence Level Desired for Design (percent)

80

Punch:	A	B	C	D	E	F	G
For Conf. Level of:	50%	80%	95%	99%	99.9%	99.99%	99.999%

** See explanation on following page.

EXPLANATIONS OF SPECIFICALLY INDICATED DESIGNER'S RESTRAINT VARIABLES ON CARD NO. 4

4.3-4.8* Overlay Inputs

If no overlay is planned for the facility 4.3 should be (at least) equal to the analysis period while items 4.4, 4.5, 4.6, 4.7, and 4.8 can be left blank.

If only one type of overlay, either asphalt or concrete, is planned, the thickness limits for the desired overlay type may be input while the thickness limits for the other type may be left blank.

4.10** Average Level Up Thickness

This is the designer's estimate of the average thickness required by a contractor to restore a pavement to its original profile before overlay. It would be correspondingly larger for example on a rough road, than for a fairly smooth road. If no information is available, a value of 1 inch may be used.

PERFORMANCE VARIABLES
CARD NO. 5

5.1 Initial Serviceability Index (expected)

							●		
1	2	3	4	5	6	7	8	9	10

5.2 Terminal Serviceability Index (accepted)

							●		
11	12	13	14	15	16	17	18	19	20

5.3 Serviceability Index After an Overlay (expected)

							●		
21	22	23	24	25	26	27	28	29	30

5.4* Probability of Conjunction of Bad Soil and Site (percent)

							●		
31	32	33	34	35	36	37	38	39	40

5.5** Swelling Rate Constant

							●		
41	42	43	44	45	46	47	48	49	50

5.6*** Swelling Activity, Estimated Differential Movement (inches) (potential vertical rise)

							●		
51	52	53	54	55	56	57	58	59	60

* See explanation on following page.

** See explanation on following page.

*** See explanation on following page.

EXPLANATIONS OF SPECIFICALLY INDICATED PERFORMANCE VARIABLES ON CARD NO. 5

5.4* Swelling Probability

At present, three constants are used to calculate the reduction of the serviceability index with time due to swelling clay and other non-traffic causes of serviceability loss. The first constant, swelling probability (6.4), is a fraction between 0 and 1 which represents the proportion of the project length which is likely to experience swell. This suggests that swelling clay must be present, and that local conditions must be conducive to swelling. Cuts, grade points, bridge approaches, grass root grade lines, and choppy fills seem to be more of a problem than uniform fills. Local experience must be input for this value until more definite guidelines can be developed.

5.5** Swelling Rate Constant

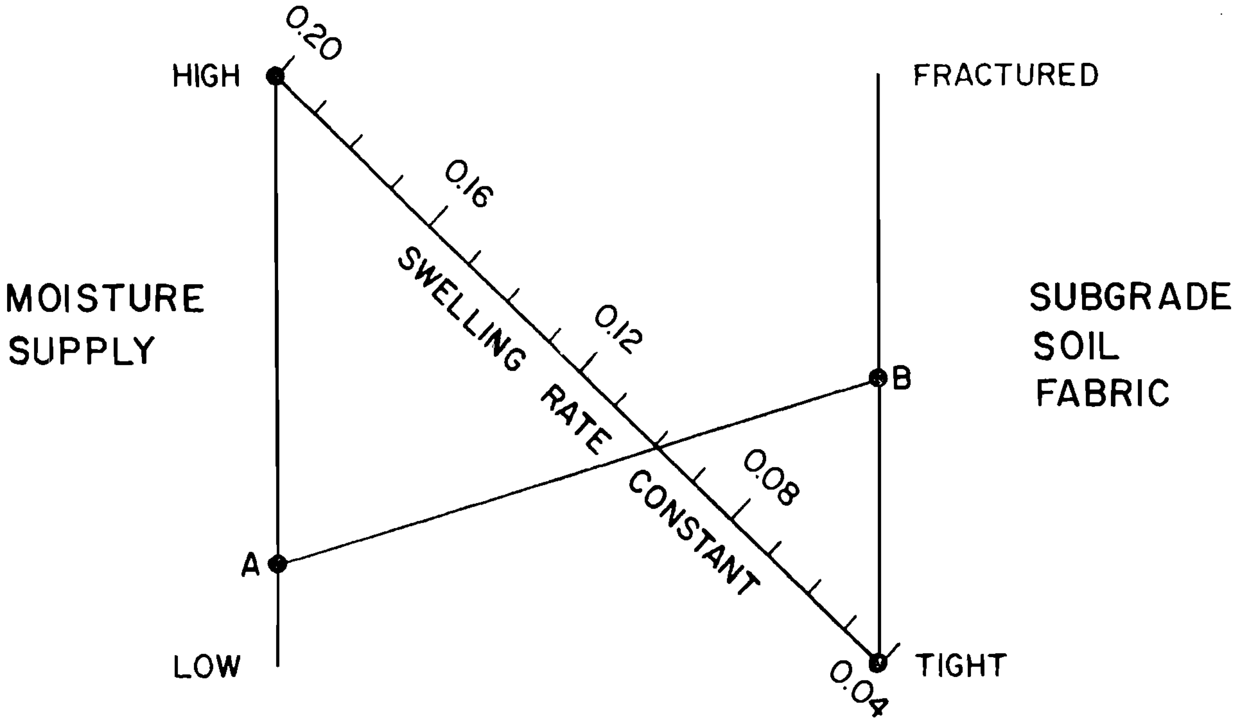
The swelling rate constant is used to calculate how fast swelling takes place. This constant lies between .04 and .20. It is larger when the soil is cracked and open, and when a large moisture supply is available due to poor drainage, high rainfall, underground seeps, or other sources of water. When drainage conditions are good or the soil is tight the swelling rate constant becomes smaller.

The nomograph in Fig 5.1 gives a method of selecting this input based upon the judgement of the designer of local soil and moisture conditions.

Figure 5.2 shows the effects (in the absence of traffic) for three values of PVR and two values of the swelling rate constant on the performance curve. For the curves shown the swelling probability used is 1.0. The effect of other values of swelling probability can be evaluated considering that this input is used solely as a multiplying modifier on PVR in the program. For example, a swelling probability of 0.10 and PVR of 10 inches is exactly equal in the program to a swelling probability of 1.0 and a PVR of 1 inch.

5.6*** Potential Vertical Rise

The potential vertical rise (PVR) is a measure of how much the surface of the bed of clay can rise if it is supplied with all the moisture it can absorb.



<u>NOTES</u>: (a) LOW MOISTURE SUPPLY

Low Rainfall
Good Drainage

(b) HIGH MOISTURE SUPPLY

High Rainfall
Poor Drainage
Vicinity of Culverts, Bridge Abutments, Inlet Leads

(c) SOIL FABRIC CONDITIONS

Self-Explanatory

(d) USE OF THE NOMOGRAPH

(1) Select the appropriate moisture supply condition which may be somewhere between low and high (such as A).

(2) Select the appropriate soil fabric (such as B).

(3) Draw a straight line between the selected points (A to B).

(4) Read SWRATE from the diagonal axis (read 0.10).

Fig A5.1. Nomograph for selecting swelling rate constant.

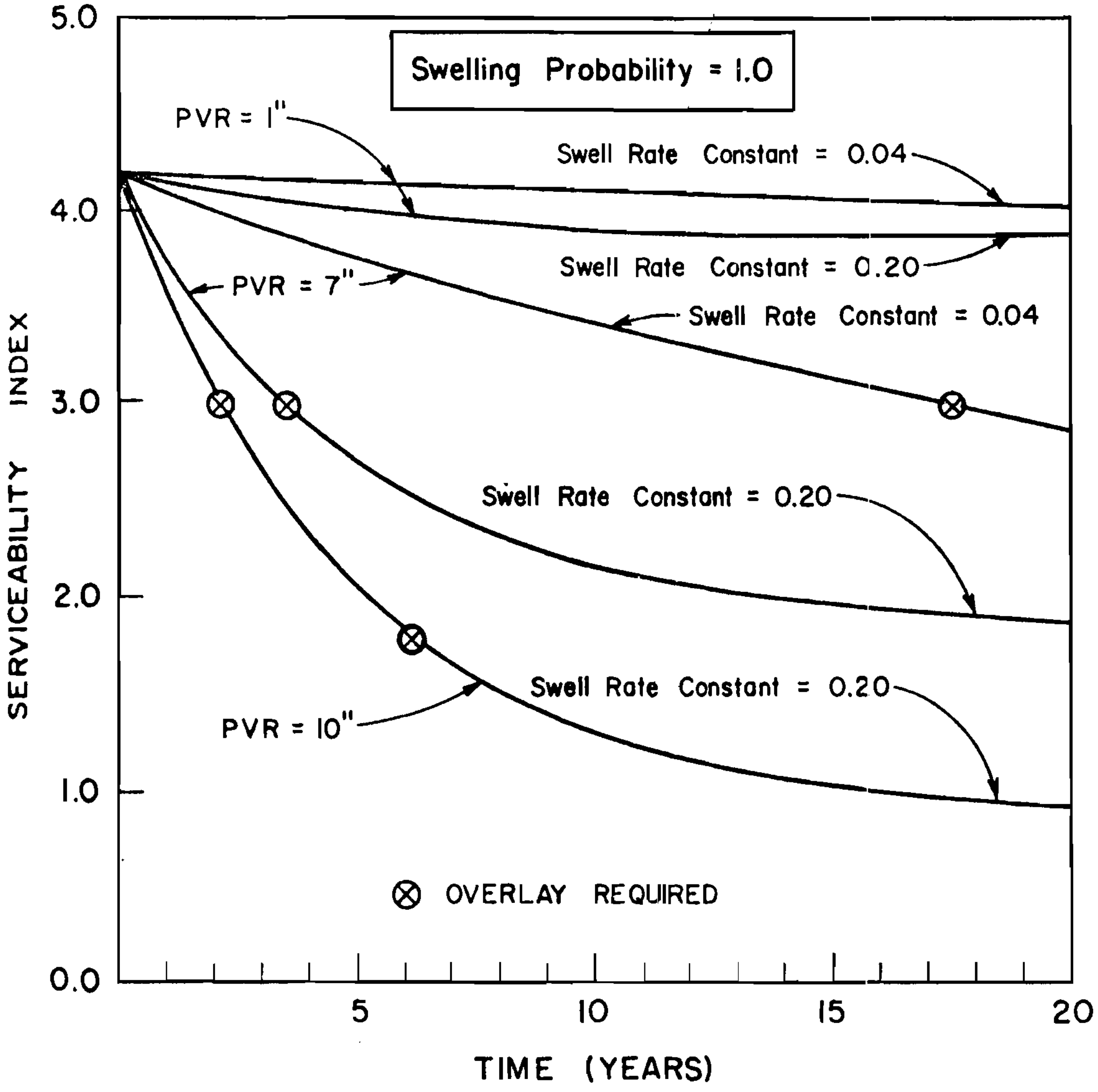


Fig A5.2. Performance curves illustrating serviceability loss not caused by traffic.

PVR can either be estimated in a particular locality from the total amount of differential heave the designer (or maintenance personnel) would expect to observe over a long period of time, or by using Texas Test Method, Tex-124-E. Extremely bad clay may have a PVR in the order of 10 to 20 inches.

For highways that have been in existence for some time, the remaining potential for swelling should be reduced by the amount of swell that has already occurred. How much has occurred will depend on the age of the roadbed and the swell rate constant which is discussed in the next section. Figure 5.3 provides a multiplier (ratio) to apply to the original PVR if the swell rate constant and age of an existing road are known.

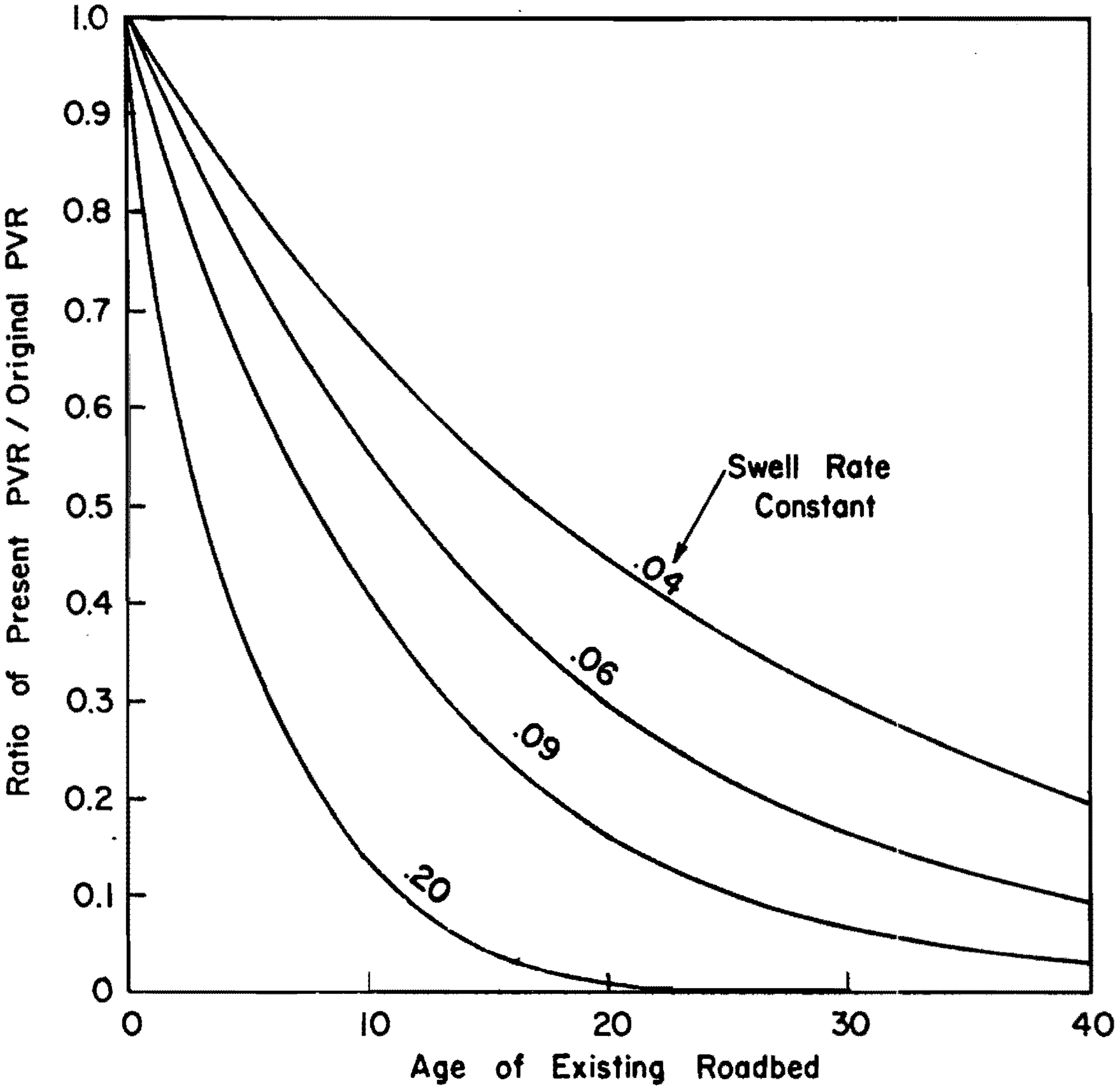


Fig A5.3. Chart for estimating PVR for an existing road.

TRAFFIC DELAY COST VARIABLES
CARD NO. 6

6.1* Distance Over Which Traffic is Slowed in Overlay Direction (miles)

							●		
1	2	3	4	5	6	7	8	9	10

6.2* Distance Over Which Traffic is Slowed in Non-Overlay Direction (miles)

							●		
11	12	13	14	15	16	17	18	19	20

6.3* Distance Measured Along Detour Around Overlay Zone (miles)

							●		
21	22	23	24	25	26	27	28	29	30

6.4 Number of Hours Per Day that Overlay Construction Takes Place

							●		
41	42	43	44	45	46	47	48	49	50

6.5 Number of Open Lanes in Restricted Zone in Overlay Direction

55

6.6* Number of Open Lanes in Restricted Zone in Non-Overlay Direction

60

6.7 Type of Road

80

= 1 indicates rural roads

= 2 indicates urban roads

* See item 7.8 before filling in these values.

TRAFFIC DELAY COST VARIABLES
CARD NO. 7

7.1 Percent of Vehicles Stopped by Construction Equipment and Personnel, Overlay Direction (percent)

							●		
1	2	3	4	5	6	7	8	9	10

7.2 Percent of Vehicles Stopped by Construction Equipment and Personnel, Non-Overlay Direction (percent)

							●		
11	12	13	14	15	16	17	18	19	20

7.3 Average Delay Per Vehicle Due to Road Equipment and Personnel, Overlay Direction (hours)

							●		
21	22	23	24	25	26	27	28	29	30

7.4 Average Delay Per Vehicle Due to Road Equipment and Personnel, Non-Overlay Direction (hours)

							●		
31	32	33	34	35	36	37	38	39	40

7.5 Average Approach Speed to Overlay Area (mph)

							●		
41	42	43	44	45	46	47	48	49	50

7.6 Average Speed Through the Restricted Zone, Overlay Direction (mph)

							●		
51	52	53	54	55	56	57	58	59	60

7.7 Average Speed Through the Restricted Zone, Non-Overlay Direction (mph)

							●		
61	62	63	64	65	66	67	68	69	70

7.8** Model Number Which Describes Traffic Situation During Overlay Construction

80

** See explanation on following page.

EXPLANATION OF SPECIFICALLY INDICATED TRAFFIC DELAY COST VARIABLES ON CARDS 5, 6, and 7

7.8** Model Number Which Describes Traffic Situation for Overlay

There are currently five models describing the separate ways in which traffic might be handled during overlay construction.

The designer must specify which model would be used for the particular type of facility being designed by input of a 1, 2, 3, 4, or 5. These models are respectively drawn in Figs 7.1 through 7.5.

Variable 6.3; Distance Measured Along Detour Around Overlay Zone (miles); is only necessary if Model 5 is used and may be left blank when selecting the other models.

Variables 6.5 and 6.6; the Number of Open Lanes in Restricted Zone in Overlay Direction and Non-Overlay Direction respectively should neither be greater than three lanes.

6.5* and 6.6* Number of Open Lanes

Both the number of open lanes in the overlay direction and the number of open lanes in the nonoverlay direction must be greater than zero. For example, Model 2 in Fig 7.2, appears to indicate that one direction should have a "1" input and the other direction a zero; however, this is incorrect. Both must have a "1" input or the program will not run correctly.

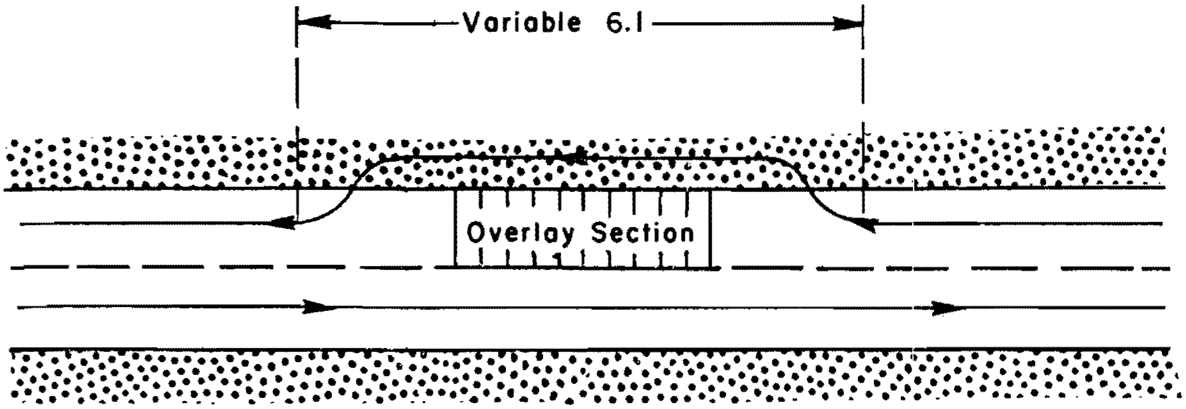


Fig A7.1. Detour model No. 1.

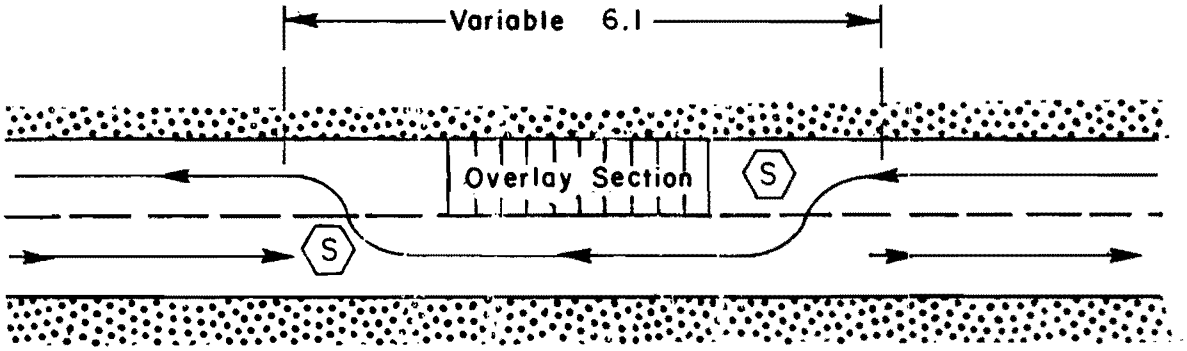


Fig A7.2. Detour model No. 2.

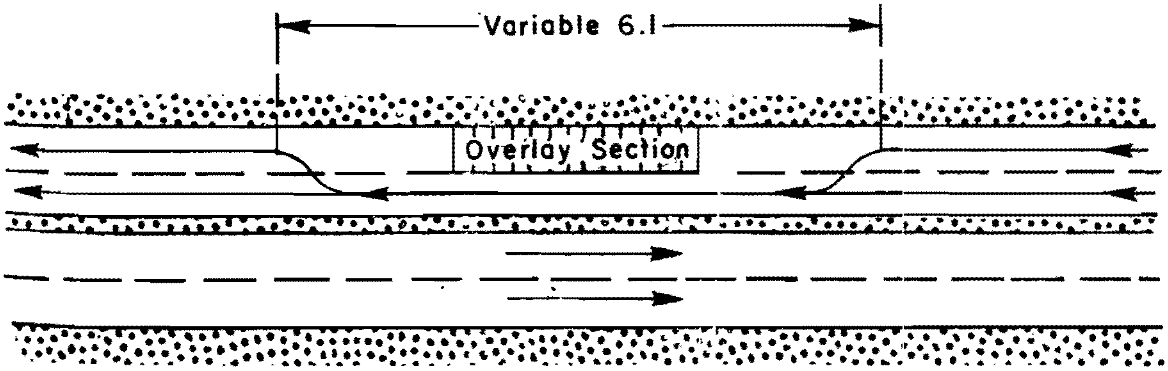


Fig A7.3. Detour model No. 3.

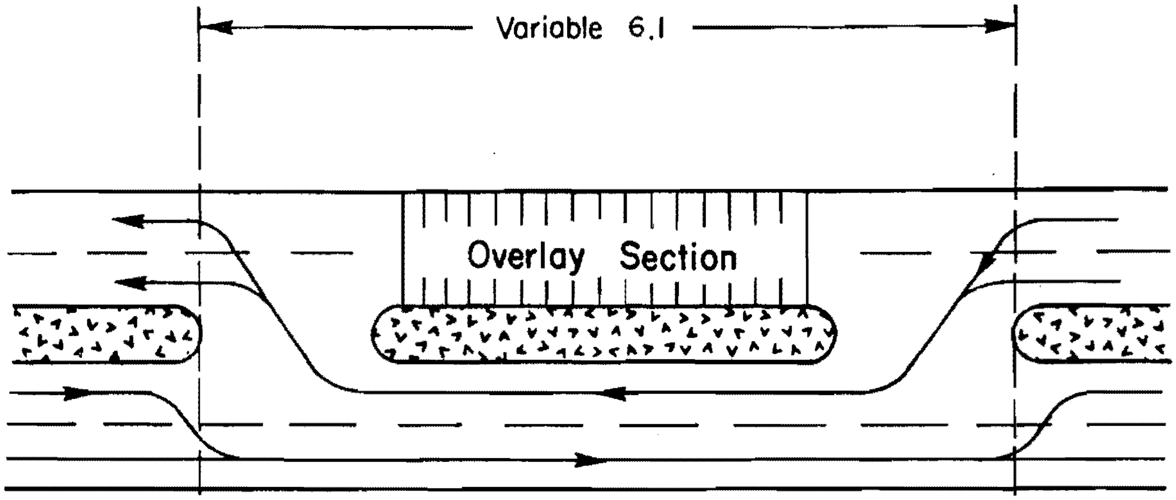


Fig A7.4. Detour model No. 4

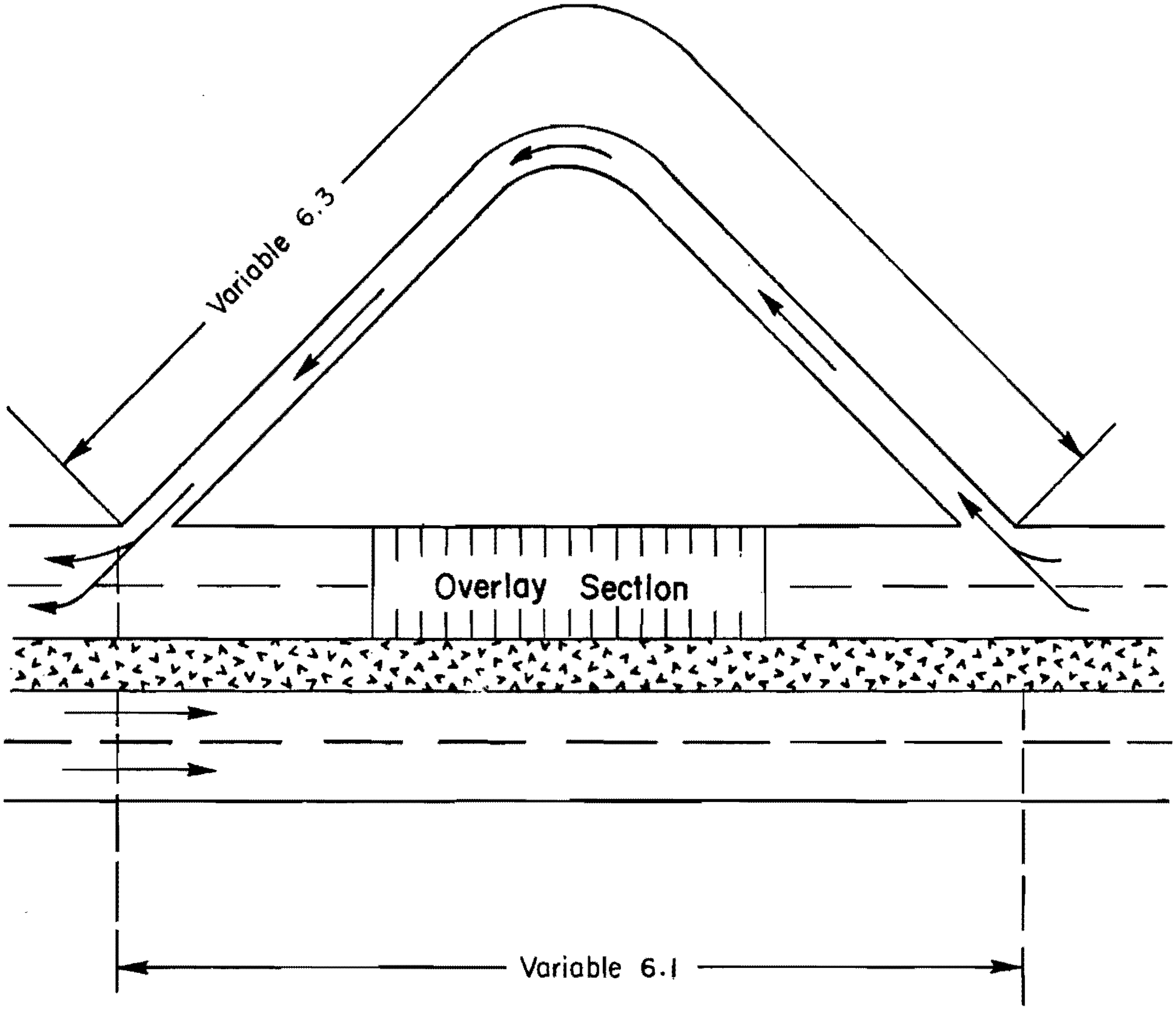


Fig A7.5. Detour model No. 5.

MATERIALS, CONCRETE
CARD(S) NO. 8

8.1 Number of Concrete Types

5

(Maximum number of concrete types is six)

Include this input only for the first concrete type*

8.2 Number of Days at Which Concrete Flexural Strength was Measured (7 or 28)

7	8

Indicate in column 8 for 7-day strength

Indicate in columns 7 and 8 for 28-day strength

8.3 Type of Concrete Flexure Test

10

= 1 for flexural strength obtained by center point loading

= 2 for flexural strength obtained by third point loading

8.4 Concrete Flexural Strength (psi)

			●	
11	12	13	14	15

8.5 Unit Weight of Concrete (pounds per cubic foot)

			●	
26	27	28	29	30

8.6 Modulus of Elasticity at 28 Days (psi)

									●
31	32	33	34	35	36	37	38	39	40

8.7 Tensile Strength of Concrete (psi)

			●	
41	42	43	44	45

8.8 Equipment Cost Per Lane Mile for Placing Concrete for the Initial Construction (dollars)

							●		
46	47	48	49	50	51	52	53	54	55

8.9 Cost Per Cubic Yard of Concrete (dollars)

							●		
56	57	58	59	60	61	62	63	64	65

* An additional card including only items 8.2 through 8.11 should be added for each concrete type.

8.10 Cost Per Lane Mile of Surfacing Concrete Pavement - Finish, Texture, and Curing (dollars) ______

							●		
66	67	68	69	70	71	72	73	74	75

8.11 Salvage Value of Concrete at End of Analysis Period (percent) ______

		●		
76	77	78	79	80

CONCRETE DIMENSIONS
CARD NO. 9

9.1 Minimum Allowable Concrete Thickness (inches) ____

							●		
11	12	13	14	15	16	17	18	19	20

9.2 Maximum Allowable Concrete Thickness (inches) ____

							●		
21	22	23	24	25	26	27	28	29	30

9.3* Practical Increment at Which Concrete Can Be Easily Poured or the Increment at Which the Solutions Should Be Made (inches) ____

							●		
31	32	33	34	35	36	37	38	39	40

* The minimum thickness for incrementing placement of the concrete should be .50 inch.

MATERIALS, SUBGRADE
CARD NO. 10

10.1 Subgrade K-value (pci) ______

							●		
1	2	3	4	5	6	7	8	9	10

10.2 Texas Triaxial Class Value ______

							●		
31	32	33	34	35	36	37	38	39	40

10.3* Friction Factor Between Subgrade and Concrete ______

		●		
61	62	63	64	65

10.4** Subgrade Erodability Factor ______

		●		
66	67	68	69	70

10.5 Cost Per Lane Mile of Subgrade Preparation (dollars) ______

							●		
71	72	73	74	75	76	77	78	79	80

* See explanation on following page.

** See explanation on following page.

EXPLANATIONS OF SPECIFICALLY INDICATED SUBGRADE MATERIAL VARIABLES ON CARD NO. 10

10.3* Friction Factor Between Subgrade and Concrete

This input may be left out if the design minimum subbase thickness is greater than zero. If the minimum thickness of subbase is specified as zero, then a friction factor must be included. A general range for friction factors is shown in Table 11.1.

10.4** Subgrade Erodability Factor

This input may be left out if the design minimum subbase thickness is greater than zero. If the minimum thickness of subbase is specified as zero, then an erodability factor must be included. The erodability factor for the subgrade material should be higher than that for subbase. An explanation of the subbase erodability factors is found on page 171, Fig 11.1 and the same estimation technique should be used for obtaining the subgrade erodaility factor which should be between zero and three. Generally a value of 3.0 is input for the erodability factor of the subgrade.

MATERIALS, SUBBASE
CARD NO. 11

This card must be input, even if blank, in the case where the designer wishes to design without a subbase. In this event, all that is needed is a "1" in column 5.

11.1* Number of Subbase Types

5

(Maximum number of Subbase Types is four)

Include this input only for the first subbase type*

11.2 Description of Subbase

6	7	8	9	10	11	12	13	14	15

(Any combination of letters and/or numbers)

11.3** Erodability Factor for Subbase

		●		
16	17	18	19	20

11.4*** Friction Factor Between Subbase and Concrete

		●		
21	22	23	24	25

11.5 Elastic Modulus of Subbase (psi)

									●
31	32	33	34	35	36	37	38	39	40

11.6 Equipment Cost Per Lane Mile for Initial Subbase Construction (dollars)

							●		
41	42	43	44	45	46	47	48	49	50

11.7 Cost Per Cubic Yard of Compacted Subbase (dollars)

							●		
51	52	53	54	55	56	57	58	59	60

11.8 Salvage Percent of Subbase at End of Analysis Period (percent)

		●		
61	62	63	64	65

11.9 Minimum Allowable Subbase Thickness (inches)________________________________

		●		
66	67	68	69	70

11.10 Maximum Allowable Subbase Thickness (inches)________________________________

		●		
71	72	73	74	75

11.11**** Practical Increment at Which Subbase Can Be Easily Placed (inches)____________________

		●		
76	77	78	79	80

* An additional card including only items 11.2 through 11.11 should be added for each subbase type.

** See explanation following completion of this card.

*** See explanation following completion of this card.

**** See explanation on following page.

EXPLANATIONS OF SPECIFICALLY INDICATED SUBBASE VARIABLES ON CARD NO. 11

11.3** Erodability Factor for Subbase

A theoretical attempt is made to evaluate the effects of systems loss of support characterized by a term "erodability factor." This factor essentially defines the size of the area of pavement slab which experiences a complete loss of support due to erosion. Based upon experience and engineering judgement, three sizes and shapes of these areas, as explained in Fig 11.1, are chosen under a standard slab to define the erodability factors of one, two, and three.

Theoretically E_f should be a function of factors such as precipitation, amount of water on and under the pavement, erosion, cross slope, grades, joint patterns and sealing efficiency, subbase materials, subgrade, compaction, slab thickness, and traffic loads and their repetitions, etc.

11.4*** Friction Factor Between Subbase and Concrete

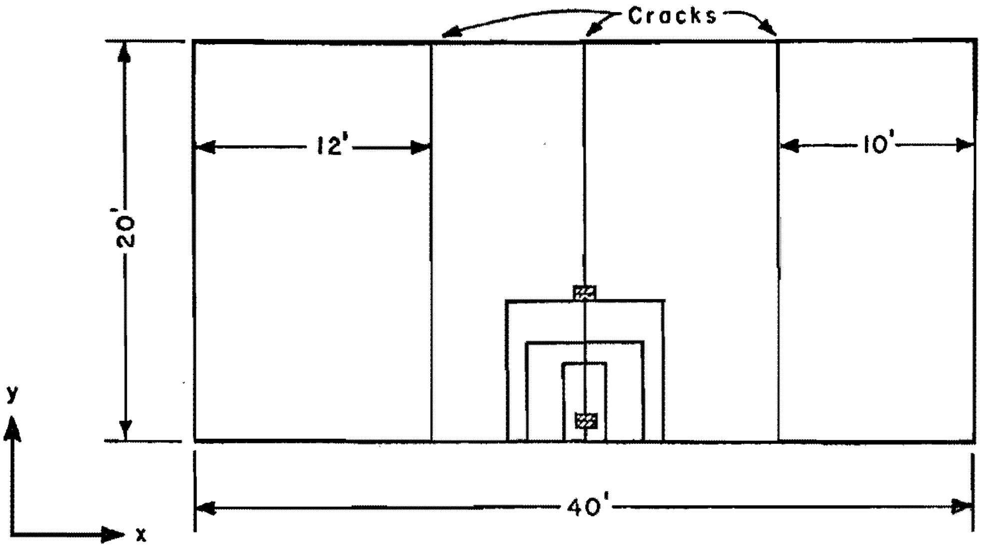
The friction factor variable is a coefficient which expresses the ability of the subbase to develop frictional forces which oppose contraction and expansion movements. In a study run for the Texas Highway Department, the factors shown in Table 11.1 were suggested for use.

11.11**** Practical Increment for Subbase Placement

This input should have a minimum value of 2 inches for a granular type of subbase and 1 inch for a stabilized subbase.

TABLE 11.1. FRICTION FACTOR VALUES

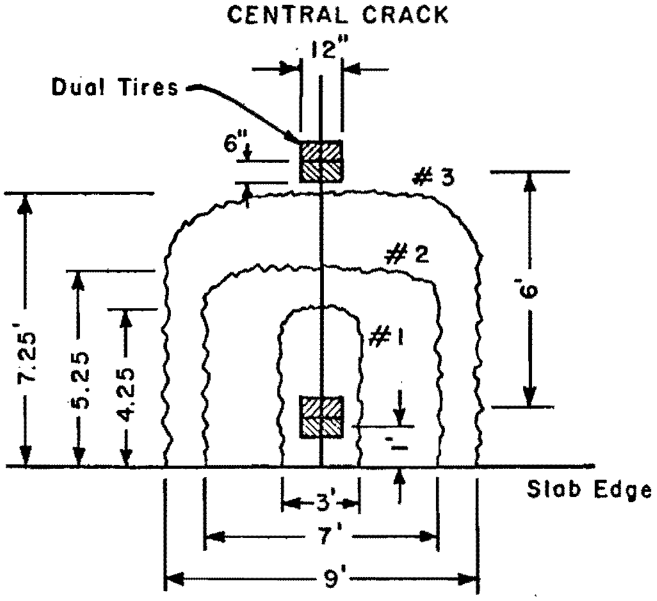
Subbase Type	Subbase Coefficient
Surface Treatment	2.2
Lime Stabilization	1.8
Asphalt Stabilization	1.8
Cement Stabilization	1.8
River Gravel	1.5
Crushed Stone	1.5
Sandstone	1.2
Natural Subgrade	0.9



Stiffness in x-Direction Reduced by 75% at the Cracks

SLAB PROPERTIES

Thickness = 8"
Concrete Modulus = 5 x 10^6 psi
Poisson's Ratio = 0.25
4 Tires are 6000 lbs Each



Void Space	% Area of Slab	Erodability Factor
	0.00	0
# 1	1.59	1
# 2	4.59	2
# 3	8.16	3

Fig A11.1. Slab and support conditions for erodability analysis.

MATERIALS, BAR STEEL - LONGITUDINAL
CARD NO. 12

(Include this card only if input 2.3 is equal to 1 or blank)

12.1(a) Bar Steel Identification Number

1	2	3	4	5	6	7	8	9	10

(Any combination of letters and/or numbers)

12.1(b) Tensile Yield Point Strength of Steel (psi)

11	12	13	14	15

(No decimal required)

12.1(c) Cost Per Pound of Bar Steel (dollars per pound)

		●		
16	17	18	19	20

12.2(a) Bar Steel Identification Number

21	22	23	24	25	26	27	28	29	30

(Any combination of letters and/or numbers)

12.2(b) Tensile Yield Point Strength of Steel (psi)

31	32	33	34	35

(No decimal required)

12.2(c) Cost Per Pound of Bar Steel (dollars per pound)

		●		
36	37	38	39	40

12.3(a) Bar Steel Identification Number

41	42	43	44	45	46	47	48	49	50

(Any combination of letters and/or numbers)

12.3(b) Tensile Yield Point Strength of Steel (psi)

51	52	53	54	55

(No decimal required)

12.3(c) Cost Per Pound of Bar Steel (dollars per pound) ____

		●		
56	57	58	59	60

12.4(a) Bar Steel Identification Number ____

61	62	63	64	65	66	67	68	69	70

(Any combination of letters and/or numbers)

12.4(b) Tensile Yield Point Strength of Steel (psi) ____

71	72	73	74	75

(No decimal required)

12.4(c) Cost Per Pound of Bar Steel (dollars per pound) ____

		●		
76	77	78	79	80

MATERIALS, BAR STEEL - <u>TRANSVERSE</u>
CARD NO. 13

(Include this card only if input 2.3 is equal to 1 or blank)

13.1(a) Bar Steel Identification Number

1	2	3	4	5	6	7	8	9	10

(Any combination of letters and/or numbers)

13.1(b) Tensile Yield Point Strength of Steel (psi)

11	12	13	14	15

(No decimal required)

13.1(c) Cost Per Pound of Bar Steel (dollars per pound)

		●		
16	17	18	19	20

13.2(a) Bar Steel Identification Number

21	22	23	24	25	26	27	28	29	30

(Any combination of letters and/or numbers)

13.2(b) Tensile Yield Point Strength of Steel (psi)

31	32	33	34	35

(No decimal required)

13.2(c) Cost Per Pound of Bar Steel (dollars per pound)

		●		
36	37	38	39	40

13.3(a) Bar Steel Identification Number

41	42	43	44	45	46	47	48	49	50

(Any combination of letters and/or numbers)

13.3(b) Tensile Yield Point Strength of Steel (psi)

51	52	53	54	55

(No decimal required)

13.3(c) Cost Per Pound of Bar Steel (dollars per pound) ____

		●		
56	57	58	59	60

13.4(a) Bar Steel Identification Number ____

61	62	63	64	65	66	67	68	69	70

(Any combination of letters and/or numbers)

13.4(b) Tensile Yield Point Strength of Steel (psi) ____

71	72	73	74	75

(No decimal required)

13.4(c) Cost Per Pound of Bar Steel (dollars per pound) ____

		●		
76	77	78	79	80

MATERIALS, WIRE MESH
CARD NO. 14

(Include this card only if input 2.3 is equal to 2 or blank)

14.1(a) Wire Mesh Steel Identification Number

1	2	3	4	5	6	7	8	9	10

(Any combination of letters and/or numbers)

14.1(b) Tensile Yield Point Strength of Steel (psi)

11	12	13	14	15

(No decimal required)

14.1(c) Cost Per Pound of Wire Mesh Steel (dollars per pound)

		●		
16	17	18	19	20

14.2(a) Wire Mesh Steel Identification Number

21	22	23	24	25	26	27	28	29	30

(Any combination of letters and/or numbers)

14.2(b) Tensile Yield Point Strength of Steel (psi)

31	32	33	34	35

(No decimal required)

14.2(c) Cost Per Pound of Wire Mesh Steel (dollars per pound)

		●		
36	37	38	39	40

14.3(a) Wire Mesh Steel Identification Number

41	42	43	44	45	46	47	48	49	50

(Any combination of letters and/or numbers)

14.3(b) Tensile Yield Point Strength of Steel (psi)

51	52	53	54	55

(No decimal required)

14.3(c) Cost Per Pound of Wire Mesh Steel
(dollars per pound) ______

		●		
56	57	58	59	60

14.4(a) Wire Mesh Steel Identification Number ______

61	62	63	64	65	66	67	68	69	70

(Any combination of letters or numbers)

14.4(b) Tensile Yield Point Strength of Steel
(psi) ______

71	72	73	74	75

(No decimal required)

14.4(c) Cost Per Pound of Wire Mesh Steel
(dollars per pound) ______

		●		
76	77	78	79	80

MATERIALS, TIE BAR STEEL
CARD NO. 15

(Include this card only if input 2.3 is equal to 2 or blank)

15.1(a) Tie Bar Steel Identification Number

1	2	3	4	5	6	7	8	9	10

(Any combination of letters and/or numbers)

15.1(b) Tensile Yield Point Strength of Steel (psi)

11	12	13	14	15

(No decimal required)

15.1(c) Cost Per Pound of Tie Bar Steel (dollars per pound)

		●		
16	17	18	19	20

15.2(a) Tie Bar Steel Identification Number

21	22	23	24	25	26	27	28	29	30

(Any combination of letters and/or numbers)

15.2(b) Tensile Yield Point Strength of Steel (psi)

31	32	33	34	35

(No decimal required)

15.2(c) Cost Per Pound of Tie Bar Steel (dollars per pound)

		●		
36	37	38	39	40

15.3(a) Tie Bar Steel Identification Number

41	42	43	44	45	46	47	48	49	50

(Any combination of letters and/or numbers)

15.3(b) Tensile Yield Point Strength of Steel (psi)

51	52	53	54	55

(No decimal required)

15.3(c) Cost Per Pound of Tie Bar Steel
(dollars per pound) ————

		●		
56	57	58	59	60

15.4(a) Tie Bar Steel Identification Number ————

61	62	63	64	65	66	67	68	69	70

(Any combination of letters and/or numbers)

15.4(b) Tensile Yield Point Strength of Steel
(psi) ————

71	72	73	74	75

(No decimal required)

15.4(c) Cost Per Pound of Tie Bar Steel
(dollars per pound) ————

		●		
76	77	78	79	80

MATERIALS, STEEL SIZES
CARD NO. 16

16.1 Leave all 16.1 inputs blank if input 2.3 is equal to 2.

16.1(a) Bar Number To Be Tried

				●
1	2	3	4	5

16.1(b) Bar Number To Be Tried

				●
6	7	8	9	10

16.1(c) Bar Number To Be Tried

				●
11	12	13	14	15

16.1(d) Bar Number To Be Tried

				●
16	17	18	19	20

16.2 Mesh Sizes To Be Tried
Leave all 16.2 inputs blank if input 2.3 is equal to 1.

16.2(a) Spacing of Longitudinal Wires (inches)

		●		
21	22	23	24	25

16.2(a) Spacing of Transverse Wires (inches)

		●		
26	27	28	29	30

16.2(b) Spacing of Longitudinal Wires (inches)

		●		
31	32	33	34	35

16.2(b) Spacing of Transverse Wires (inches)

		●		
36	37	38	39	40

16.2(c) Spacing of Longitudinal Wires (inches)

		●		
41	42	43	44	45

16.2(c) Spacing of Transverse Wires (inches)

		●		
46	47	48	49	50

16.2(d) Spacing of Longitudinal Wires (inches) ____

		●		
51	52	53	54	55

16.2(d) Spacing of Transverse Wires (inches) ____

		●		
56	57	58	59	60

16.3 Leave all 16.3 inputs blank if input 2.3 is equal to 1.

16.3(a) Tie Bar Number To Be Tried ____

				●
61	62	63	64	65

16.3(b) Tie Bar Number To Be Tried ____

				●
66	67	68	69	70

16.3(c) Tie Bar Number To Be Tried ____

				●
71	72	73	74	75

16.3(d) Tie Bar Number To Be Tried ____

				●
76	77	78	79	80

OVERLAYS, MATERIAL DATA
CARD NO. 17

17.1 Equipment Cost Per Lane Mile for Asphalt Concrete Overlays (dollars) ______

							●		
1	2	3	4	5	6	7	8	9	10

17.2 Cost Per Cubic Yard of In-Place Compacted Asphalt Concrete (dollars) ______

							●		
11	12	13	14	15	16	17	18	19	20

(Omit this input if input 2.2 is equal to 1)

17.3 Salvage Value of Asphalt Concrete at End of Analysis Period (percent) ______

							●		
21	22	23	24	25	26	27	28	29	30

(Omit this input if input 2.2 is equal to 1)

17.4 Asphaltic Concrete Modulus Value (psi) ______

									●
31	32	33	34	35	36	37	38	39	40

(Omit this input if input 2.2 is equal to 1)

17.5 Production Rate of Compacted Asphalt Concrete (cubic yard/hour) ______

							●		
41	42	43	44	45	46	47	48	49	50

(Omit this input if input 2.2 is equal to 1)

17.6 Concrete Production Rate (cubic yard/hour) ______

							●		
51	52	53	54	55	56	57	58	59	60

(Omit this input if input 2.2 is equal to 2)

17.7 Concrete Coefficient for Corps of Engineers Formula ______

							●		
61	62	63	64	65	66	67	68	69	70

= 0.35 for badly cracked slabs

= 1.00 for slabs in excellent condition

(Omit this input if input 2.2 is equal to 2)

17.8 Any Additional Cost Per Square Yard for Overlay Construction (dollars) ______

							●		
71	72	73	74	75	76	77	78	79	80

OVERLAYS, CONSTRUCTION DATA

CARD NO. 18

18.1 Military Hour of the Day When Overlay Construction Begins ____________

9	10

(If only one digit place in column 10)

18.2 Military Hour of the Day When Overlay Construction Ends ____________

19	20

(If only one digit place in column 20)

18.3 Number of Days Concrete Must Cure Before Traffic Is Allowed ____________

29	30

(If number of days less than 10 place single digit in column 30)

18.4* Total Number of Lanes To Be Overlaid ____________

39	40

(If number of lanes less than 10 place single digit in column 40)

18.5* Total Overlay Length In One Lanes (miles) ____________

		●	
47	48	49	50

(indicate length to nearest tenth of a mile)

*EXPLANATIONS OF SPECIFICALLY INDICATED OVERLAY CONSTRUCTION VARIABLES ON CARD NO. 18

18.4 - 18.5 Overlay Construction Inputs

The total number of lanes to be overlaid will be multiplied by the total overlay length in one lane to obtain the total length of pavement to be overlaid. Therefore, if the number of lanes to be overlaid is 3, but the lengths of overlay in each lane are not the same, then input total number of lanes equal to "1" and input for total overlay length the amount of three projects.

JOINTS
CARD NO. 19

19.1 Cost Per Foot of Transverse Joints - Dowels, Sawing and/or Sealing, etc. (dollars)

							●		
1	2	3	4	5	6	7	8	9	10

19.2 Cost Per Foot of Longitudinal Joints, Excluding Cost of the Bars (dollars)

							●		
11	12	13	14	15	16	17	18	19	20

19.3 Transverse Joint Spacing To Be Tried for Jointed Concrete Pavements, Lower Value (feet)

							●		
31	32	33	34	35	36	37	38	39	40

19.4 Transverse Joint Spacing To Be Tried for Jointed Concrete Pavements, Upper Value (feet)

							●		
41	42	43	44	45	46	47	48	49	50

19.5 Increment in Spacing To Be Tried for Transverse Joints (feet)

							●		
51	52	53	54	55	56	57	58	59	60

19.6 Number of Transverse Construction or Warping Joints Per Mile Provided for Continuously Reinforced Concrete Pavement (>0)

68	69	70

(Place last digit of number in column 70)

MAINTENANCE, DIMENSIONS, AND MISCELLANEOUS
CARD NO. 20

20.1 Days of Freezing Temperature Per Year

							●		
1	2	3	4	5	6	7	8	9	10

20.2* Composite Labor Wage (dollars per unit hour of maintenance)

							●		
11	12	13	14	15	16	17	18	19	20

20.3* Composite Maintenance Equipment Rental Rate (dollars per unit hour of maintenance)

							●		
21	22	23	24	25	26	27	28	29	30

20.4* Cost of Materials (dollars per unit operation)

							●		
31	32	33	34	35	36	37	38	39	40

20.5 Rate of Interest or Time Value of Money (percent per year)

							●		
41	42	43	44	45	46	47	48	49	50

20.6 Width of Each Lane (feet)

							●		
61	62	63	64	65	66	67	68	69	70

20.7 Total Number of Lanes in Both Directions

79	80

(Place last digit of number in column 80)

* See explanation on following page.

EXPLANATION OF SPECIFICALLY INDICATED MAINTENANCE VARIABLES ON CARD NO. 20

20.2* Composite Labor Wage
20.3* Composite Maintenance Equipment Rental Rate
20.4* Cost of Materials

These variables may be specifically calculated using the procedure outlined by NCHRP Report 42, entitled "Interstate Highway Maintenance Requirements and Unit Maintenance Expenditure Index." The following values are recommended at the present:

Composite Labor Rate = \$2.20/unit hour of maintenance

Composite Maintenance Equipment Rental Rate = \$2.72/maintenance unit

Material Cost = \$1.00/unit operation

CONFIDENCE LEVEL VARIABLES
CARD NO. 21

21.1 Percent Coefficient of Variation of Flexural Strength of Concrete

							●		
11	12	13	14	15	16	17	18	19	20

21.2 Standard Deviation of Elastic Modulus of Concrete (psi)

							●		
21	22	23	24	25	26	27	28	29	30

21.3 Standard Deviation of Subgrade K-value

							●		
31	32	33	34	35	36	37	38	39	40

21.4 Standard Deviation of Continuity Factor J

							●		
41	42	43	44	45	46	47	48	49	50

21.5 Standard Deviation of Initial Serviceability Index, P1

							●		
51	52	53	54	55	56	57	58	59	60

21.6 Standard Deviation of Terminal Serviceability Index, P2

							●		
61	62	63	64	65	66	67	68	69	70

21.7 Standard Deviation of Thickness of Concrete (inches)

							●		
71	72	73	74	75	76	77	78	79	80

APPENDIX 4

RPS-3 PROGRAM LISTING

```
      PROGRAM RPS3(INPUT, OUTPUT, TAPE5 = INPUT, TAPE6 = OUTPUT)
      COMMON /MAIN1/ AVGL(30),    ATBPF(4),    BARN(4),
     1   BONY(12),    CTC(6),      CIS(4),      COO(30,2),   COOF(2,2),
     2   COMAN(11),   COSOV(11),   COTR(11),    CPCYC(6),    CPCYS(4),
     3   CPPBS(8),    CPPTS(4),    CPPWS(4),    CSC(6),      CTMAN(11),
     4   CTOVER(11),  CTTRAF(11),  DIAL(4),     DIAM(4),     DIAT(4),
     5   E(6),        FF(4),       ES(4),       ESL(4),      FFSR(4),
     6   L1(30),      L2(30),      LFT(4),      MANT(4),     NA(30),
     7   NAME(4,3),   NAMEBS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8   NCODE(30),   ND(6),       NDLT(4),     NP(6),       NTDCT(4),
     9   NTHT(4),     NTMT(4),     NTOT(4),     NTOTR(4),    OVID(3),
     1   OVNAM(6),    PL(12),      PVIO(2),     PVNAM(6),    RD(2,2),
     2   RNFID(2),    RNFNAM(6),   SINC(4),     SL(4),       SPAC(4),
     3   SPACL(4),    SPACT(4),    SPTIE(4),    ST(4),       SX(6),
     4   VSX(6),      SXD(6),      SXDAT(6,2),  SXDA(2,2),   SXSD(6),
     5   TBARN(4),    TCTM(11),    TCTOV(11),   TCTTD(11),   THOV(11),
     6   THOVT(11),   TITLE(15),   TS(6),       TSMAX(4),    TSMIN(4),
     7   TTCS(6),     TYSBS(8),    TYSTS(4),    TYSWS(4),    WC(6),
     8   WHO(9),      SCOT(20),    KIN(6),      PSVC(6),     PSVS(4),
     9   NODE(4),     CONF(7),     ZZCONF(7),   LEVEL(7)
      COMMON /MAIN2/ CA(30),    CC(30),    CI(30),   CJ(30),
     1   CM(30),      CO(30),      CR(30),      CSB(30),
     2   CSP(30),     CSR(30),     CT(30),      CTB(30),     IO(30),
     3   IP(30),      IR(30),      JMR(30),     JNR(30),     JPR(30),
     4   MC(30),      MLR(30),     MS(30),      MTB(30),     MTR(30),
     5   NMB(24),     NO(30),      NPP(30),     PLF(30,13),  RLN(30,4),
     6   RLS(30,4),   RTN(30,4),   RTS(30,4),   STJ(30),     SUMOV(30),
     7   THN(30,4),   TBSP(30,4),  TC(30),      TCT(30),     TU(30,12),
     8   TSUB(30)
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SUV, THCC, WL, XNJM, MNDLR, MNOTB,MNOTR
      COMMON/ARRAY/ CPSYR,CTC,CTIN,CTJ,CTRF,CTSB,CTSP,CTSR,CTTR,KK,
     1              LPL,MNOC,MNOS,NODES,NREQ,NR2,THSB,LM
      COMMON /LIF/ P2, PSS, XJ, TOPKE, WT, THETA, SACT,
     1        VTHCC, VTOPKE, VE, VXJ, ZZ, VP1, VP2
      COMMON /MANC/ CERR, CLW, CMAT, DFTY
      COMMON /TOC/ HPDC,PVSO,PVSN,DEQO,DEQN,AAS,ASOD,
     1        ASND, MODEL, DTSO, DTSN, DOOZ, NOLO, NOLN, ADT
      COMMON /ALL/ AP,ADTGR,ITYPE,RINT,NDAYCU,IDOV,ALANES,OVERLEN
      COMMON / INPUT / ACE,ACPR,AGF,BUMIN,CINC,CIOV,CMAX,CDEF,CPCYAC,
     1     CPLMSG,CPR,DDF,DFL,DSD,EFSG,EOF,ESD,FFSG,IKOUNT,ILEVEL,
     2     ISX,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSB,
     3     DFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSNA,PSVAC,PSXSO,
     4     P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5     TTC,WWW,XJSD,XKSD
      COMMON / OUTPUT / KANAL,KFUND,KLIF,KLIFE,KREJ,KSUB,NN,NNC,NNR,
     1     NNT,NOID,NOIN
      COMMON /NUM/ N1,N2
      REAL K11, K22, M1, M2, M3, NCODE, LAMDA, N1, N2
      DATA CODE/3HSIN, 3HTAN, 3HGLE, 3HDEM /
      DATA OVID/4H  AC,4H  CC,4HNONE/
      DATA PVIO/3HJCP,3HCRC/
      DATA RU/3H RU, 3H UR, 3HRAL, 3HBAN /
      DATA RNFID/4HBARS,4HMESH/
      DATA SXDA/3HCEN,3H TH,3HTER,3HIRD/
      DATA CONF/50.0, 80.0, 95.0, 99.0, 99.9, 99.99, 99.999/
      DATA LEVEL/1HA, 1HB, 1HC, 1HD, 1HE, 1HF, 1HG /
      DATA ZZCONF/0.0, 0.8415, 1.6450, 2.3267, 3.090, 3.75, 4.5/
10         CONTINUE
      CALL INPUT (I,J,NCS1,NCS2,PSN1,PSN2)
      IN1=N1+.5000001
      IN2=N2+.5000001
      CALL INITIAL (JJ,L,MOR1,NCS1,NCS12,NCS2)
           IF (NCS1 .EQ. 2) GO TO 420
                XJ = 3.2
                IDPV = 1
           GO TO 430
420             XJ = 2.2
                IDPV = 2
 430  CALL NUMBER (I,KIND)
 460  CALL TRAFFIC (ALOG10,I,J,KLFCK,PSN2)
           DO 1200 I = 1, NC
                MNOC = I
                CTC = 3.0/(1760.0*WL)*(CIC(I)+CSC(I))+CPCYC(I)/36.
     1                *THCC
           DO 1260 J = 1, NSB
                MNOS = J
                KRCK = 0
C
C         KRCK  CHECKS THE REINFORCEMENT FROM BEING DESIGNED MORE
C               THAN ONCE WITH THE INCREMENTS OF SUBBASE THICKNESS
C
                THSB = TSMIN(J)
                THMAX = TSMAX(J)
 510       IF ((THCC+THSB) .LE. TMAX) GO TO 520
                KREJ = KREJ+1
           GO TO 1250
 520            KSUB = KSUB+1
C
C         KSUB  IS A COUNTER TO GIVE THE NUMBER OF SUCH DESIGNS
C               (OUT OF ALL THE POSSIBLE DESIGNS) WHICH DO MEET THE
C               MINIMUM INITIAL THICKNESS REQUIREMENT
                CTSB = CPCYS(J)/36.0*THSB+CIS(J)*3.0/(1760.0*WL)
                ESJ = ES(J)
                EEF = EF(J)
C
C         START EQUATIONS FOR FINDING K AT THE TOP OF THE SUBBASE
C
           IF (THSB .EQ. 0.0) GO TO 560
                E1 = (ALOG10(ESJ)-5.06)/0.35
                E2 = E1**2-4.0
                E3 = 1.0/6.0*(E1**3-7.0*E1)
                M1 = (SGE-8100.)/1500.
                M2 = 1.0/8.0*(3.0*M1**2-35.0)
                M3 = 1.0/24.0*(5.0*M1**3-101.0*M1)
           IF (THSB .LT. 6.0) GO TO 530
           IF (THSB .LE. 12.0) GO TO 540
           GO TO 550
 530            T1 = (THSB-3.0)/3.0
                T2 = 3.0*T1**2-2.0
                TOPK = 385.76202+69.6978*T1+8.58994*T2+27.06117*E1
     1                +3.98285*E2+5.55074*E3+66.48248*M1-1.60374*M2
     2                +0.43241*M3+31.07086*T1*E1+4.40539*T1*E2+5.05764
     3                *T1*E3+7.08264*T1*M1-2.35151*T1*M2+4.00969*T2
```

```
     4          *E1+0.42254*T2*E2+1.12694*T2*M1+3.55564*E1*M1
     5          -0.38658*E1*M2+0.36171*E2*M1-0.19788*E2*M2+1.05619
     6          *E3*M1+4.21905*T1*E1*M1-0.45553*T1*E1*M2+0.47169
     7          *T1*E2*M1-0.17973*T1*E2*M2+0.66341*T2*E1*M1
     8          +0.10999*T2*E2*M1+0.13451*E1*M3+0.13786*T1*E1
     9          *M3+0.24915*T1*M3
      GO TO 570
 540        T1 = (THSA-9.0)/3.0
            T2 = 3.0*T1**2-2.0
            TOPK = 578.61706+115.16060*T1+108.03355*E1+13.39099
     1          *E2+13.09083*E3+88.39701*M1-7.08938*M2+1.34638
     2          *M3+45.94402*T1*E1+4.57328*T1*E2+2.92403*T1
     3          *E3+13.81048*T1*M1-2.9967*T1*M2+0.58481*T1*M3
     4          +15.35524*E1*M1-1.45862*E1*M2+0.39667*E1*M3
     5          +1.54525*E2*M1-0.45022*E2*M2+0.07024*E2*M3+2.35879
     6          *E3*M1+6.92728*T1*E1*M1-0.56362*T1*E1*M2+0.12992
     7          *T1*E1*M3+0.60521*T1*E2*M1-0.09651*T1*E2*M2
     8          +0.59329*T2
      GO TO 570
 550        T1 = (THSA-15.0)/3.0
            T2 = 3.0*T1**2-2.0
            TOPK = 810.62222+118.98818*T1+200.53012*E1+23.20865
     1          *E2+18.74713*E3+116.49854*M1-13.38744*M2+2.6625
     2          *M3+46.53836*T1*E1+5.34689*T1*E2+2.75181*T1
     3          *E3+14.18543*T1*M1-3.30254*T1*M2+0.71233*T1
     4          *M3+29.34840*E1*M1-2.93899*E1*M2+0.73782*E1
     5          *M3+2.99806*E2*M1-0.72239*E2*M2+0.16776*E2*M3
     6          +3.19113*E3*M1-0.53567*E3*M2+7.08050*T1*E1*M1
     7          -0.92383*T1*E1*M2+0.19601*T1*E1*M3+0.88198*T1
     8          *E2*M1-0.16666*T1*E2*M2
      GO TO 570
 560        TOPK = SGE/23.925
            EEF = EFSG
C
C       START EQUATIONS FOR FINDING K AT THE TOP AFTER ERODABILITY
C
            FFSB(1) = FFSG
 570    IF (EEF .EQ. 0.0) GO TO 580
            EF1 = (EEF-1.5)/0.5
            EF2 = (EF1**2-5.0)/4.0
            EF3 = (5.0*EF1**3-41.0*EF1)/12.0
            XLK = ALOG10(TOPK)
            XLOK = 10.0*(XLK-2.3)
            XLOK2 = (XLOK**2-21.0)/4.0
            XLOK3 = (XLOK**3-37.0*XLOK)/12.0
            TOPKEL = 1.68537-0.21029*EF1+0.00681*EF2+0.02305
     1          *EF3+0.08057*XLOK+0.00478*XLOK2+0.00175*XLOK3
     2          -0.01030*EF1*XLOK-0.00151*EF1*XLOK2-0.00583
     3          *EF2*XLOK-0.00548*EF2*XLOK2+0.00563*EF3*XLOK
     4          +0.00382*EF3*XLOK2+0.00116*EF3*XLOK3-0.00188
     5          *EF2*XLOK3-0.00043*EF1*XLOK3
            TOPKE = 10.0**TOPKEL
      GO TO 590
 580        TOPKE = TOPK
C
C       THIS FINISHES THE TREATMENT OF K VALUE
C
 590    IF (TOPKE .LT. 5.0) TOPKE = 5.0
```

```
            PL(1) = 0.0
      CALL AGE2 (P1, THCC, PL(2), SXU(I), E(I), PL(1), OFMIN, VSX(I))
         IF (PL(2) .GE. OFMIN) GO TO 600
            KLIFE = KLIFE+1
C
C       KLIFE COUNTER OF DESIGNS REJECTED BY INITIAL LIFE RESTRAINT
         GO TO 1250
 600        KLIF = KLIF+1
C
C       KLIF IS THE NUMBER OF SUCH DESIGNS WHICH PASSED THE TIME TO
C       THE FIRST OVERLAY RESTRAINT
            PL(1) = 0.0
            PLP = PL(2)
         IF (PLP .GE. AP) PLP = AP
      CALL MANCE (PL(1), PLP, COMAN(1))
      CALL REINF(I,J,CTIN,CTC,CTJ,CTRF,CTSP,CTTB,CTSB)
         IF (CTIN .GT. CMAX) GO TO 1250
            KFUND = KFUND+1
C
C
C        KFUND  IS THE NUMBER OF SUCH DESIGNS WHICH PASS THE
C             RESTRAINT OF THE MAXIMUM INITIAL FUNDS AVAILABLE
C
            LM = 0
        IF ((NCS1 .EQ. 0) .AND. (XJ .EQ. 2.2)) LM = 1
        IF ((XJ .EQ. 2.2) .AND. (NCS2 .EQ. 0)) LM = 2
        IF ((NCS2 .EQ. 0) .AND. (NCS1 .NE. 0)) LM = 0
        IF (PL(2) .LT. AP) GO TO 910
            L = 1
            LPL = L+1
            IDOV = 3
            KLFCK = KLFCK+1
            KANAL = KANAL+1
            COTR(1) = 0.0
            COSOV(1) = 0.0
            THOVT(1) = 0.0
            PL(1) = 0.0
            THOV(1) = 0.0
        GO TO 1100
 910    IF (OFMIN .GE. AP) GO TO 1250
C
C       KIND  IS THE NUMBER OF DESIGNS WHICH PASS ALL RESTRAINTS
C             WITHIN EACH COMBINATION
C
            KIND = KIND+1
 920        NTHICK = 0
            NTIME = 0
            NODES = 0
            NDUEL = 0
            NCONS = 0
            LIFCAL = 0
            MANCAL = 0
            NTDCAL = 0
            COTR(1) = 0.0
            COSOV(1) = 0.0
            THOV(1) = 0.0
            THOVT(1) = 0.0
            PL(1) = 0.0
```

```
            XINCR = 0.5
         IF (NCS2 .EQ. 1) GO TO 930
            OMIN = OMINA
            OMAX = OMAXA
C        FIRST BLOCK OF EQUATIONS
         IF ( OMINA.EQ. 0.0 ) GO TO 940
            E11 = (ACE-450000.0)/350000.0
            E22 = 3.0*E11**2-2.0
            D11 = THCC-9.0
            D22 = 1.0/4.0*(D11**2-5.0)
            D33 = 1.0/12.0*(5.0*D11**3-41.0*D11)
            K11 = (ALOG10(TOPKE)-2.30103)/0.6989
            K22 = 3.0*K11**2-2.0
            EFOV = 11.77033+0.79408*E11+0.05925*E22+0.93256*D11
     1           +0.032*D22+0.5545*K11+0.1155*K22-0.01952*E11
     2           *D11-0.15887*E11*K11-0.02921*E11*K22+0.00713
     3           *E22*D11+0.01438*E22*K11-0.03193*D11*K11-0.02356
     4           *D11*K22+0.043*D22*K11+0.01433*D22*K22+0.02228
     5           *E11*D11*K11+0.00814*E11*D11*K22-.02238*E11
     6           *D22*K11
         GO TO 940
 930        OMIN = OMINC
            OMAX = OMAXC
 940        L = 1
 950        L = L+1
         IF (L-9) 970,970,960
 960        NDUEL = NDUEL+1
C
C       NDUEL  IS THE NUMBER OF TIMES THE TOTAL NUMBER OF OVERLAYS
C              REQUIRED WERE MORE THAN THE MAXIMUM NUMBER SPECIFIED
C
         GO TO 1000
 970        THOV(L) = OMIN
 980        THOVT(L) = THOVT(L-1)+THOV(L)
         IF (THOVT(L) .GT. OMAX) GO TO 990
         GO TO 1020
 990        NTHICK = NTHICK+1
C        NTHICK   IS THE NUMBER OF TIMES THE MAXIMUM TOTAL OVERLAY
C        THICKNESS RESTRAINT WAS HIT WHILE THE STRATEGY WAS TRYING
C        TO REACH THE ANALYSIS PERIOD
C        GO TO BACK OFF TO THE PREVIOS OVERLAY THICKNESS AND INCREASE
C        IT BY THE SPECIFIED INCREMENT
 1000       L = L-1
         IF (L .LE. 1) GO TO 1230
C        THE ABOVE STATEMENT QUITS THE OVERLAYING PROCEDURE FOR A
C        PARTICULAR INITIAL DESIGN. THIS WILL HAPPEN IN ANY OF THE
C        FOLLOWING CASES.
C           1. WHEN OVERLAY NUMBER 1 THICKNESS,PASSING THE THICKNESS
C              RESTRAINT IS SUFFICIENT TO LAST THE ANALYSIS PERIOD
C           2. WHEN THE OVERLAY NUMBER 1 THICKNESS HITS THE THICKNESS
C              RESTRAINT
C        OR 3. WHEN AFTER CONSIDERING A NUMBER OF SUCCESSFUL OVERLAY
C              STRATEGIES, THE PROGRAM REACHES ANY OF THE ABOVE STATED.
 1010       THOV(L) = THOV(L)+XINCR
         GO TO 980
C        CALL AGE TO CALCULATE THE LIFE OF THE PAVEMENT OVERLAY COMB.
 1020    IF (NCS2 .EQ. 1) GO TO 1030
            IDOV = 1
         IF ( OMINA .EQ. 0.0 ) GO TO 1021
            T11 = (THOVT(L)-6.0)/3.0
            T22 = T11**2-2.0
            T33 = 1.0/6.0*(5.0*T11**3-17.0*T11)
            EFOT = 1.50661*T11+0.1104*T22-0.02239*T33+0.42692
     1           *T11*E11-0.03819*T11*E22-0.03936*T11*D11+0.01239
     2           *T11*D22+0.0083*T11*E11*D11*K11+0.25962*T11
     3           *K11+0.05293*T11*K22+0.02232*T22*E11-0.00796
     4           *T22*E22-0.00467*T22*D11-0.01509*T22*K11-0.01425
     5           *T33*E11-0.0087*T11*E11*D11-0.09388*T11*E11
     6           *K11-0.01642*T11*E11*K22+0.00422*T11*E22*D11
     7           -0.00864*T11*D11*K11-0.00937*T11*D11*K22
            DEFF = EFOV+EFOT
         GO TO 1022
 1021       DEFF = THCC
 1022       CTOVER(L) = (CIOV*3.0/(1760.0*WL)+(THOV(L)+THLEV)/36.0
     1      *CPCYAC) / ((1.0+RINT/100.0)**PL(L) )
            COSOV(L) = COSOV(L-1)+CTOVER(L)
            HPSY =(THOV(L)+THLEV) / (36.0*ACPR )
         GO TO 1040
 1030       IDOV = 2
            RR = THOVT(L)**1.4+COEF*THCC**1.4
            DEFF = RR**(1.0/1.4)
            COSOV(1) = 0.0
            CTOVER(L) = (3.0/(1760.0*WL)*(CIC(I)+CSC(I))+CPCYC(I)
     1           /36.*(THOV(L)+THLEV))/((1.0+RINT/100.0)**PL(L))
            COSOV(L) = COSOV(L-1)+CTOVER(L)
            HPSY = ( THOV(L)+THLEV ) / (36.0*CPR)
 1040 CALL AGE2 (POV, DEFF, PP, SXD(I), E(I), PL(L), BOMIN, VSX(I))
            LIFCAL = LIFCAL+1
C        LIFCAL IS THE NUMBER OF TIMES AGE SUBROUTINE IS CALLED
            PL(L+1) = PL(L)+PP
         IF (PL(L+1) .GT. AP)  GO TO 1045
         IF (PP .GE. BOMIN)  GO TO 1045
            NTIME = NTIME+1
C        NTIME  IS  NUMBER OF SUCH STRATEGIES WHICH WERE ABANDONED
C              BECAUSE TIME BETWEEN OVERLAYS AS CALCULATED AT ANY
C              TIME WAS LESS THAN THE MINIMUM SPECIFIED.
C        GO NOW TO INCREASE THAT PARTICULAR THICKNESS BY THE INCREMENT
         GO TO 1010
C        CALCULATE DELAY COSTS
 1045       COTR(1) = 0.0
      CALL TDC3 (PL(L),THOV(L),CTTRAF(L),HPSY,IN1,IN2)
            NTDCAL = NTDCAL+1
            COTR(L) = COTR(L-1)+CTTRAF(L)
            PLP = AP
         IF (PL(L+1) .LT. AP) PLP = PL(L+1)
C        CALCULATE MAINTENANCE FROM PL(L) TO PLP
      CALL MANCE (PL(L), PLP, CTMAN(L))
            MANCAL = MANCAL+1
            COMAN(L) = COMAN(L-1)+CTMAN(L)
C
         IF (PL(L+1) .LT. AP) GO TO 950
 1050    CONTINUE
            LPL = L+1
         IF (IDOV .EQ. 2) GO TO 1100
            OVCOS = THOVT(L) * CPCYAC * PSVAC / 3600.
         GO TO  1110
```

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 1100          OVCOS = THOVT(L) * CPCYC(I) * PSVC(I) / 3600.
 1110          CTSR = -(THCC * CPCYC(I) * PSVC(I) / 3600. + OVCOS + THSB
    1              * CPCYS(J) * PSVS(J) / 3600.) / ((1.0 + RINT / 100.0)
    2              ** AP)
               TCOST = CTIN+COSOV(L)+COTR(L)+COMAN(L)+ CTSR
    1                 +CPSYR
               JJ = 0
      CALL ORDER (IDOV,IDPV,L,M,NN,TCOST)
          IF (IDOV .EQ. 3) GO TO 1260
               NCONS = NCONS+1
C         NCONS  IS THE NUMBER OF SUCH STRATEGIES WHICH PASSED ALL TESTS
C         AND RESTRAINTS AND HIT THE ANALYSIS PERIOD. EACH STRATEGY
C         WILL MAKE ONE DESIGN IN COMBINATION WITH THE INITIAL DESIGN.
C         AFTER THIS. THICKNESS INCREMENT WILL BE GIVEN TO THE OVERLAY
C         PREVIOUS TO THE ONE WHICH MADE THE PRESENT STRATEGY POSSIBLE.
          GO TO 1000
 1230     CONTINUE
               LM = LM+1
               NCONS = NCONS - NODES
               NTHT(LM) = NTHT(LM)+NTHICK
               LFT(LM) = LFT(LM)+LIFCAL
               NTDCT(LM) = NTDCT(LM)+NTDCAL
               MANT(LM) = MANT(LM)+MANCAL
               NTMT(LM) = NTMT(LM)+NTIME
               NCNT(LM) = NCNT(LM)+NCONS
               NODE(LM) = NODE(LM) + NODES
               NDLT(LM) = NDLT(LM)+NDUEL
               NTOTR(LM) = NTHT(LM)+NTMT(LM)+NDLT(LM)
               NTOT(LM) = NTOTR(LM)+NCNT(LM)+NODE(LM)
               KIN(LM) = KIND
          IF (NCS2 .NE. 0) GO TO 1240
               NCS2 = 1
          GO TO 920
 1240          NCS2 = MOR1
 1250     IF (THSB .EQ. THMAX) GO TO 1260
               THSB = THSB+SINC(J)
          IF (THSB .GT. THMAX) THSB = THMAX
          GO TO 510
 1260     CONTINUE
C         ABOVE STATEMENT IS FOR SUBBASE TYPES AND CONCRETE TYPES LOOPS
C         AS WELL AS SUBBASE THICKNESS INCREMENTS.
               NCSB = NC*NSB
          IF (KLFCK .EQ. NCSB) GO TO 1270
C         KLFCK  HAS TO BE EQUAL TO NCSB BY CONSECUTIVE ADDITION TO
C                QUIT CONCRETE THICKNESS LOOP. OTHERWISE. THE DESIGN
C                PROCESS WILL GO ON IN THE NORMAL FASHION
          IF (THCC .EQ. TCMAX) GO TO 1270
               THCC = THCC+CINC
          IF (THCC .GT. TCMAX) THCC = TCMAX
          GO TO 460
 1270     CONTINUE
          IF (XJ .EQ. 2.2) GO TO 1280
          IF (NCS1 .NE. 0) GO TO 1280
          GO TO 420
 1280          LM = 2
          IF (NCS12 .EQ. 0) LM = 4
          IF (NCS12 .GT. 2) LM = 1
          IF ((NCS12 .EQ. 2) .AND. (NCS1 .EQ. 1)) LM = 1
          DO 1290 IS = 1, LM
               NNT = NNT+NTOT(IS)
               NNR = NNR+NTOTR(IS)
 1290          NNC = NNC+NCNT(IS)+NODE(IS)
      CALL OUTPUT(1,J,NPROB,THLEV,PSN1)
          GO TO 10
 1900     CONTINUE
C         ABOVE STATEMENT IS USED TO END THE PROGRAM
C
C
      END
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      SUBROUTINE INPUT (I,J,NCS1,NCS2,PSN1,PSN2)
      COMMON /MAIN1/ AVGL(30),   ATBPF(4),   BARN(4),
     1  BONY(12),    CTC(6),     CIS(4),     COD(30,2),  CODE(2,2),
     2  COMAN(11),   COSOV(11),  COTR(11),   CPCYC(6),   CPCYS(4),
     3  CPPBS(8),    CPPTS(4),   CPPWS(4),   CSC(6),     CTMAN(11),
     4  CTOVER(11),  CTTRAF(11), DIAL(4),    DIAM(4),    DIAT(4),
     5  E(6),        FF(4),      ES(4),      ESL(4),     FFSB(4),
     6  L1(30),      L2(30),     LFT(4),     MANT(4),    NA(30),
     7  NAME(4,3),   NAMERS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8  NCODE(30),   ND(6),      NDLT(4),    NP(6),      NTDCT(4),
     9  NTHT(4),     NTMT(4),    NTOT(4),    NTDTR(4),   OVID(3),
     1  OVNAM(6),    PL(12),     PVID(2),    PVNAM(6),   RD(2,2),
     2  RNFID(2),    RNFNAM(6),  SINC(4),    SL(4),      SPAC(4),
     3  SPACL(4),    SPACT(4),   SPTIE(4),   ST(4),      SX(6),
     4  VSX(6),      SXD(6),     SXDAT(6,2), SXDA(2,2),  SXSD(6),
     5  TBARN(4),    TCTM(11),   TCTOV(11),  TCTTD(11),  THOV(11),
     6  THOVT(11),   TITLF(15),  TS(6),      TSMAX(4),   TSMIN(4),
     7  TYCS(6),     TYSBS(8),   TYSTS(4),   TYSWS(4),   WC(6),
     8  WHO(9),      SCOT(20),   KIN(6),     PSVC(6),    PSVS(4),
     9  NODE(4),     CONF(7),    ZZCONF(7),  LEVEL(7)
      COMMON /REINFO/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SUV, THCC, WL, XNJM, MNOLR, MNOTB,MNOTR
      COMMON/ARRAY/ CPSYR,CTC,CTIN,CTJ,CTRF,CTSB,CTSP,CTSR,CTTB,KK,
     1              LPL,MNOC,MNOS,NODES,NREQ,NR2,THSB,LM
      COMMON /LIF/ P2, PSS, XJ, TDPKE, WT, THETA, SACT,
     1       VTHCC, VTOPKE, VE, VXJ, ZZ, VP1, VP2
      COMMON /MANC/ CERR, CLW, CMAT, DFTY
      COMMON /TDC/ HPDC,PVSO,PVSN,DEQO,DEQN,AAS,ASOD,
     1      ASND, MODFL, DTSO, DTSN, DDOZ, NOLO, NOLN, ADT
      COMMON /ALL/ AP,ADTGR,ITYPE,RINT,NDAYCU,IDOV,ALANES,OVERLEN
      COMMON / INPUT / ACE,ACPR,AGF,BOMIN,CINC,CIOV,CMAX,COEF,CPCYAC,
     1     CPLMSG,CPR,DDF,DFL,DSD,EFSG,EOF,ESO,FFSG,IKOUNT,ILEVEL,
     2     ISX,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSB,
     3     OFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSN4,PSVAC,PSXSD,
     4     P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5     TTC,WWW,XJSD,XKSD
      COMMON /NUM/ N1,N2
      REAL NCODE
      REAL N1,N2,NDAYCU
C
C                    READ INPUT DATA
C
C
C                    PROBLEM IDENTIFICATION
C
      READ (5,1910) NPROB, TITLE
         IF (EOF, 5) 1900,20
 20   WRITE (6,1920) NPROB, TITLE
C
C                    PROGRAM CONTROL CARD
C
      READ(5,1940) NCS1,NCS2,NCS3,PSN1,PSN4
      PSN2 = 1.0
         IF(PSN2.EQ.1.0) GO TO 55
C
C                    TRAFFIC INPUT
C
      READ (5,1950) NL, L1(1), L2(1), NCODE(1), NA(I)
         IF (NL-1) 30, 55, 40
 30   WRITE(6,1960)
         GO TO 1900
 40      DO 50 I=2,NL
      READ (5,1950) NLCK, L1(I), L2(1), NCODE(I), NA(I)
         IF (NLCK.NE.0) GO TO 30
 50      CONTINUE
C
C                    TRAFFIC GROWTH AND DISTRIBUTION
C
 55   READ (5,1970) AGF, ADTGR, DDF, DFL, ADT, WWW
C
C                    USERS DECISIONS OR RESTRAINTS
C
      READ (5,1980) CMAX, TMAX, OFMIN, BOMIN, OMAXA, OMINA, OMAXC,
     1      OMINC, AP, THLEV, ILEVEL
C
C                    PERFORMANCE VARIABLES
C
      READ(5,1990) P1, P2, POV, PSS, THETA, SACT
C
C                    TRAFFIC DELAY COST VARIABLES
C
      READ (5,2000) DTSO,DTSN,DDOZ,HPDC,NOLO,NOLN,ITYPE
      READ (5,2010) PVSO, PVSN, DEQO, DEQN, AAS, ASOD, ASND, MODEL
C
C                    MATERIALS (CONCRETES)
C
      READ (5,2020) NC, ND(1), NP(1), SX(1),           WC(1),
     1      E(1), TS(1), CIC(1), CPCYC(1), CSC(1), PSVC(1)
         IF (NC-1) 60,80,70
 60   WRITE (6,2030)
         GO TO 1900
 70   READ (5,2040) ((ND(I), NP(I), SX(I),           WC(I),
     1      E(I), TS(I), CIC(I), CPCYC(I), CSC(I), PSVC(I)),I = 2, NC)
 80      CONTINUE
C
C                    CONCRETE DIMENSIONS
C
      READ (5,2050) TCMIN, TCMAX, CINC
         IF (CINC .EQ. 0.0) CINC = 1.0
C
C                    MATERIALS (SUBGRADE)
C
      READ (5,2060) SGK, TTC, FFSG, EFSG, CPLMSG
C
C                    MATERIALS (SUBBASE)
C
      READ (5,2070) NSB, (NAME(1,J), J = 1,3), EF(1), FFSB(1), ES(1),
     1      CIS(1), CPCYS(I), PSVS(1), TSMIN(1), TSMAX(1), SINC(1)
         IF (NSB-1)110,110,100
 100  READ (5,2090) (((NAME(I, J), J = 1, 3), EF(I), FFSB(I),
     1      ES(I), CIS(I), CPCYS(I), PSVS(I), TSMIN(I), TSMAX(I),
     2      SINC(I)), I= 2, NSB)
 110     CONTINUE
         DO 120 I = 1, NSB
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120       IF (TSMAX(I) .GT. 18.0) TSMAX(I) = 18.0
          DO 150 I = 1, 4
               TYSBS(I) = 0.0
               TYSBS(I+4) = 0.0
               TYSWS(I) = 0.0
150            TYSTS(I) = 0.0
C
C                  MATERIALS (STEEL)
C              MAXIMUM OF FOUR TYPES CAN BE SPECIFIED FOR EACH OF
C              1. LONGTIDINAL BAR STEEL
C              2. TRANSVERSE BAR STEEL
C              3. WIRE MESH REINFORCEMENT
C              4. TIE BAR STEEL
C
          IF (NCS3 .NE. 2) READ (5,2100) (((NAMEBS(I, J), J = 1,
     1         3), TYSBS(I), CPPBS(I)), I = 1, 4)
          IF (NCS3 .NE. 2) READ (5,2100) (((NAMEBS(I, J), J = 1,
     1         3), TYSBS(I), CPPBS(I)), I = 5, 8)
          IF (NCS3 .NE. 1) READ (5,2100) (((NAMEWS(I, J), J = 1,
     1         3), TYSWS(I), CPPWS(I)), I = 1, 4)
          IF (NCS3 .NE. 1) READ (5,2100) (((NAMETS(I, J), J = 1,
     1         3), TYSTS(I), CPPTS(I)), I = 1, 4)
C
C        BAR AND MESH SIZES TO BE TRIED
C
      READ (5,2110) (BARN(I), I = 1, 4), (SL(I), ST(1), I = 1, 4),
     1      TBARN
C
C                  MATERIALS (OVERLAY)
C
      READ (5,2120) CTOV, CPCYAC, PSVAC, ACE, ACPR, CPR, COEF,  CPSYR
C
C              OVERLAY CONSTRUCTION DATA
C
   69 READ (5,2015) N1,N2,NDAYCU,ALANES,OVERLEN
C
C                  JOINTS
C
      READ (5,2140) CPFTJ, CPFLJ, SLV, SUV, SPINC, NJM
          IF ( SPINC .EQ. 0.0 ) SPINC = 10.0
C
C              MAINTENANCE,DIMENSIONS AND MISCELLANEOUS
C
      READ (5,2150) DFTY, CLW, CERR, CMAT, RINT, WL, NLT
C
C              CONFIDENCE LEVEL DATA
C
      READ (5,2155)                PSXSD, ESD, XKSD, XJSD, P1SD, P2SD, DSD
              VE = FSD * ESD
              VTHCC = DSO * DSD
              VTOPKF = XKSD * XKSD
              VXJ = XJSD * XJSD
              VP1 = P1SO * P1SD
              VP2 = P2SD * P2SD
          IF (PSN2.EQ.1.0) GO TO 165
C
C              THIS SECTION IS NO LONGER USED TO DETERMINE TRAFFIC
C              BECAUSE PSN2 HAS BEEN SET EQUAL TO ONE IN THE
C                  BEGINNING OF THIS ROUTINE
C
C
C                       PRINT INPUT DATA
C
          DO 160 I=1,NL
               M=NCODE(I)
               COD(1,1)=CODE(M,1)
               COD(I,2)=COUE(M,2)
160            AVGL(I)=(L1(I)+L2(I))/2000.
C         AVGL AVERAGE LOAD IN KIPS
      WRITE(6,2160)
      WRITE(6,2170) (L1(I),L2(I),AVGL(I),COD(I,1),COD(I,2),
     1     NA(I), I=1,NL)
165   WRITE (6,2180) AGF, ADTGR, ODF, DFL, ADT
          IF (PSN2.EQ.1.0) WRITE(6,2185) WWW
      WRITF (6,1920) NPROB, TITLE
      WRITF (6,2190)
               K1 = NCS1+1
          GO TO (170,180,190), K1
170   WRITF (6,2200)
          GO TO 200
180   WRITF (6,2210)
          GO TO 200
190   WRITF (6,2220)
200            K2 = NCS2+1
          GO TO (210,220,230), K2
210   WRITE (6,2230)
          GO TO 240
220   WRITF (6,2240)
          GO TO 240
230   WRITE (6,2250)
240            K3 = NCS3+1
          GO TO (250,260,270), K3
250   WRITF (6,2260)
          GO TO 280
260   WRITE (6,2270)
          GO TO 280
270   WRITE (6,2280)
280       IF (PSN1 .EQ. 1.) WRITE (6,2290)
          IF (PSN1 .EQ. 0.) WRITE (6,2300)
      WRITE (6,2310) PSN4
      WRITE (6,2320) CMAX, TMAX, OFMIN, BOMIN
          IF (NCS2 .NE. 1) WRITE (6,2330) OMAXA, OMINA
          IF (NCS2 .NF. 2) WRITE (6,2340) OMAXC, OMINC
      WRITE (6,2341) THLEV
      WRITF (6,2350) AP
               ZZ = 0.0
          DO 286 I = 1, 7
          IF (ILEVEL .EQ. LEVEL(I))  GO TO 284
          GO TO 286
 284  WRITE(6,2355)  LEVEL(I), CONF(I)
               ZZ = ZZCONF(I)
          GO TO 288
 286      CONTINUE
               I = 1
      WRITE (6,2355) LEVEL(I), CONF(I)
 288      CONTINUE
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      WRITE (6,2360) P1, P2, POV, PSS, THETA, SACT
      WRITE (6,2370) DTSO, DTSN, NOLO, NOLN
      WRITE (6,2380) PVSO, PVSN, DEQO, DEQN, ASOD, ASND, AAS
      WRITE (6,2390) DDOZ,HPDC,MODEL
         IF (ITYPE .EQ. 1) WRITE (6,2400)
         IF (ITYPE .EQ. 2) WRITE (6,2410)
      WRITE (6,1920) NPROB, TITLE
         DO 290 I = 1, NC
         IF (NP(I) .EQ. 0) NP(I) = 2
         IF (ND(I) .EQ. 0) ND(I) = 28
            SXD(I) = SX(I)
         IF (ND(I) .EQ. 7) SXD(I) = 1.23*SXD(I)
         IF (NP(I) .EQ. 1) SXD(I) = 0.90*SXD(I)
         IF (TS(I) .LE. 0.0) TS(I) = 0.40*SXD(I)
             SXSD(I) = PSXSD * SX(I) / 100.0
            VSX(I) = SXSD(I) * SXSD(I)
            ISX = NP(I)
            SXDAT(I, 1) = SXDA(ISX, 1)
290         SXDAT(I, 2) = SXDA(ISX, 2)
      WRITE (6,2420) (I, I = 1, NC)
      WRITE (6,2430) (NO(I), I = 1, NC)
      WRITE (6,2440) ((SXDAT(I, J), J = 1, 2), I = 1, NC)
      WRITE (6,2450) (SX(I), I = 1, NC)
      WRITE (6,2480) (TS(I), I = 1, NC)
      WRITE (6,2490) (E(I), I = 1, NC)
      WRITE (6,2500) (WC(I), I = 1, NC)
      WRITE (6,2510) (CIC(I), I = 1, NC)
      WRITE (6,2520) (CPCYC(I), I = 1, NC)
      WRITE (6,2530) (CSC(I), I = 1, NC)
      WRITE (6,2535)  (PSVC(I), I = 1, NC)
      WRITE (6,2540) TCMIN, TCMAX, CINC
            KOUNT1 = 0
            KOUNT2 = 0
            KOUNT3 = 0
            KOUNT4 = 0
            KOUNT5 = 0
            KOUNT6 = 0
            KOUNT7 = 0
         DO 300 I = 1, 4
         IF (TYSBS(I) .NE. 0.) KOUNT1 = KOUNT1+1
            J = I+4
         IF (TYSBS(J) .NE. 0.) KOUNT2 = KOUNT2+1
         IF (TYSWS(I) .NE. 0.) KOUNT3 = KOUNT3+1
         IF (SL(I) .NE. 0.) KOUNT4 = KOUNT4+1
         IF (TYSTS(I) .NE. 0.) KOUNT5 = KOUNT5+1
         IF (BARN(I) .NE. 0.) KOUNT6 = KOUNT6+1
         IF (TBARN(I) .NE. 0.) KOUNT7 = KOUNT7+1
300      CONTINUE
            IKOUNT = MAX0(KOUNT1, KOUNT2, KOUNT3, KOUNT5)
            KOUNT2 = KOUNT2+4
      WRITE (6,2550) (I, I = 1, IKOUNT)
         IF (NCS3 .EQ. 2) GO TO 310
      WRITE (6,2560) ((NAMEBS(I, J), J = 1, 3), I = 1, KOUNT1)
      WRITE (6,2570) (TYSBS(I), I = 1, KOUNT1)
      WRITE (6,2580) (CPPBS(I), I = 1, KOUNT1)
      WRITE (6,2590) ((NAMEBS(I, J), J = 1, 3), I = 5, KOUNT2)
      WRITE (6,2570) (TYSBS(I), I = 5, KOUNT2)
      WRITE (6,2580) (CPPBS(I), I = 5, KOUNT2)
      WRITE (6,2600) (BARN(I), I = 1, KOUNT6)
310      IF (NCS3 .EQ. 1) GO TO 320
      WRITE (6,2610) ((NAMEWS(I, J), J = 1, 3), I = 1, KOUNT3)
      WRITE (6,2570) (TYSWS(I), I = 1, KOUNT3)
      WRITE (6,2620) (CPPWS(I), I = 1, KOUNT3)
      WRITE (6,2630) (SL(I), I = 1, KOUNT4)
      WRITE (6,2640) (ST(I), I = 1, KOUNT4)
      WRITE (6,2650) ((NAMETS(I, J), J = 1, 3), I = 1, KOUNT5)
      WRITE (6,2570) (TYSTS(I), I = 1, KOUNT5)
      WRITE (6,2660) (CPPTS(I), I = 1, KOUNT5)
      WRITE (6,2670) (TBARN(I), I = 1, KOUNT7)
320      CONTINUE
      WRITE (6,1920) NPROB, TITLE
         IF (SGK)  330, 360, 330
C       MODULUS VALUE (SGE) FOR SUBGRADE WILL BE CALCULATED FROM SGK
330            SGE = 23.925*SGK
      WRITE (6,2680) SGK
         GO TO 390
C        MODULUS VALUE (SGE) FOR SUBGRADE WILL BE CALCULATED FROM TTC
360            SGEL = 4.90586-0.10744*TTC**1.5
               SGE = 10.0**SGEL
      WRITE (6,2710) TTC
390   WRITE (6,2740) FFSG, EFSG, CPLMSB
      WRITE (6,2750) ((NAME(I, J), J = 1, 3), I = 1, NSB)
      WRITE (6,2760) (EF(I), I = 1, NSB)
      WRITE (6,2770) (FFSH(I), I = 1, NSB)
      WRITE (6,2790) (ES(I), I = 1, NSB)
      WRITE (6,2800) (CIS(I), I = 1, NSB)
      WRITE (6,2810) (CPCYS(I), I = 1, NSB)
      WRITE (6,2815) (PSVS(I), I = 1, NSB)
      WRITE (6,2820) (TSMIN(I), I = 1, NSB)
      WRITE (6,2830) (TSMAX(I), I = 1, NSB)
      WRITE (6,2840) (SINC(I), I = 1, NSB)
      WRITE (6,2850) CIOV
         DO 395 I=1,NSB
395      IF (SINC(I) .EQ. 0.0) SINC(I) = 2.0
         IF (NCS2 .NE. 1) WRITE (6,2860) CPCYAC, PSVAC, ACE, ACPR
         IF (NCS2 .NE. 2) WRITE (6,2870) CPR, COEF
         IF (CPSYR .NE. 0.0) WRITE (6,2880) CPSYR
      WRITE (6,2900) CPFTJ, CPFLJ, SLV, SUV, SPINC
         IF (NCS1 .NE. 1) WRITE (6,2910) NJM
            XNJM=NJM
         IF (NJM .EQ. 0) XNJM = 10.**10.
      WRITE (6,2920) DFTY, CLW, CERR, CMAT, WL, NLT, RINT
      WRITE (6,1920) NPROB, TITLE
      WRITE (6,3860) PSXSD, ESD, XKSD, XJSO, P1SD, P2SD, USD,
     1                 (I, SXSD(I), I = 1, NC)
      WRITE (6,2415) N1,N2,NDAYCU,ALANES,OVERLEN
1910 FORMAT  ( A4, 6X, 15A4 )
1920 FORMAT  ( 1H1,//,4X,1H1,7X,29HRIGID  PAVEMENT  SYSTEM  3
     1          27HCENTER FOR HIGHWAY RESEARCH,2X, 10HDEC 1974  ,
     1          3X,7HRFC III,2X,
     2          10HI-----TRIM,/12X, 5HPROB ,A4, 6X, 15A4)
1940 FORMAT(3I10,10X,1F10.0,20X,F10.0)
1950 FORMAT  ( 3I10, F10.0, I10 )
1960 FORMAT   ( /,20X,45H*********************************************
     1            /,20X,45H*                                           *
     2            /,20X,45H*    ERROR IN INPUT DATA FOR TRAFFIC        *
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     3            /,20X,45H*    NUMBER OF LOAD GROUPS OR  CARDS        *
     4            /,20X,45H*              NOT  IN  ORDER               *
     5            /,20X,45H*                                           *
     6            /,20X,45H*             PROGRAM TERMINATED            *
     7            /,20X,45H*********************************************)
1970 FORMAT  ( 2(2F10.0, 10X),2F10.0)
1980 FORMAT  ( 4F10.0, 4F5.0, F10.0, F5.0, 4X, A1 )
1990 FORMAT  ( 8F10.0 )
2000 FORMAT (3F10.0,10X,F10.0,2I5,10X,I10)
2010 FORMAT  ( 7F10.0, I10)
2015 FORMAT (5F10.0)
2020 FORMAT  ( I5, I3, I2,  F5.0,10X, F5.0, F10.0, F5.0, 3F10.0, F5.0)
2030 FORMAT   ( /,20X,45H*********************************************
     1            /,20X,45H*                                           *
     2            /,20X,45H*             NO DATA ON CONCRETE           *
     3            /,20X,45H*                                           *
     4            /,20X,45H*             PROGRAM TERMINATED            *
     5            /,20X,45H*********************************************)
2040 FORMAT  ( 5X, I3, I2,  F5.0,10X, F5.0, F10.0, F5.0, 3F10.0, F5.0)
2050 FORMAT  (10X, 4F10.0)
2060 FORMAT  ( 2(F10.0, 20X), 2F5.0, F10.0 )
2070 FORMAT  (I5, 2A4, A2, 2F5.0, 5X, 3F10.0, 4F5.0)
2090 FORMAT  (5X, 2A4, A2, 2F5.0, 5X, 3F10.0, 4F5.0)
2100 FORMAT  (4(2A4, A2, 2F5.0))
2110 FORMAT  (16F5.0)
2120 FORMAT  ( 8F10.0 )
2140 FORMAT  (2F10.0, 10X, 3F10.0,        I10)
2150 FORMAT  (5F10.0, 10X, F10.0, I10)
2155 FORMAT  (      10X, 7F10.0)
2160 FORMAT  ( ///, 44X, 13HTRAFFIC INPUT, ///24X, 10HLOAD RANGE, 10X,
     1          9HAVG. LOAD, 6X, 4HAXLE, 8X, 11HNO. OF AXLE, / 45X
     2          7HIN KIPS, 7X, 4HCODE, 8X, 12HAPPLICATIONS / )
2170 FORMAT  (18X, I8, 2H -, I8, 7X, F8.3, 7X, 2A3, 5X, I10)
2180 FORMAT  ( ///, 35X, 31HTRAFFIC GROWTH AND DISTRIBUTION, ///
     1    7X,53HAXLE GROWTH FACTOR, PERCENT PER YEAR
     2    15X,F8.2/
     3    7X,53HADT GROWTH RATE, PERCENT PER YEAR
     4    15X,F8.2/
     5    7X,53HDIRECTIONAL DISTRIBUTION FACTOR, PERCENT
     6    15X,F8.2/
     7    7X,53HDESIGN LANE DISTRIBUTION FACTOR, PERCENT
     8    15X,F8.2/
     9    7X,54HINITIAL AVERAGE DAILY TRAFFIC, ONE DIRECTION
     1    14X,F8.2)
2185 FORMAT (7X,55HTOTAL 18 KIP AXLES FOR ANALYSIS PERIOD, BOTH DIRECTI
     1ONS)1X,F10.0/)
2190 FORMAT  (//37X, 16HPROGRAM CONTROLS,/ 20X, 18HDESIGNER SPECIFIES/)
2200 FORMAT  ( 7X, 39HBOTH CRCP AND JCP PAVEMENTS TO BE TRIED  )
2210 FORMAT  ( 7X, 25HDESIGN JCP PAVEMENTS ONLY  )
2220 FORMAT  ( 7X, 26HDESIGN CRCP PAVEMENTS ONLY  )
2230 FORMAT  ( 7X, 35HBOTH CC AND AC OVERLAYS TO BE TRIED  )
2240 FORMAT  ( 7X, 24HPROVIDE CC OVERLAY ONLY  )
2250 FORMAT  ( 7X, 24HPROVIDE AC OVERLAY ONLY  )
2260 FORMAT  ( 7X, 49HBOTH DEFORMED BAR AND WIRE MESH REINFORCEMENT TO
     1          8HBE TRIED  )
2270 FORMAT  ( 7X, 39HDESIGN DEFORMED BAR REINFORCEMENT ONLY  )
2280 FORMAT  ( 7X, 44HDESIGN WELDED WIRE MESH REINFORCEMENT ONLY  )
2290 FORMAT  ( 7X, 26HPRINT SHORT FORM OF OUTPUT  )
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2300 FORMAT  ( 7X, 26HPRINT LONG FORM OF OUTPUT  )
2310 FORMAT  ( 7X, 11HPRINT FIRST, F3.0, 27H DESIGNS IN INCREASING ORDE
     1          16HR OF TOTAL COST    )
2320 FORMAT(//,7X,30X, 34HDESIGNERS  DECISIONS OR RESTRAINTS  //
     1    7X,53HMAXIMUM INITIAL FUNDS AVAILABLE, DOLLARS PER SQ. YD.
     2    15X,F8.2/
     3    7X,53HMAX INITIAL THICKNESS, SLAB PLUS SUBBASE, INCHES
     4    15X,F8.2/
     5    7X,53HMIN TIME TO FIRST OVERLAY, YEARS
     6    15X,F8.2/
     6    7X,53HMIN TIME BETWEEN OVERLAYS, YEARS
     7    15X,F8.2)
2330 FORMAT(7X,53HMAX TOTAL AC OVERLAY THICKNESS,INCHES
     1    15X,F8.2/
     2    7X,53HMIN AC OVERLAY THICKNESS AT ONE TIME, INCHES
     3    15X,F8.2)
2340 FORMAT(7X,53HMAX TOTAL CONC OVERLAY THICKNESS, INCHES
     1    15X,F8.2/
     2    7X,53HMIN CONC OVERLAY THICKNESS AT ONE TIME, INCHES
     3    15X,F8.2)
2341 FORMAT(7X,53HAVERAGE LEVEL UP THICKNESS, INCHES
     1    15X,F8.2)
2350 FORMAT(7X,53HLENGTH OF ANALYSIS PERIOD, YEARS
     1    15X,F8.2)
2355 FORMAT(7X,17HCONFIDENCE LEVEL(, A1, 10H), PERCENT
     1    40X,F8.3)
2360 FORMAT  (//, 34X, 21HPERFORMANCE VARIABLES  //
     1    7X,53HINITIAL SERVICEABILITY INDEX, EXPECTED
     2    15X,F8.2/
     3    7X,53HTERMINAL SERVICEABILITY INDEX, ACCEPTED
     4    15X,F8.2/
     5    7X,53HSERVICEABILITY INDEX AFTER AN OVERLAY, EXPECTED
     6    15X,F8.2/
     7    7X,56HPROBABILITY OF CONJUNCTION OF BAD SOIL AND SITE, PERCENT
     8    12X,F8.2/
     9    7X,53HSWELLING RATE CONSTANT
     1    15X,F8.2/
     2    7X,58HSWELLING ACTIVITY, ESTIMATED DIFFERENTIAL MOVEMENT, INCHE
     CS
     3    10X,F8.2)
2370 FORMAT(//,31X,29HTRAFFIC DELAY COST VARIABLES,//,
     1    7X,59HDISTANCE OVER WHICH TRAFFIC IS SLOWED, MILES, OV.DIRECTIO
     2N              9X,F8.2/
     3    7X,42X,16HNON.OV.DIRECTION     10X,F8.2/
     4    7X,59HNO. OF OPEN LANES IN RESTRICTED ZONE, MILES,  OV.DIRECTIO
     5N              9X,I8/
     6    7X,42X,16HNON.OV.DIRECTION     10X,I8)
2380 FORMAT(7X,59HPERCENT VEHICLES STOPPED BY ROAD EQUIPMENT,    OV.DIRE
     2CTION          9X,F8.2/
     3    7X,42X,16HNON.OV.DIRECTION     10X,F8.2/
     4    7X,59HAVG DELAY CAUSED BY ROAD EQUIP, HOURS ,        OV.DIRECTIO
     2N              9X,F8.2/
     6    7X,42X,16HNON.OV.DIRECTION     10X,F8.2/
     7    7X,59 HAVG SPEED THROUGH OVERLAY ZONE, MPH           OV.DIRECTI
     8ON             9X,F8.2/
     9    7X,42X,16HNON.OV.DIRECTION     10X,F8.2/
     1    7X,50HAVERAGE APPROACH SPEED TO OVERLAY AREA, MPH
     1    18X,F8.2)
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2390 FORMAT(7X,50HUETOUR DISTANCE AROUND OVERLAY ZONE, MILFS
    1   18X,F8.2/
    4   7X,50HNO. OF HOURS/DAY OVERLAY CONSTRUCTION OCCURS
    5   18X,F8.2/
    5   7X,50HTRAFFIC MODEL USED IN THE ANALYSIS
    6   18X,I8/
    7   7X,13HROAD LOCATION)
2400 FORMAT  (1H., 77X, 5HRURAL)
2410 FORMAT  (1H., 77X, 5HURBAN)
2415 FORMAT(//,30X,30HOVERLAY CONSTRUCTION VARIABLES,///,
    1   7X,57HMILITARY HOUR OF THE DAY WHEN OVERLAY CONSTRUCTION BEGINS
    2   11X,F10.0/
    3   7X,57HMILITARY HOUR OF THE DAY WHEN OVERLAY CONSTRUCTION ENDS
    4   11X,F10.0/
    5   7X,56HNUMBER OF DAYS CONCRETE MUST CURE
    6   12X,F10.0/
    7   7X,56HTOTAL NUMBER OF LANES TO BE OVERLAID
    8   12X,F10.0/
    9   7X,56HTOTAL OVERLAY LENGTH IN ONE LANE
    1   12X,F10.0/ )
2420 FORMAT  (///, 39X, 20HMATERIALS, CONCRETE  //
    1   7X,53HCONCRETE MIX DESIGN NUMBER
    2   3X,6(I5,5X))
2430 FORMAT(7X,53HAGE OF TESTING CONCRETE, DAYS
    3   3X,6(I5,5X))
2440 FORMAT(7X,53HMEASURING POINT
    5   2X,6(2A3,4X))
2450 FORMAT(7X,49HFLEXURAL STRENGTH, PSI
    7   2X,6F10.2)
2480 FORMAT(7X,49HTENSILE STRENGTH, PSI
    1   2X,6F10.2)
2490 FORMAT(7X,49HELASTIC MODULUS, PSI
    1   2X,6F10.0)
2500 FORMAT(7X,49HUNIT WEIGHT, PCF
    1   2X,6F10.2)
2510 FORMAT(7X,49HCONSTRUCTION EQUIPMENT COST, PER LANE MILE
    1   2X,6F10.2)
2520 FORMAT(7X,49HCOST PER CUBIC YARD OF CONCRETE, DOLLARS
    1   2X,6F10.2)
2530 FORMAT(7X,49HCOST OF SURFACING CONCRETE, DOLLARS/PER LANE MILE
    1   2X,6F10.2)
2535 FORMAT(7X,49HSALVAGE VALUE OF CONCRETE, PERCENT
    1   2X,6F10.2)
2540 FORMAT(//,7X,49HMINIMUM ALLOWABLE CONCRETE THICKNESS, INCHES
    1   19X,F8.2/
    2   7X,49HMAXIMUM ALLOWABLE CONCRETE THICKNESS, INCHES
    3   19X,F8.2/
    4   7X,49HPRACTICAL INCREMENT FOR POURING CONCRETE, INCHES
    5   17X,F10.2/)
2550 FORMAT  (//, 36X, 17HMATERIALS, STEEL , //, 38X, 4(10X, I2))
2560 FORMAT  (12X, 4HBARS, /, 16X, 12HLONGITUDINAL, /,
    1            18X, 20HBAR STEEL ASTM DESIG, 4(2X, 2A4, A2))
2570 FORMAT  (18X, 20HTENSILE STRENGTH,PSI, 4(2X, F10.2))
2580 FORMAT  (18X, 20HCOST/LB, DOLLARS      4(2X, F10.3))
2590 FORMAT  (16X, 10HTRANSVERSE, /,
    1            16X, 20HBAR STEEL ASTM DESIG, 4(2X, 2A4, A2))
2600 FORMAT  (16X, 20HBAR NOS. TO BE TRIED, 2X, 4(2X, F10.0))
2610 FORMAT  (/, 12X, 11HWIRE MESHES, /,
    1            18X, 20HWIRE MESH ASTM DESIG, 4(2X, 2A4, A2))
2620 FORMAT  (18X, 20HCOST/LB, DOLLARS      4(2X, F10.3))
2630 FORMAT  (16X, 22HMESH SIZES TO BE TRIED, /,
    1            17X, 21HLONG. WIRE SPACING,FT   4(2X, F10.2))
2640 FORMAT  (17X, 21HTRAN. WIRE SPACING,FT   4(2X, F10.2))
2650 FORMAT  (/, 12X, 26HTIE BARS USED WITH W. MESH, /,
    1            18X, 20HTIE BAR ASTM  DESIG.,4(2X, 2A4, A2))
2660 FORMAT  (18X, 16HCOST/LB, DOLLARS      4(2X, F10.3))
2670 FORMAT  (16X, 24HTIE BAR NOS TO BE TRIED  4(F10.0, 2X))
2680 FORMAT  (//, 35X, 20HMATERIALS, SUBGRADE , //,  7X,15HSUBGRADE K,
    1PCI              53X,F8.2)
2710 FORMAT  (///, 46X, 8HSUBGRADE, ///, 20X, 22HTEXAS TRIAXIAL CLASS,
    1            33X, F8.2)
2740 FORMAT  ( 7X, 24HSUBGRADE FRICTION FACTOR, 44X, F8.2
    1            /,  7X, 27HSUBGRADE ERODABILITY FACTOR, 41X, F8.2, /
    2             7X, 51HCOST PER LANE MILE OF SUBGRADE PREPARATION, DOLLA
    3RS          17X, F8.2)
2750 FORMAT  (/,  35X, 19HMATERIALS, SUBBASE , //,  7X, 12HSUBBASE TYPE
    1            39X, 4(2A4, A2))
2760 FORMAT(7X,44HERODABILITY FACTOR
    1   3X,4F10.2)
2770 FORMAT(7X,44HFRICTION FACTOR
    1   3X,4F10.2)
2790 FORMAT(7X,44HELASTIC MODULUS, PSI
    1   3X,4F10.0)
2800 FORMAT(7X,46HCONSTRUCTION EQUIPMENT COST, DOLLARS/LANE MILE
    1   1X,4F10.2)
2810 FORMAT(7X,44HCOST PER COMPACTED CU YD , DOLLARS
    1   3X,4FI0.2)
2815 FORMAT(7X,44HSALVAGE PERCENT VALUE, PERCENT
    1   3X,4F10.2)
2820 FORMAT(7X,44HMIN ALLOWED THICKNESS, INCHES
    1   3X,4F10.2)
2830 FORMAT(7X,44HMAX ALLOWED THICKNESS, INCHES
    1   3X,4F10.2)
2840 FORMAT(7X,44HINCREMENT FOR SUBBASE, INCHES
    1   3X,4F10.2)
2850 FORMAT  (/,  35X, 7HOVERLAY, //,  7X,
    1   61HINITIAL COST PER LANE MILE OF EQUIPMENT FOR OVERLAYS, DOLLAR
    2S                                        7X,F8.2)
2860 FORMAT( 7X,61HCOST / CU YD OF IN PLACE COMPACTED ASPHALT CONCRETE,
    1 DOLLARS                                 7X,F8.2,/,
    2 7X,61HSALVAGE VALUE OF ASPHALT CONCRETE, PERCENT
    1                                         7X,F8.2,/,
    1 7X,61HASPHALT CONCRETE MODULUS VALUE, PSI
    1                                         7X,F8.0,/,
    1 7X,61HPRODUCTION RATE OF COMPACTED ASPHALT CONCRETE, CU YD / HR
    1                                         7X,F8.2)
2870 FORMAT(7X,61HCONCRETE PRODUTION RATE, CU YD /HR
    1                                         7X,F8.2,/,
    17X,61HCONCRETE COEFFICIENT
    1                                         7X,F8.2)
2880 FORMAT(7X,61HRANDOM ADDITIONAL COST / SQ YD FOR ANYTHING
    1                                         7X,F8.2)
2900 FORMAT( /,35X,6HJOINTS,2X,//,7X,65HCOST/FT OF TRANS. JOINT,  SAWIN
    1G, DOWELS, AND/OR SEALING, DOLLARS
    1                                         5X,F8.2,/,
    4   7X,65HCOST/FT OF LONG. JOINT, SEALING, DOLLARS
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     1                                          5X,F8.2,/,
     1 7X,65HRANGE OF SPACING FOR TRANSVERSE JOINTS, LOWER VALUE, FT
     1                                          5X,F8.2,/,
     1  47X,15HUPPER VALUE, FT,       15X,F8.2,/,
     8   7X,65HINCREMENT OF SPACING TO BE TRIED FOR TRANSVERSF JOINTS, F
     1T                                         4X,F9.2)
2910 FORMAT(  7X,65HNO. OF TRANS. CONST. OR WRAPPING JOINTS/MILE FOR CR
     1CP                                        5X,I8,//)
2920 FORMAT( 7X,3X,44HMAINTENANCE, DIMENTIONS AND MISCELLANEOUS
     1,//,7X,65HDAYS OF FREEZING TEMPERATURE PER YEAR
     1                                          3X,F8.2,/,
     27X,65HCOMPOSITF LABOR WAGE FOR MAINTENANCE OPERATIONS, DOLLARS/HR
     1                                          3X,F8.2,/,
     47X,65HCOMPOSITE EQUIPMENT RENTAL RATE FOR MAINT. OPERATION, DOLLAR
     1S                                         3X,F8.2,/,
     57X,65HCOST OF MATERIALS FOR MAINTENANCE OPERATIONS, DOLLARS
     1                                          3X,F8.2,/,
     67X,65HWIDTH OF EACH LANE, FEET
     1                                          3X,F8.2,/,
     97X,65HTOTAL NUMBER OF LANES IN BOTH DIRECTIONS
     1                                          3X,I8,/,
     17X,65HRATE OF INTEREST OR TIME VALUE OF MONEY, PERCENT
     1                                          3X,F8.2)
3860 FORMAT   (////,30X,26HCONFIDENCE LEVEL VARIABLES,//,
     1 20X,40HPERCENT COEFF. OF VARIATION OF FLEXURAL ,/,
     2 30X,20HSTRENGTH OF CONCRETE,23X,F10.2,//,
     3 20X,46HSTD. DEV. OF ELASTIC MODULUS OF CONCRETE (PSI),7X,
     4 F10.2,//,
     5 20X,29HSTD. DEV. OF SUBGRADE K VALUE,24X,F10.2,/
     6 20X,34HSTD. DEV. OF CONTINUITY FACTOR (J),19X,F10.2,/,
     7 20X,45HSTD. DFV. OF INITIAL SERVICABILITY INDEX (P1),8X,F10.2,//,
     8 20X,46HSTD. DEV. OF TERMINAL SERVICABILITY INDEX (P2),7X,F10.2,
     9 //,20X,34HSTD. DEV. OF THICKNESS OF CONCRETE,19X,F10.2,//,
     T 20X,46HSTD. DEV. OF FLEXURAL STRENGTH OF DESIGN WITH:,/,
     1 (40X,3HMIX,I5,25X,F10.2))
      RETURN
1900 STOP 77
      END
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      SUBROUTINE INITIAL (JJ,L,MORI,NCS1,NCS12,NCS2)
      COMMON /MAIN1/ AVGL(30),    ATBPF(4),    BARN(4),
     1   BONY(12),    CTC(6),     CIS(4),      COD(30,2),   CODE(2,2),
     2   COMAN(11),   COSOV(11),  COTR(11),    CPCYC(6),    CPCYS(4),
     3   CPPBS(8),    CPPTS(4),   CPPWS(4),    CSC(6),      CTMAN(11),
     4   CTOVER(11),  CTTRAF(11), DIAL(4),     DIAM(4),     DIAT(4),
     5   E(6),        FF(4),      ES(4),       ESL(4),      FFSH(4),
     6   L1(30),      L2(30),     LFT(4),      MANT(4),     NA(30),
     7   NAME(4,3),   NAMEBS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8   NCODE(30),   ND(6),      NDLT(4),     NP(6),       NTDCT(4),
     9   NTHT(4),     NTMT(4),    NTOT(4),     NTOTR(4),    OVID(3),
     1   OVNAM(6),    PL(12),     PVIO(2),     PVNAM(6),    RD(2,2),
     2   RNFIU(2),    RNFNAM(6),  SINC(4),     SL(4),       SPAC(4),
     3   SPACL(4),    SPACT(4),   SPTIE(4),    ST(4),       SX(6),
     4   VSX(6),      SXD(6),     SXDAT(6,2),  SXOA(2,2),   SXSD(6),
     5   TBARN(4),    TCTM(11),   TCTOV(11),   TCTTO(11),   THOV(11),
     6   THOVI(11),   TITLE(15),  TS(6),       TSMAX(4),    TSMIN(4),
     7   TTCS(6),     TYSBS(8),   TYSTS(4),    TYSWS(4),    WC(6),
     8   WHO(9),      SCOT(20),   KIN(6),      PSVC(6),     PSVS(4),
     9   NODE(4),     CONF(7),    ZZCONF(7),   LEVEL(7)
      COMMON /MAIN2/ CA(30),    CC(30),    CI(30),   CJ(30),
     1   CM(30),      CO(30),     CR(30),      CSB(30),
     2   CSP(30),     CSR(30),    CT(30),      CTB(30),     IO(30),
     3   IP(30),      IR(30),     JMR(30),     JNR(30),     JPR(30),
     4   MC(30),      MER(30),    MS(30),      MTB(30),     MTR(30),
     5   NMR(24),     NO(30),     NPP(30),     PLF(30,13),  RLN(30,4),
     6   RLS(30,4),   RTN(30,4),  RTS(30,4),   STJ(30),     SUMOV(30),
     7   TRN(30,4),   TRSP(30,4), TC(30),      TCT(30),     TO(30,12),
     8   TSUB(30)
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SUV, THCC, WL, XNJM, MNOLR, MNOTB,MNOTR
      COMMON/ARRAY/ CPSYR,CTC,CTIN,CTJ,CTRF,CTSB,CTSP,CTSR,CTTB,KK,
     1              LPL,MNOC,MNOS,NODES,NREQ,NR2,THSB,LM
      COMMON / INPUT / ACE,ACPR,AGF,BOMIN,CINC,CIOV,CMAX,COEF,CPCYAC,
     1     CPLMSG,CPR,DOF,OFL,OSD,EFSG,EOF,ESD,FFSG,IKOUNT,ILEVEL,
     2     TSX,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSB,
     3     OFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSN4,PSVAC,PSASD,
     4     P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5     TTC,WWW,XJSD,XKSD
      COMMON / OUTPUT / KANAL,KFUND,KLIF,KLIFE,KREJ,KSUB,NN,NNC,NNR,
     1     NNT,NOID,NOTN
           JJ = 0
C
C                INITIALIZING
C
           NN = 0
      IF (PSN4 .EQ. 0.0) PSN4 = 14.
           NREQ = PSN4
           KSUB = 0
           NNT = 0
           KLIFE = 0
           KREJ = 0
           NNR = 0
           KLIF = 0
           NNC = 0
           KFUND = 0
```

```
          NR2 = 0
          MORT = NCS2
          NCS12 = NCS1+NCS2
          NOIN = 0
          KANAL = 0
      DO 400 L = 1, 4
          NTHT(L) = 0
          LFT(L) = 0
          MANT(L) = 0
          NTMT(L) = 0
          NTOTR(L) = 0
          NCNT(L) = 0
          NODE(L) = 0
          NTOT(L) = 0
          NTOCT(L) = 0
          NOLT(L) = 0
          KIN(L) = 0
400   CONTINUE
          NREQ1 = NREQ+1
          NREQ5 = NREQ+5
      DO 410 KLM = NREQ1, NREQ5
410       TCT(KLM) = 10000.0
          CTSP = CPLMSG*3.0/(1760.0*WL)
   RETURN
   END
```

```
      SUBROUTINE NUMBER (I,KIND)
      COMMON /MAIN1/ AVGL(30),   ATBPF(4),   BARN(4),
     1  BONY(12),   CTC(6),     CTS(4),     COD(30,2),  CODF(2,2),
     2  COMAN(11),  COSOV(11),  COTR(11),   CPCYC(6),   CPCYS(4),
     3  CPPBS(8),   CPPTS(4),   CPPWS(4),   CSC(6),     CTMAN(11),
     4  CTOVER(11), CTTRAF(11), DIAL(4),    DIAM(4),    DIAT(4),
     5  E(6),       FF(4),      ES(4),      ESL(4),     FFSR(4),
     6  L1(30),     L2(30),     LFT(4),     MANT(4),    NA(30),
     7  NAME(4,3),  NAMEBS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8  NCODE(30),  ND(6),      NOLT(4),    NP(6),      NTOCT(4),
     9  NTHT(4),    NTMT(4),    NTOT(4),    NTOTR(4),   OVID(3),
     1  OVNAM(6),   PI(12),     PVID(2),    PVNAM(6),   RD(2,2),
     2  RNFID(2),   RNFNAM(6),  SINC(4),    SL(4),      SPAC(4),
     3  SPACC(4),   SPACT(4),   SPTIE(4),   ST(4),      SX(6),
     4  VSX(6),     SXD(6),     SXDAT(6,2), SXDA(2,2),  SXSD(6),
     5  TBARN(4),   TCTM(11),   TCTOV(11),  TCTTD(11),  THOV(11),
     6  THOVT(11),  TITLE(15),  TS(6),      TSMAX(4),   TSMIN(4),
     7  TTCS(6),    TYSBS(8),   TYSTS(4),   TYSWS(4),   WC(6),
     8  WHD(9),     SCOT(20),   KIN(6),     PSVC(6),    PSVS(4),
     9  NODE(4),    CONF(7),    ZZCONF(7),  LEVEL(7)
      COMMON /REINFO/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1    KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1    KOUNT7, NCS1, NJM, NLT, SLV, SPINC, SPTJ,
     1    SUV, THCC, WL, XNJM, MNOLR, MNOTR,MNOTR
      COMMON / INPUT / ACE,ACPR,AGF,BUMIN,CINC,CIOV,CMAX,COEF,CPCYAC,
     1    CPLMSG,CPR,DDF,DFL,DSD,EFSG,EOF,ESD,FFSG,IKOUNT,ILEVEL,
     2    TSX,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSB,
     3    OFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSN4,PSVAC,PSXSD,
     4    P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5    TTC,WWW,XJSD,XKSD
      COMMON / OUTPUT / KANAL,KFUND,KLIF,KLIFE,KREJ,KSUB,NN,NNC,NNR,
     1    NNT,NOID,NOIN
              THCC = TCMIN
              KIND = 0
              NOS = 0
              KTHCK = 0
          DO 440 I = 1, NSB
          IF ((TCMIN+TSMIN(I)) .GT. TMAX) KTHCK = KTHCK+1
              SON = (TSMAX(I)-TSMIN(I))/SINC(I)
              NON = SON
              SONS = NON
          IF (SON .GT. SONS) NON = NON+1
              NOS = NOS+NON+1
440       CONTINUE
              NOC = 0
          DO 450 I = 1, NC
              SON = (TCMAX-TCMIN)/CINC
              NON = SON
              SONS = NON
          IF (SON .GT. SONS) NON = NON+1
              NOC = NOC+NON+1
450       CONTINUE
              NOID = NOS*NOC
              NOIN = NOIN+NOID
      IF (KTHCK.LT.NSB) RETURN
      WRITE (6,2930)
2930  FORMAT    ( /,20X,45H*********************************************
     1             /,20X,45H*                                           *
```

```
2              /,20X,45H*      NO COMBINATION OF CONCRETE AND          *
3              /,20X,45H*      SUBBASE THICKNESSES IS POSSIBLE         *
4              /,20X,45H*        EVEN AT THEIR MINIMUM LEVELS          *
5              /,20X,45H*                                              *
6              /,20X,45H*             PROGRAM  TERMINATED              *
7              /,20X,45H*********************************************)
 STOP 77
 END
```

```
      SUBROUTINE TRAFFIC (ALOG10,I,J,KLFCK,PSN2)
      COMMON /MAIN1/ AVGL(30),    ATBPF(4),    HARN(4),
     1  BONY(12),    CIC(6),      CIS(4),      COD(30,2),   CODF(2,2),
     2  COMAN(11),   COSOV(11),   COTR(11),    CPCYC(6),    CPCYS(4),
     3  CPPHS(8),    CPPTS(4),    CPPWS(4),    CSC(6),      CTMAN(11),
     4  CTOVER(11),  CTTRAF(11),  DIAL(4),     DIAM(4),     DIAT(4),
     5  E(6),        FF(4),       ES(4),       ESL(4),      FFSB(4),
     6  L1(30),      L2(30),      LFT(4),      MANT(4),     NA(30),
     7  NAME(4,3),   NAMEBS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8  NCODE(30),   ND(6),       NOLT(4),     NP(6),       NTDCT(4),
     9  NTHT(4),     NTMT(4),     NTOT(4),     NTOTR(4),    DVID(3),
     1  OVNAM(6),    PL(12),      PVID(2),     PVNAM(6),    RD(2,2),
     2  RNFID(2),    RNFNAM(6),   SINC(4),     SL(4),       SPAC(4),
     3  SPACL(4),    SPACT(4),    SPTIE(4),    ST(4),       SX(6),
     4  VSX(6),      SXD(6),      SXDAT(5,2),  SXDA(2,2),   SXSD(6),
     5  THARN(4),    TCTM(11),    TCTOV(11),   TCTTO(11),   THOV(11),
     6  THOVT(11),   TITLE(15),   TS(6),       TSMAK(4),    TSMIN(4),
     7  TTCS(6),     TYSBS(8),    TYSTS(4),    TYSWS(4),    WC(6),
     8  WHO(9),      SCOT(20),    KIN(6),      PSVC(6),     PSVS(4),
     9  NODE(4),     CONF(7),     ZZCONF(7),   LEVEL(7)
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SUV, THCC, XL, XNJM, MNOLR, MNOTB,MNOTR
      COMMON /LIF/ P2, PSS, XJ, TOPKE, WT, THETA, SACT,
     1        VTHCC, VTOPKE, VE, VXJ, ZZ, VP1, VP2
      COMMON /ALL/ AP,ADTGR,ITYPE,RINT,NDAYCU,IDOV,ALANES,OVERLEN
      COMMON / INPUT / ACE,ACPR,AGF,BOMIN,CINC,CIOV,CMAX,COEF,CPCYAC,
     1     CPLMSG,CPR,DDF,DFL,DSD,EFSG,EOF,ESD,FFSG,IKOUNT,ILEVEL,
     2     ISX,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSB,
     3     OFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSN4,PSVAC,PSXSD,
     4     P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5     TTC,WWW,XJSD,XKSD
      REAL NCODE
         DO 470 J = 1, NSB
         IF ((THCC+TSMIN(J)) .LE. TMAX) GO TO 480
  470    CONTINUE
         GO TO 500
  480       WT =WWW * DDF * OFL /(10.0**4)
         IF (PSN2.EQ.1.0) GO TO 500
C
C             PSN2 HAS BEEN SET BY SUBROUTINE INPUT TO BE EQUAL
C             TO ONE. SO THIS SECTION IS NOT USED.  HOWEVER
C             IT IS LEFT IN THE PROGRAM SO THAT FUTURE USE MAY BE
C             MADE OF THIS TYPE OF INPUT OPTION
C
C
C             COMPUTING EQUIVALENT 18 KIP SINGLE AXLE LOADS
C
C       COMPUTE SERVICEABILITY TERM
              GT=ALOG10((P1-P2)/(P1-1.5))
C             BETA FOR 18 KIP, SINGLE AXLE LOAD
              B18=1.0+3.63*19.**5.20/(THCC+1.)**8.46
              WT=0.0
         DO 490 I=1,NL
              XN=AVGL(I)+NCODE(I)
C       CALCULATE BETA FOR EACH AXLE LOAD GROUP
              B=1.0+3.63*XN**5.20/(THCC+1.0)**8.46
```

```
C         CALCULATE EQUIVALENCY FACTOR FOR EACH LOAD GROUP
                EQ =(YN/19.0)**4.62*10.0**(GT/B18-GT/B)/NCODE(I)**3.28
C         CALCULATE TOTAL EQUIVALENT 18-KIP AXLES
                WT=WT+NA(I)*EQ
 490       CONTINUE
C         INCLUDE GROWTH AND DISTRIBUTION FACTORS
                WT=WT*365.0*DFL*DDF/(10.0**4)
                WT=WT*(1.0+AGF*AP/200.0)
                WT=WT*AP
C              WT     TOTAL  18 KIP SINGLE AXLES FOR ENTIRE ANALYSIS PERIO
C
C         KLFCK CUTS THE INITIAL DESIGNS AFTER FINDING THAT INITIAL
C               LIFE FOR ALL CONCRETE AND SUBBASE TYPES IS MORE THAN
C               THE ANALYSIS PERIOD
C
 500            KLFCK = 0
      RETURN
      END
```

```
      SUBROUTINE AGE2 (P1, D, T, SX, E, TUPTO, JUMP,  VSX)
      COMMON /LIF/ P2, PSS, XJ, TOPKE, WTOT, THETA, SACT,
     1        VD, VTOPKE, VE, VXJ, ZZ, VP1, VP2
      COMMON /ALL/ AP,ADTGR,ITYPE,RINF,NDAYCU,IODV,ALANES,OVERLEN

         AGE2 FINDS THE TIME IN YEARS TO BRING A DESIGN FROM ITS
         INITIAL TO ITS TERMINAL SERVICEABILITY

      REAL JUMP

              PEST = 0.001
              KK = 1
              Z = E/TOPKE
              C1 = AP*ADTGR/(AP*ADTGR+200.)
              C2 = 200./(AP*ADTGR+200.)
              PRO = 5.85-4.62*ALOG10(19.0)
              XL = (Z*(D**3.0)/11.52)**0.25
              RHOSP = (XJ*9000./D**2.)*(1.-7.15*SQRT(2.)/XL)
              R18L = 1.010*ALOG10(RHOSP*690./SX)+ALOG10(0.301)
              D1L = 1.995-0.517*R18L
              D1 = 10.0**D1L
              BETA = 1.+(3.63*19.0**5.20)/(D1)**8.46
              CLK = 7.35*D1L + PRO
              CK = 10.0 ** CLK

              Q1 = 7.35*0.517*1.01
              Q2 = 3.63*19.0**5.2
              Q3 = 7.15*SQRT(2.0)
              Q5 = 0.43429

              WSX = (Q1*Q5)**2 *VSX /(SX*SX)
              WXJ = (Q1*Q5)**2 *VXJ /(XJ*XJ)
              WP2 = (Q5/Q5)**2* VP2/((P1-P2)**2)
              WP1 = (Q5/Q5)**2 * (1./(P1-P2) - 1./(P1-1.5))**2*VP1
              WK1=(1./(1.-(Q3/(((E*D**3)/(11.52*TOPKE))**.25))))*Q5
              WK2=(Q3/4.)*((11.52/(E*(D**3)*(TOPKE**3)))**.25)
              WK = (-Q1*WK1*WK2)**2*VTOPKE
              WE1 = WK1
              WE2=(Q3/4.)*(((11.52*TOPKE)/((D**3)*(E**5)))**.25)
              WE = (Q1*WE1*WE2)**2*VE
              WD1 = 2.0*Q1*Q5/D
              WD2 = - (3.0*Q1*Q3*Q5/(4.0*(D**1.75)*
     1             ((E/(11.52*TOPKE))**0.25 - Q3/(D**0.75))))
              WD3 = (ALOG10((P1-P2)/(P1-1.5)) * Q2 * 8.46
     1             * (D+1.0)**7.46  /
     2             ((Q2 + (D+1.0)**8.46)**2))
              WD = (WD1 + WD2 + WD3)**2 * VD

              VLOGW = WSX+WXJ+WP1+WP2+WK+WE+WD+0.0354
              SDLW = SQRT ( VLOGW )
              WUPTO = (10.0**(ZZ*SDLW))*(WTOT*(C1*(TUPTO/AP)**2
     1               +C2*TUPTO/AP))

              RKK = AP - TUPTO
         IF (JUMP .LT. RKK)  RKK = JUMP
              DIFFR = 0.0
 700          T = TUPTO + RKK
 710          WT = (10.0**(ZZ*SDLW))*(WTOT*(C1*(T/AP)**2+C2*T/AP))
```

```
             WINK = WT - WUPTO
             DIFF = P2-(P1-(P1-1.5)*(WINK**BETA)/(CK**BETA)
     1                 -(0.335*PSS*SACT)*(EXP(-THETA*TUPTO)
     2                 -EXP(-THETA*T)))
          IF (DIFF)  740, 750, 740
  740     IF (ABS(DIFF) .LT. PEST)  GO TO 750
          IF (KK.EQ.2)  GO TO 741
          IF (DIFF) 741, 742, 742
  742        T = T - 0.000001
          GO TO 750
  741     CONTINUE
             DIFFR = (P1-1.5)*BETA*(WINK**(BETA-1.0))/(CK**BETA)*
     1                 WTOT * (10.0**(ZZ*SOLW))*
     1                 (C2/AP+2.0*C1*T/(AP**2))+0.335*PSS*SACT*THETA
     2                 *EXP(-THETA*T)
             KK = 2
             T = T - DIFF/DIFFR
          GO TO 710
  750        T = T-TUPTO
C
C         T       IS THE LIFE OF THE DESIGN
C           THIS WILL BE TAKEN BACK TO THE MAIN PROGRAM
C
      RETURN
      END
```

```
      SUBROUTINE MANCE (PLP, PLF, TMPSY)
      COMMON /MANC/ CERR, CLW, CMAT, DFTY
      COMMON /ALL/ AP,ADTGR,ITYPE,RINT,NDAYCU,IDOV,ALANES,OVERLEN
      REAL LAB, MAT, MTOT
      DATA     PLW,PERR,PMAT/0.60,0.19,0.21/
      DATA     PLWR,PERRR,PMATR/0.44,0.21,0.35/
                T = PLF-PLP
         IF (PLF .GT. AP) T = AP-PLP
C
C        PLP PERFORMANCE LIFE PREVIOUS
C        PLF PERFORMANCE LIFE FOLLOWING
C        T - YEARS OF MAINTENANCE
C
         IF (ITYPE .EQ. 2) GO TO 7000
                XLW = PLWR
                XERR = PERRR
                XMAT = PMATR
         GO TO 7010
 7000           XLW = PLW
                XERR = PERR
                XMAT = PMAT
 7010    CONTINUE
                MTOT = 0.0
                NT = T+1.0
         DO 7020 I = 1, NT
                XI1 = I-1
                YP = 19.72*(XI1)**2.+13.72*DFTY-183.0
         IF (YP .LE. 0.0) GO TO 7020
                LAB = YP*XLW*CLW
                EQUIP = YP*XERR*CERR
                MAT = YP*XMAT*CMAT
                TOT = (LAB+EQUIP+MAT)/(1.+RINT/100.)**(XI1+PLP)
         IF (I .EQ. NT) GO TO 7030
                MTOT = MTOT+TOT
C
C        MTOT  TOTAL MAINTENANCE COST FOR T YRS AFTER APPLYING RINT
C
 7020    CONTINUE
 7030           T1 = NT
                FTOT = TOT*(T1-T)
                TOT = TOT-FTOT
                MTOT = MTOT+TOT
                TMPSY = MTOT/(1760.0*16.0)
C
C        TMPSY TOTAL MAINTENANCE COST PER SQUARE YARD
C              THIS WILL BE TAKEN BACK TO THE MAIN PROGRAM
C
      RETURN
      END
```

```
      SUBROUTINE REINF(I,J,CTIN,CTC,CTJ,CTRF,CTSP,CTTB,CTSB)
      COMMON /LIF/ P2, PSS, XJ, TOPKE, WT, THETA, SACT,
     1       VTHCC, VTOPKE, VE, VXJ, ZZ, VP1, VP2
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IORF,JM,JN,JP,
     1   KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1   KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1   SUV, THCC, WL, KNJM, MNOLR, MNOTB,MNOTR
      COMMON /MAIN1/ AVGL(30),    ATBPF(4),    BARN(4),
     1  BONY(12),    CTC(6),      CTS(4),      COD(30,2),   CODE(2,2),
     2  COMAN(11),   COSOV(11),   COTR(11),    CPCYC(6),    CPCYS(4),
     3  CPPBS(8),    CPPTS(4),    CPPWS(4),    CSC(6),      CTMAN(11),
     4  CTOVER(11),  CTTRAF(11),  DIAL(4),     DIAM(4),     DIAT(4),
     5  E(6),        FF(4),       ES(4),       ESL(4),      FFSB(4),
     6  L1(30),      L2(30),      LFT(4),      MANT(4),     NA(30),
     7  NAME(4,3),   NAMEBS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8  NCODE(30),   ND(6),       NDLT(4),     NP(6),       NTDCT(4),
     9  NTHT(4),     NTMT(4),     NTOT(4),     NTOTR(4),    OVID(3),
     1  OVNAM(6),    PL(12),      PVID(2),     PVNAM(6),    RD(2,2),
     2  RNFID(2),    RNFNAM(6),   SINC(4),     SL(4),       SPAC(4),
     3  SPACL(4),    SPACT(4),    SPTIE(4),    ST(4),       SX(6),
     4  VSX(6),      SXD(6),      SXDAT(6,2),  SXDA(2,2),   SXSD(6),
     5  TBARN(4),    TCTM(11),    TCTOV(11),   TCTTD(11),   THOV(11),
     6  THOVT(11),   TITLE(15),   TS(6),       TSMAX(4),    TSMIN(4),
     7  TTCS(6),     TYSBS(8),    TYSTS(4),    TYSWS(4),    WC(6),
     8  WHO(9),      SCOT(20),    KIN(6),      PSVC(6),     PSVS(4),
     9  NODE(4),     CONF(7),     ZZCONF(7),   LEVEL(7)
      COMMON /MAIN2/ CA(30),    CC(30),    CI(30),   CJ(30),
     1  CM(30),      CO(30),      CR(30),      CSB(30),
     2  CSP(30),     CSR(30),     CT(30),      CTB(30),     IO(30),
     3  IP(30),      IQ(30),      JMR(30),     JNR(30),     JPR(30),
     4  MC(30),      MLR(30),     MS(30),      MTB(30),     MTR(30),
     5  NMB(24),     NO(30),      NPP(30),     PLF(30,13),  RLN(30,4),
     6  RLS(30,4),   RTN(30,4),   RTS(30,4),   STJ(30),     SUMOV(30),
     7  TBN(30,4),   TBSP(30,4),  TC(30),      TCT(30),     TO(30,12),
     8  TSUB(30)
      COMMON /TDC/ HPOC,PVSO,PVSN,DEQO,DEQN,AAS,ASOD,
     1       ASND, MODEL, DTSO, DTSN, DDOZ, NOLO, NOLN, ADT
            KRCK = KRCK+1
C
C        KRCK PREVENTS THE STEEL FROM BEING DESIGNED MORE THAN ONCE
C             WITH AN INCREASE IN THICKNESS OF THE SAME SUBBASE
C
         IF (KRCK .GT. 1) GO TO 900
            IDRF = 1
            CTRJB = 0.0
            CTLSB = 0.0
            JN = 0
            JM = 0
            JP = 0
            XNLT = NLT
            WIDTH = XNLT*WL
            NJNT = NLT - 1
            XNJN = NJNT
         IF (MODEL-2) 615, 615, 610
  610       WIDTH = WIDTH/2.0
            NJNT = NLT-2
            XNJN = NJNT
  615    IF (XJ .NE. 3.2) GO TO 690
            CTRJ = 1000.
         IF (NCS3 .EQ. 2) GO TO 650
         DO 640 ISTEEL = 1, KOUNT1
            SPATJ = SLV
  620       ASPFW = THCC/24.*WC(I)*SPATJ*FFSB(J)/(TYSBS(ISTEEL)
     1            *0.75)
            COSTLS = 12.0*ASPFW*CPPBS(ISTEEL)*490.0/1728.0
            COSTTJ = CPFTJ/SPATJ
            CTLRTJ = COSTLS+COSTTJ
         IF (CTLRTJ .GE. CTRJ) GO TO 630
            CTRJ = CTLRTJ
            CTLS = COSTLS
            CTTJ = COSTTJ
            ASPF = ASPFW
C        ABOVE COSTS ARE PER SQ FT AND AREA OF STEEL IS PER FT WIDTH
            MNOLR = ISTEEL
            SPTJ = SPATJ
  630    IF (SPATJ .EQ. SUV) GO TO 640
            SPATJ = SPATJ+SPINC
         IF (SPATJ .GT. SUV) SPATJ = SUV
         GO TO 620
  640    CONTINUE
            CTRJB = CTRJ
         IF (NCS3 .EQ. 1) GO TO 730
  650    DO 680 IMESH = 1, KOUNT3
            SPATJ = SLV
  660       ASPFW = THCC/24.*WC(I)*SPATJ*FFSB(J)/(TYSWS(IMESH)
     1            *0.75)
            COSTLS = 12.0*ASPFW*CPPWS(IMESH)*490.0/1728.0
            COSTTJ = CPFTJ/SPATJ
            CTLRTJ = COSTLS+COSTTJ
         IF (CTLRTJ .GE. CTRJ) GO TO 670
            CTRJ = CTLRTJ
            CTLS = COSTLS
            CTTJ = COSTTJ
            ASPF = ASPFW
            MNOLR = IMESH
            SPTJ = SPATJ
  670    IF (SPATJ .EQ. SUV) GO TO 680
            SPATJ = SPATJ+SPINC
         IF (SPATJ .GT. SUV) SPATJ = SUV
         GO TO 660
  680    CONTINUE
         IF (CTRJ .EQ. CTRJB) GO TO 730
C
C        FOR JCP AND CRCP, BOTH, THE PROGRAM DESIGNS THE BARS IF
C        THE COSTS OF MESHES AND BARS HAPPEN TO BE THE SAME
C        WHEN BOTH TYPES OF REINFORCEMENT ARE TO BE TRIED
C
            IDRF = 2
         GO TO 790
  690       CTLS = 1000.0
            ASLIM = 0.4*12.0*THCC/100.0
         IF (NCS3 .EQ. 2) GO TO 710
         DO 700 ISTEEL = 1, KOUNT1
            ASPFW = 12.0*THCC*(1.3-0.2*FFSB(J))*TS(I)/(0.75*TYSBS(IST
     1            EEL))
         IF (ASPFW .LT. ASLIM) ASPFW = ASLIM
```

```
            COSTLS = 12.0*ASPFW*CPPBS(ISTEEL)*490.0/1728.0
      IF (COSTLS .GE. CTLS) GO TO 700
            CTLS = COSTLS
            ASPF = ASPFW
            MNOLR = ISTEEL
700   CONTINUE
            CTLSB = CTLS
      IF (NCS3 .EQ. 1) GO TO 730
710   DO 720 IMESH = 1, KOUNT3
            ASPFW = 12.0*THCC*(1.3-0.2*FFSB(J))*TS(1)/(0.75*TYSWS(IME
     1            SH))
      IF (ASPFW .LT. ASLIM) ASPFW = ASLIM
            COSTLS = 12.0*ASPFW*CPPWS(IMESH)*490./1728.
      IF (COSTLS .GE. CTLS) GO TO 720
            CTLS = COSTLS
            ASPF = ASPFW
            MNOLR = IMESH
720   CONTINUE
      IF (CTLS .LT. CTLSB) GO TO 790
730   DO 760 ISP = 1, KOUNT6
            SPAC(ISP) = 3.0/64.0*3.14159*(BARN(ISP))**2.0/ASPF
      IF (XJ-3.2) 740,750,750
740         BOND = 3.14159*BARN(ISP)/(8.0*SPAC(ISP)*THCC)
      IF (BOND .LT. 0.03) GO TO 760
750         JN = JN+1
            SPACL(JN) = SPAC(ISP)
            DIAL(JN) = BARN(ISP)
760   CONTINUE
            CTTS = 1000.0
      DO 770 ISTEEL = 5, KOUNT2
            ATSF = THCC/24.0*WC(I)*WIDTH*FFSB(J)/(TYSBS(ISTEEL)
     1            *0.75)
            COSTTS = 12.0*ATSF*CPPBS(ISTEEL)*490.0/1728.0
      IF (COSTTS .GE. CTTS) GO TO 770
            CTTS = COSTTS
            ATSPF = ATSF
            MNOTR = ISTEEL
770   CONTINUE
      DO 780 ISP = 1, KOUNT6
            SPAC(ISP) = 3.0/64.0*3.14159*(BARN(ISP))**2.0/ATSPF
            JM = JM+1
            SPACT(JM) = SPAC(ISP)
            DIAT(JM) = BARN(ISP)
780   CONTINUE
            JP = JM
            CTTBR = XNJN*ATSPF*60.0*DIAT(1)/8.0*CPPBS(MNOTR)
     1            *490.0/1728.0*1.0/(XNLT*WL)
C     COST OF TIE BARS IS CALCULATED FROM FIRST TIE BAR PRINTED OUT
            CTRF = (CTLS+CTTS)*9.0
            CTTB = CTTBR*9.0
      GO TO 870
790         IDRF = 2
      DO 820 ISP = 1, KOUNT4
            DIAM(ISP) = (ASPF*SL(ISP)/(3.0*3.14159))**0.5
      IF (XJ-3.2) 800,810,810
800         BOND = 3.14159*DIAM(ISP)/(SL(ISP)*THCC)
      IF (BOND .LT. 0.03) GO TO 820
810         JN = JN+1
            SPACL(JN) = SL(ISP)
            DIAL(JN) = DIAM(ISP)
820   CONTINUE
830         ATSPF = THCC/24.0*WC(1)*WIDTH*FFSB(J)/TYSWS(MNOLR)
     1            *4.0/3.0
            CTTS = 12.0*ATSPF*CPPWS(MNOLR)*490.0/1728.0
            MNOTR = MNOLR
      DO 840 ISP = 1, KOUNT4
            DIAM(ISP) = (ATSPF*ST(ISP)/(3.0*3.14159))**0.5
            JM = JM+1
            SPACT(JM) = ST(ISP)
            DIAT(JM) = DIAM(ISP)
840   CONTINUE
            CSTTB = 1000.0
      DO 850 ITB = 1, KOUNT5
            ATBPF(ITB) = THCC/24.0*WC(I)*WIDTH*FFSB(J)/TYSTS(ITB)
     1            *4.0/3.0
            COSTTB = 12.0*ATBPF(ITB)*CPPTS(ITB)*490.0/1728.0
      IF (COSTTB .GE. CSTTB) GO TO 850
            CSTTB = COSTTB
            ATB = ATBPF(ITB)
            MNOTB = ITB
850   CONTINUE
      DO 860 JPP = 1, KOUNT7
            JP = JP+1
            SPTIE(JPP) = 3.0/64.0*3.14159*(TBARN(JPP))**2.0/ATB
860   CONTINUE
            CTTBR = XNJN*ATBPF(1)*60.0*TBARN(1)/8.0*CPPTS(1)
     1            *490.0/1728.0*1.0/(XNLT*WL)
            CTRF = (CTLS+CTTS)*9.0
            CTTB = CTTBR*9.0
870   CONTINUE
      IF (XJ-3.2) 880,890,890
880         CTJ = XNJN*CPFLJ/(XNLT*WL)*9.0+NJM/1760.0*3.0*CPFTJ
            SPTJ = 5280.0/XNJM
      GO TO 900
890         CTJ = (XNJN*CPFLJ/(XNLT*WL)+CTTJ)*9.0
900         CTIN = CTSP+CTC+CTSB+CTRF+CTJ+CTTB
C     CTIN  INITIAL COST
   RETURN
   END
```

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      SUBROUTINE TDC3 (PLAT,OVTM,TDCSY,HPSY,N1,N2)
      COMMON /ALL/ AP,ADTGR,ITYPE,RINT,NDAYCU,IDOV,ALANES,OVERLEN
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SUV, THCC, NL, XNJM, MNOLR, MNDTB,MNOTR
      COMMON /TDC/ HPDC,PVSO,PVSN,DEQO,DEQN,AAS,ASOD,
     1       ASND, MODEL, DTSO, DTSN, DDOZ, NOLO, NOLN, ADT
      COMMON / INPUT / ACE,ACPR,AGF,BUMIN,CINC,CIOV,CMAX,COEF,CPCYAC,
     1     CPLMSG,CPR,DDF,DFL,DSD,EFSG,EOF,ESD,FFSG,IKOUNT,ILEVEL,
     2     ISX,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSR,
     3     OFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSN4,PSVAC,PSXSD,
     4     P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5     TTC,WWW,XJSD,XKSD
      DIMENSION AVPH(24)
      DIMENSION CCSR(6,7), CCSU(6,7), CURS(12,2), COD(1,2), CAP(4,3)
C
C
C         THE FOLLOWING ARE TABLES CONTAINING THE USER COSTS.
C
C
C    COST OF SLOWING DOWN IN A RURAL AREA IN TEXAS.
C
C
C     EXCESS COST ABOVE CONTINUING AT INITIAL SPEED
C     IT INCLUDES OPERATING AS WELL AS TIME COST OF SPEED CHANGE CYCLE
C     **DOLLARS PER 1000 CYCLES **
      DATA CCSR/10.676, 22.932, 39.753, 63.454, 98.194, 151.888,
     1       0., 11.860, 27.079, 49.907, 83.454, 134.793, 2*0., 14.306,
     2       35.812, 67.935, 116.527, 3*0., 19.902, 50.326, 95.788,
     3       4*0., 28.491, 71.070,5*0., 40.931, 6*0./
C
C    COST OF SLOWING DOWN IN AN URBAN AREA
C
      DATA CCSU/7.395, 14.329, 24.570, 37.838, 56.705, 85.514, 0.,
     1       7.059, 16.2, 28.896, 47.046, 74.330, 2*0., 8.191, 20.13,
     2       37.303, 61.884, 3*0., 10.845, 27.024, 50.705, 4*0.0,
     3       14.939 , 36.994, 5*0.0, 20.704, 6*0./
C
C    COST OF OPERATING AT A UNIFORM SPEED IN TEXAS
C     DIFFERANCE OF TWO VALUES GIVES THE EXCESS COST OF OPERATING AT
C     REDUCED SPEED
C     IT INCLUDES OPERATING AS WELL AS TIME COST
C     ** DOLLARS PER 1000 VEHICLE MILES **
C
      DATA CURS/945.25, 495.77, 345.43, 270.31, 225.70, 196.62,
     1       176.63, 162.58, 152.54, 145.54, 141.04, 138.80, 872.00,
     2       456.66, 317.78, 248.30, 206.84, 179.64, 160.75, 147.22,
     3       137.31, 130.08, 124.97,121.88/
C
C    COST OF IDLING
C     IT INCLUDES OPERATING AS WELL TIME COST
C     ** DOLLARS PER 1000 VEHICLE HOURS **
C
      DATA COD / 4409.70, 4111.52/
C
C    CAPACITY TABLE
C     OUTPUT AND RECOVERY RATES, VEHICLES PER HOUR IN ONE DIRECTION
C     USED TO CALCULATE PO1,PN1,DO1 AND DN1 FOR MODEL NOS 3,4 AND 5
C
      DATA CAP / 1350., 3000., 1400., 3000., 2700., 4500., 2800.,
     1       4700., 4350., 6200., 4500., 6400. /
      REAL NDAYCU,NDAYCO,NDAYCA
      INTEGER REDUCE
C         COMPUTE FINAL ADT
                ADTT = ADT*(1.0+ADTGR/100.0*PLAT)
          IF (AAS .GT. 60.0) AAS = 60.0
          IF (ASOD .GT. 60.0) ASOD = 60.0
          IF (ASND .GT. 60.0) ASNO = 60.0
                LO = ASOD/10.0
                LO1 = ASOD*2.0/10.0
                LN = ASND/10.0
                LN1 = ASND*2.0/10.0
                K = AAS/10.0
                K1 = AAS*2.0/10.0
      SYARDS = (1760*OVERLEN) * ((WL/3.0)*(ALANES))
      IF (IDOV.EQ.2) GO TO 994
      HTCAO = HPSY * SYARDS
      NDAYCA = HTCAO/HPDC
      GO TO 995
  994 HTCCO = HPSY * SYARDS
      NDAYCO = HTCCO/HPDC
  995 CONTINUE
      CALL VPHCAL (ADTT,AVPH)
      REDUCE = 0
      ITIMEOV = 1
      N2DUM = N2-1
      NUM1 = N1
  996 DCHT = 0.0
  998 DO 999 I=N1,N2DUM
      VPH = AVPH(I)
C   ****
C   MODEL NUMBER ONE
C   ****
                PO1 = 0.
                PN1 = 0.
                DO1 = 0.
                DN1 = 0.
C
C         ABOVE VALUES ARE BEING GIVEN FOR MODEL NUMBER ONE BUT THESE
C         VALUES ARE ALSO USED FOR OTHER MODELS IN CASE SEPERATE VALUES
C         OF THESE VARIABLES ARE NOT COMPUTED FOR THEM
                PO2 = PVSO/100.
                PN2 = PVSN/100.
                DO2 = DEQD
                DN2 = DEQN
                D = 1./12.
          GO TO (790,750,760,770,760), MODEL
C   ****
C   MODEL NUMBER TWO
C   ****
 750            A = DTSO/ASOD
                AQ = A*VPH
                PO1 = 0.5*(1.-EXP(-AQ))**2
                PN1 = PO1
                DO1 = (1.+EXP(2.*AQ))*(EXP(AQ)-AQ-1.)/(2.*VPH*PO1
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```
    1                *(EXP(2.*AQ)-EXP(AQ)+1.))
                 DN1 = DO1
           GO TO 790
C   ****
C   MODEL NUMBERS THREE AND FIVE
C   ****
 760             OUTRAT = CAP(2*ITYPE-1, NOLO)
                 RECRAT = CAP(2*ITYPE, NOLO)
           IF (VPH .LE. OUTRAT) GO TO 790
      RECVPH=AMAX1(1.0,RECRAT-VPH)
  765            PO1 = HPDC*(VPH-OUTRAT)/(2.*VPH*D)
           IF (PO1 .GT. 1.) PO1 = 1.
                 DO1 = HPDC*(VPH-OUTRAT)*(RECRAT-OUTRAT)/(2.*VPH*PO1
    1 *(RECVPH))
           GO TO 790
C   ****
C   MODEL NUMBER FOUR
C   ****
 770             OUTRAT = CAP(2*ITYPE-1, NOLO)
                 RECRAT = CAP(2*ITYPE, NOLO)
           IF (VPH .LE. OUTRAT) GO TO 780
      RECVPH=AMAX1(1.0,RECRAT-VPH)
                 PO1 = HPDC*(VPH-OUTRAT)/(2.*VPH*D)
           IF (PO1 .GT. 1.) PO1 = 1.
                 DO1 = HPDC*(VPH-OUTRAT)*(RECRAT-OUTRAT)/(2.*VPH*PO1
    1 *(RECVPH))
 780             OUTRAT = CAP(2*ITYPE-1, NOLN)
                 RECRAT = CAP(2*ITYPE, NOLN)
           IF (VPH .LE. OUTRAT) GO TO 790
                 PN1 = HPDC*(VPH-OUTRAT)/(2.*VPH*D)
           IF (PN1 .GT. 1.) PN1 = 1.
                 DN1 = HPDC*(VPH-OUTRAT)*(RECRAT-OUTRAT)/(2.*VPH*PN1
    1                  *(RECRAT-VPH))
           GO TO 790
 790       CONTINUE
C
C   START COLLECTING ALL PERTINENT INFORMATION ABOUT DIFFERENT TYPES OF
C   DELAY COSTS. THE FOLLOWING ARE THE DIFFERENT TYPES OF TRAFFIC DELAY
C   COSTS PER VEHICLE
C
           GO TO (800,810), ITYPE
C   COST OF STOPPING FROM APPROACH SPEED IN A RURAL AREA.
 800             CO1 = (CCSR(K, 1)+(CCSR(K+1, 1)-CCSR(K, 1))*(AAS
    1                 /10.0-K))/1000.0
                 CN1 = CO1
C   COST OF SLOWING TO THRU SPEED IN A RURAL AREA.
                 CO41 = CCSR(K, LO+1)+(CCSR(K+1, LO+1)-CCSR(K, LO
    1                 +1))*(AAS/10.-K)
                 CO42 = CCSR(K, LO+2)+(CCSR(K+1, LO+2)-CCSR(K, LO
    1                 +2))*(AAS/10.-K)
                 CO4 = (CO41-(CO41-CO42)*(ASOD/10.0-LO))/1000.0
                 CN41 = CCSR(K, LN+1)+(CCSR(K+1, LN+1)-CCSR(K, LN
    1                 +1))*(AAS/10.-K)
                 CN42 = CCSR(K, LN+2)+(CCSR(K+1, LN+2)-CCSR(K, LN
    1                 +2))*(AAS/10.-K)
                 CN4 = (CN41-(CN41-CN42)*(ASND/10.0-LN))/1000.0
           GO TO 820
C   COST OF STOPPING FROM APPROACH SPEED IN AN URBAN AREA.
 810             CO1 = (CCSU(K, 1)+(CCSU(K+1, 1)-CCSU(K, 1))*(AAS
    1                 /10.0-K))/1000.0
                 CN1 = CO1
C   COST OF SLOWING TO THRU SPEED IN AN URBAN AREA.
                 CO41 = CCSU(K, LO+1)+(CCSU(K+1, LO+1)-CCSU(K, LO
    1                 +1))*(AAS/10.-K)
                 CO42 = CCSU(K, LO+2)+(CCSU(K+1, LO+2)-CCSU(K, LO
    1                 +2))*(AAS/10.-K)
                 CO4 = (CO41-(CO41-CO42)*(ASOD/10.0-LO))/1000.0
                 CN41 = CCSU(K, LN+1)+(CCSU(K+1, LN+1)-CCSU(K, LN
    1                 +1))*(AAS/10.-K)
                 CN42 = CCSU(K, LN+2)+(CCSU(K+1, LN+2)-CCSU(K, LN
    1                 +2))*(AAS/10.-K)
                 CN4 = (CN41-(CN41-CN42)*(ASND/10.0-LN))/1000.0
C   COST OF DELAY DUE TO CONGESTION OUTSIDE THE RESTRICTED AREA.
 820             CO2 = DO1*COD(1, ITYPE)/1000.
                 CN2 = DN1*COD(1, ITYPE)/1000.
           IF (MODEL .EQ. 5) GO TO 830
C   COST OF DRIVING AT A REDUCED SPEED.
                 CO31 = CURS(LO1, ITYPE)-(CURS(LO1, ITYPE)-CURS(LO1
    1                 +1, ITYPE))*(ASOD*2.0/10.0-LO1)/2.0
                 CO32 = CURS(K1, ITYPE)-(CURS(K1, ITYPE)-CURS(K1+1,
    1                  ITYPE))*(AAS*2.0/10.0-K1)/2.0
                 CO3 = (CO31-CO32)*DTSO/1000.0
                 CN31 = CURS(LN1, ITYPE)-(CURS(LN1, ITYPE)-CURS(LN1
    1                 +1, ITYPE))*(ASND*2.0/10.0-LN1)/2.0
                 CN3 = (CN31-CO32)*DTSN/1000.0
C   EXCESS COST OF STOPPING FROM THRU SPEED + COST OF IDLE TIME, ALL
C   WITHIN THE RESTRICTED AREA.
           GO TO 840
 830             CO31 = CURS(LO1, ITYPE)-(CURS(LO1, ITYPE)-CURS(LO1
    1                 +1, ITYPE))*(ASOD*2.0/10.0-LO1)/2.0
                 CO32 = CURS(K1, ITYPE)-(CURS(K1, ITYPE)-CURS(K1+1,
    1                  ITYPE))*(AAS*2.0/10.0-K1)/2.0
                 CO3 = (CO31*DOOZ-CO32*DTSO)/1000.0
                 CN31 = CURS(LN1, ITYPE)-(CURS(LN1, ITYPE)-CURS(LN1
    1                 +1, ITYPE))*(ASND*2.0/10.0-LN1)/2.0
                 CN32 = CURS(K1, ITYPE)-(CURS(K1, ITYPE)-CURS(K1+1,
    1                  ITYPE))*(AAS*2.0/10.0-K1)/2.0
                 CN3 = (CN31-CN32)*DTSN/1000.0
 840       GO TO (850,860), ITYPE
 850             CO5 = (CCSR(LO, 1)+(CCSR(LO+1, 1)-CCSR(LO, 1))*(ASOD
    1                 /10.0-LO)+DO2*COD(1, ITYPE))/1000.
                 CN5 = (CCSR(LN, 1)+(CCSR(LN+1, 1)-CCSR(LN, 1))*(ASND
    1                 /10.0-LN)+DN2*COD(1, ITYPE))/1000.
           GO TO 870
 860             CO5 = (CCSU(LO, 1)+(CCSU(LO+1, 1)-CCSU(LO, 1))*(ASOD
    1                 /10.-LO)+DO2*COD(1, ITYPE))/1000.
                 CN5 = (CCSU(LN, 1)+(CCSU(LN+1, 1)-CCSU(LN, 1))*(ASND
    1                 /10.-LN)+DN2*COD(1, ITYPE))/1000.
C   START TOTAL COST COMPUTATIONS
C           DCH IS TOTAL TRAFFIC DELAY COST PER HOUR OF OVERLAY CONSTR.
  870 IF (REDUCE.EQ.1) GO TO 879
      DCH = VPH*(PO1*(CO1+CO2+CO3)+(1.-PO1)*(CO3+CO4)+PO2
    1     *CO5) + VPH*(PN1*(CN1+CN2+CN3)+(1.-PN1)*(CN3+CN4)
    2     +PN2*CN5)
      GO TO 881
  879 DCH = VPH*(CO3+CO4+CN3+CN4)
```

```
 881  DCHT = DCH + DCHT
 999 CONTINUE
     IF (IOOV.NE.2) GO TO 2000
     GO TO (1000,1001,1002,1003),ITIMEOV
1000 N1 = N2DUM + 1
     N2DUM = 24
     DCH1 = DCHT
     REDUCE = 1
     ITIMEOV = 2
     GO TO 996
1001 N1 = 1
     N2DUM = NUM1-1
     DCH2 = DCHT
     REDUCE = 1
     ITIMEOV = 3
     GO TO 996
1002 N1 = 1
     N2DUM = 24
     DCH3 = DCHT
     REDUCE = 1
     ITIMEOV = 4
     GO TO 996
1003 DCH4 = DCHT
     DCHTOT = (DCH1+DCH2+DCH3)*(NDAYCO) + DCH4*(NDAYCU)
     DCSYCO = DCHTOT/SYARDS
     TDCSY = DCSYCO/(1.+RINT/100.)**PLAT
     IF(TDCSY.LT.0.0) TDCSY = 0.0
     GO TO 3000
2000 DCSYAO = (NDAYCA * DCHT) / SYARDS
     TDCSY = DCSYAO/(1.+RINT/100.)**PLAT
     IF(TDCSY.LT.0.0) TDCSY = 0.0
C       TDCSY IS THE PRESENT WORTH OF TOTAL TRAFFIC DELAY COST PER
C                SQUARE YARD DURING OVERLAY CONSTRUCTION
C                THIS WILL BE TAKEN BACK TO THE MAIN PROGRAM
3000 CONTINUE
     RETURN
     END
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```
      SUBROUTINE VPHCAL (ADTT,VPH)
      DIMENSION PERADT(24),VPH(24)
      COMMON / INPUT / ACE,ACPR,AGF,BOMIN,CINC,CIOV,CMAX,COEF,CPCYAC,
     1     CPLMSG,CPR,ODF,DFL,DSD,EFSG,EOF,ESD,FFSG,IKOUNT,ILEVEL,
     2     TSA,K1,K2,K3,M,MAXO,NC,NL,NLCK,NPROB,NSB,
     3     OFMIN,OMAXA,OMAXC,OMINA,OMINC,POV,PSN4,PSVAC,PSXSD,
     4     P1,P1SD,P2SD,SGE,SGEL,SGK,TCMAX,TCMIN,THLEV,TMAX,
     5     TTC,WWW,XJSD,XKSD
      DATA PERADT / 1.044,0.691,0.520,0.509,0.606,1.605,3.174,6.334,
     1              6.081,5.938,5.961,6.035,5.691,6.127,6.382,6.894,
     2              8.114,7.606,6.117,4.400,3.269,2.669,2.401,1.621
      DDFV = DDF/100.0
      DO 10 I=1,24
         VPH(I) = ADTT*PERADT(I)/100.0 *DDFV
   10 CONTINUE
      RETURN
      END
```

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      SUBROUTINE ORDER (IDOV,IOPV,L,M,NN,TCOST)
      COMMON /MAIN1/ AVGL(30),   ATMPF(4),   BARN(4),
     1  BONY(12),    CTC(6),     CIS(4),     COD(30,2),  CODF(2,2),
     2  COMAN(11),   COSOV(11),  COTR(11),   CPCYC(6),   CPCYS(4),
     3  CPPBS(8),    CPPTS(4),   CPPWS(4),   CSC(6),     CTMAN(11),
     4  CTOVER(11), CTTRAF(11), DIAL(4),    DIAM(4),    DIAT(4),
     5  E(6),        FF(4),      ES(4),      ESL(4),     FFSH(4),
     6  L1(30),      L2(30),     LFT(4),     MANT(4),    NA(30),
     7  NAME(4,3),   NAMEBS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8  NCODE(30),   NO(6),      NOLT(4),    NP(6),      NTOCT(4),
     9  NTHT(4),     NTMT(4),    NTOT(4),    NTOTR(4),   OVIO(3),
     1  OVNAM(6),    PL(12),     PVIO(2),    PVNAM(6),   RO(2,2),
     2  RAFIO(2),    RFNAM(6),   SINC(4),    SL(4),      SPAC(4),
     3  SPACL(4),    SPACT(4),   SPTIE(4),   ST(4),      SX(6),
     4  VSX(6),      SXD(6),     SXDAT(6,2), SXDA(2,2),  SXSD(6),
     5  THARN(4),    TCTM(11),   TCTOV(11),  TCTTD(11),  THOV(11),
     6  THOVT(11),   TITLE(15),  TS(6),      TSMAX(4),   TSMIN(4),
     7  TTCS(6),     TYSBS(8),   TYSTS(4),   TYSWS(4),   WC(6),
     8  WHO(9),      SCOT(20),   KIN(6),     PSVC(6),    PSVS(4),
     9  NODE(4),     CONF(7),    ZZCONF(7),  LEVEL(7)
      COMMON /MAIN2/ CA(30),   CC(30),   CI(30),   CJ(30),
     1  CM(30),      CO(30),     CR(30),     CSB(30),
     2  CSP(30),     CSR(30),    CT(30),     CTB(30),    IO(30),
     3  IP(30),      IR(30),     JMR(30),    JNR(30),    JPR(30),
     4  MC(30),      MLR(30),    MS(30),     MTB(30),    MTR(30),
     5  NMB(24),     NO(30),     NPP(30),    PLF(30,13), RLN(30,4),
     6  RLS(30,4),   RTN(30,4),  RTS(30,4),  STJ(30),    SUMOV(30),
     7  TBN(30,4),   TBSP(30,4), TC(30),     TCT(30),    TO(30,12),
     8  TSUB(30)
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SUV, THCC, WL, XNJM, MNOLR, MNOTB,MNOTR
      COMMON/ARRAY/ CPSYR,CTC,CTIN,CTJ,CTRF,CTSB,CTSP,CTSR,CTTB,KK,
     1              LPL,MNOC,MNOS,NODES,NREQ,NR2,THSB,LM
      DO 1220 M = 1, 2
         NLM1 = NREQ+LM+1
      IF (IODV .EQ. 3) NLM1 = NREQ+5
      IF (M .EQ. 2) GO TO 1120
      IF (TCOST .GT. TCT(NLM1)) GO TO 1220
         NN = NLM1
      GO TO 1130
1120  CONTINUE
         NR2 = NREQ + 1
         NN = NR2
      IF (NR2 - 1)  1130, 1130, 9000
9000     NR2 = NR2 - 1
      DO 9550  NANI = 1, NR2
      IF (IOPV - IP(NANI))  9550, 9020, 9550
9020  IF (IDOV - IO(NANI))  9550, 9030, 9550
9030  IF (IDRF - IR(NANI))  9550, 9040, 9550
9040     KIRN = 0
      IF (L - NPP(NANI))  9550, 9010, 9550
9010     IGRET = 0
      IF(IDOV-3)  9210, 9310, 9310
9210  DO 9510  NOV = 2, L
      IF (THOV(NOV) - TO(NANI,NOV))  9550, 9510, 9540
9540     IGRET = IGRET + 1
9510  CONTINUE
9310  IF (MNOS - MS(NANI))  9050, 9060, 9050
9050     KIRN = KIRN + 1
9060  IF (MNOC - MC(NANI))  9070, 9080, 9070
9070     KIRN = KIRN + 1
9080  IF (THCC - TC(NANI))  9090, 9100, 9090
9090     KIRN = KIRN + 1
9100  IF (THSB - TSUB(NANI))  9110, 9120, 9110
9110     KIRN = KIRN + 1
9120  IF (IGRET)  9130, 9130, 9140
9130  IF (KIRN-1)  9550, 1211, 9550
9140  IF (KIRN)  9550, 1211, 9550
9550  CONTINUE
      IF (NR2 .GT. NREQ)  GO TO 1190
         NN = NR2
1130  CONTINUE
         IP(NN) = IOPV
         IO(NN) = IDOV
         IR(NN) = IDRF
         TC(NN) = THCC
         MC(NN) = MNOC
         TSUB(NN) = THSB
         MS(NN)=MNOS
    DO 1140 KK=1,JN
         RLS(NN,KK)=SPACL(KK)
1140     RLN(NN, KK) = DIAL(KK)
         JNR(NN) = JN
         MLR(NN) = MNOLR
      DO 1150 KK = 1, JM
         RTS(NN, KK) = SPACT(KK)
1150     RTN(NN, KK) = DIAT(KK)
         JMR(NN) = JM
         MTR(NN) = MNOTR
      DO 1160 KK = 1, JP
         TBSP(NN, KK) = SPTIE(KK)
1160     TBN(NN, KK) = TBARN(KK)
         JPR(NN) = JP
         MTB(NN) = MNOTB
         STJ(NN) = SPTJ
      DO 1170 KK = 2, LPL
1170     PLF(NN, KK) = PL(KK)
         PLF(NN, 13) = PL(LPL)
         NPP(NN) = L
      DO 1180 KK = 1, L
1180     TO(NN, KK) = THOV(KK)
         SUMOV(NN) = THOVT(L)
         CSP(NN) = CTSP
         CC(NN) = CTC
         CSB(NN) = CTSB
         CR(NN) = CTRF
         CJ(NN) = CTJ
         CTB(NN) = CTTB
         CI(NN) = CTIN
         CO(NN) = COSOV(L)
         CT(NN) = COTR(L)
         CM(NN) = COMAN(L)
         CSR(NN) = CTSR
         CA(NN) = CPSYR
```

```
                TCT(NN) = TCOST
         GO TO 1220
 1190           TCTMAX = 0.0
                NR2 = NREQ
         DO 1210 KUSM = 1, NREQ
         IF (TCT(KUSM) .GT. TCTMAX) GO TO 1200
         GO TO 1210
 1200           TCTMAX = TCT(KUSM)
                JAY = KUSM
 1210    CONTINUE
         IF (TCOST .GT. TCT(JAY)) GO TO 1220
                NN = JAY
         GO TO 1130
 1211           NR2 = NR2 - 1
                NODES = NODES + 1
         IF (TCOST - TCT(NANI))  1212, 1212, 1220
 1212           NN = NANI
         GO TO 1130
 1220    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE OUTPUT(I,J,NPROB,THLEV,PSN1)
      DATA STAR/1H*/
      COMMON /MAIN1/ AVGL(30),   ATHPF(4),   BARN(4),
     1  BONY(12),    CTC(6),      CIS(4),      COD(30,2),   CODE(2,2),
     2  COMAN(11),   COSOV(11),   COTR(11),    CPCYC(6),    CPCYS(4),
     3  CPPHS(8),    CPPTS(4),    CPPWS(4),    CSC(6),      CTMAN(11),
     4  CTOVER(11),  CTTRAF(11),  DIAL(4),     DIAM(4),     DIAT(4),
     5  F(6),        FF(4),       ES(4),       ESL(4),      FESA(4),
     6  L1(30),      L2(30),      LFT(4),      MANT(4),     NA(30),
     7  NAME(4,3),   NAMERS(8,3),NAMETS(4,3),NAMEWS(4,3),NCNT(4),
     8  NCODE(30),   NO(6),       NDLT(4),     NP(5),       NFDCT(4),
     9  NTHT(4),     NTMT(4),     NTOT(4),     NTOTR(4),    OVID(3),
     1  OVNAM(6),    PI(12),      PVID(2),     PVNAM(6),    RO(2,2),
     2  RNFID(2),    RNFNAM(6),   SINC(4),     SL(4),       SPAC(4),
     3  SPACL(4),    SPACT(4),    SPTIE(4),    ST(4),       SX(6),
     4  VSX(6),      SXD(6),      SXDAT(6,2),  SADA(2,2),   SXSD(6),
     5  THARN(4),    TCTM(11),    TCTOV(11),   TCTTD(11),   THOV(11),
     6  THOVI(11),   TITLE(15),   TS(6),       TSMAX(4),    TSMIN(4),
     7  TYCS(6),     TYSHS(8),    TYSTS(4 ,    TYSWS(4),    WC(6),
     8  WHD(9),      SCOT(20),    KIN(6),      PSVC(5),     PSVS(4),
     9  NODE(4),     CONF(7),     ZZCONF(7),   LEVEL(7)
      COMMON /MAIN2/ CA(30),   CC(30),   CT(30),   CJ(30),
     1  CM(30),      CO(30),      CR(30),      CSB(30),
     2  CSP(30),     CSR(30),     CT(30),      CTB(30),     IO(30),
     3  IP(30),      IR(30),      JMR(30),     JNR(30),     JPR(30),
     4  MC(30),      MLR(30),     MS(30),      MTB(30),     MTR(30),
     5  NMB(24),     NO(30),      NPP(30),     PLF(30,13),  RLN(30,4),
     6  RLS(30,4),   RTN(30,4),   RTS(30,4),   STJ(30),     SUMOV(30),
     7  THS(30,4),   THSP(30,4),  TC(30),      TCT(30),     TO(30,12),
     8  TSUB(30)
      COMMON /REINFD/  KRCK,CPFLJ,CPFTJ,IDRF,JM,JN,JP,
     1     KOUNT1, KOUNT2, KOUNT3, KOUNT4, KOUNT5, KOUNT6,
     1     KOUNT7, NCS3, NJM, NLT, SLV, SPINC, SPTJ,
     1     SJV, THCC, NL, XNJM, MNOLR, MNOTA,MNOTR
      COMMON/ARRAY/ CPSYR,CTC,CTIN,CTJ,CTRF,CTSA,CTSP,CTSR,CTTH,KK,
     1                   LPL,MNDC,MNOS,NODES,NREQ,NR2,THSB,LM
      COMMON / OUTPUT / KANAL,KFUND,KLIF,KLIFE,KREJ,KSUB,NN,NNC,NNR,
     1     NNT,NOLD,NOIN
           IF (KFUND .GT. 0) GO TO 1300
      WRITE (6,1920) NPROB, TITLE
      WRITE (6,2940)
           GO TO 1890
 1300      IF (NNC .GT. 0) GO TO 1310
      WRITE (6,1920) NPROB, TITLE
      WRITE (6,2950)
           GO TO 1435
 1310      DO 1430 IRK = 1, LM
                NN = NREQ+IRK
      WRITE (6,1920) NPROB, TITLE
           IF (KIN(IRK) .GT. 0) GO TO 1320
      WRITE (6,2960)
           GO TO 1430
 1320      IF (NCNT(IRK) .GT. 0) GO TO 1330
      WRITE (6,2970)
           GO TO 1430
 1330           IDPVR = IP(NN)
                IDOVR = IO(NN)
                IDRFR = IR(NN)
```

```
              NPPR = NPP(NN)
      WRITE (6,2980) PVID(IDPVR), OVID(IDOVR), PLF(NN, 2 , TC(NN),
     1         MC(NN), TSUB(NN), MS(NN)
              JNRN = JNR(NN)
              MLRN = MLR(NN)
              JMRN = JMR(NN)
              MTRN4 = MTR(NN)-4
              MTRN = MTR(NN)
              JPRN = JPR(NN)
              MTBN = MTB(NN)
C        BAR REINFORCEMENT
         IF (IDRFR .EQ. 2) GO TO 1370
         IF (JNRN) 1350,1340,1350
 1340 WRITE (6,2990)
         GO TO 1360
 1350 WRITE (6,3010) (RLN(NN, I), I = 1, JNRN)
      WRITE (6,3030) MLRN, (NAMEBS(MLRN, I), I = 1, 3)
      WRITE (6,3020) (RLS(NN, I), I = 1, JNRN)
 1360 WRITE (6,3040) (RTN(NN, I), I = 1, JMRN)
      WRITE (6,3030) MTRN4, (NAMEBS(MTRN, I), I = 1, 3)
      WRITE (6,3020) (RTS(NN, I), I = 1, JMRN)
         IF (CTB(NN) .EQ. 0.0)  GO TO 1410
      WRITE (6,3080) (RTN(NN, I), I = 1, JMRN)
      WRITE (6,3030) MTRN4, (NAMEBS(MTRN, I), I = 1, 3)
      WRITE (6,3020) (RTS(NN, I), I = 1, JMRN)
         GO TO 1410
C        MESH REINFORCEMENT
 1370    IF (JNRN) 1390,1380,1390
 1380 WRITE (6,3000)
         GO TO 1400
 1390 WRITE (6,3050) (RLS(NN, I), I = 1, JNRN)
      WRITE (6,3030) MLRN, (NAMEWS(MLRN, I), I = 1, 3)
      WRITE (6,3060) (RLN(NN, I), I = 1, JNRN)
 1400 WRITE (6,3070) (RTS(NN, I), I = 1, JMRN)
      WRITE (6,3030) MTRN, (NAMEWS(MTRN, I), I = 1, 3)
      WRITE (6,3060) (RTN(NN, I), I = 1, JMRN)
      WRITE (6,3080) (TBN(NN, I), I = 1, JPRN)
      WRITE (6,3030) MTBN, (NAMETS(MTBN, I), I = 1, 3)
      WRITE (6,3020) (TBSP(NN, I), I = 1, JPRN)
 1410    CONTINUE
              ISTJ = STJ(NN)
         IF(PVID(IDPVR).EQ.3HJCP) WRITE(6,3090) ISTJ
         IF(PVID(IDPVR).EQ.3HCRC) WRITE(6,3095) ISTJ
      WRITE (6,3100) WL
      WRITE (6,3110)
         DO 1420 KK = 2, NPPR
              KPRINT = KK-1
              OVLEV = TO(NN, KK) + THLEV
 1420 WRITE (6,3120) (KPRINT, OVLEV,      OVID(IDOVR), PLF(NN, KK))
      WRITE (6,3121) THLEV
      WRITE (6,3130) SUMOV(NN), PLF(NN, NPPR+1)
      WRITE (6,3140) CSP(NN), CC(NN), CSB(NN), CR(NN), CJ(NN)
      WRITE (6,3150) CTB(NN)
      WRITE (6,3160) CI(NN), CO(NN), CT(NN), CM(NN)
      WRITE (6,3180) CSR(NN)
         IF (CA(NN) .NE. 0.0) WRITE (6,3190) CA(NN)
              JERK = NOID-KIN(IRK)
              NACN = NCNT(IRK) + NODE(IRK)
      WRITE (6,3200) TCT(NN), NOID, JERK, KIN(IRK), NACN
 1430    CONTINUE
 1435    CONTINUE
         IF (KANAL .EQ. 0) GO TO 1440
              NN = NREQ+5
              IDPVR = IP(NN)
      WRITE (6,1920) NPROB, TITLE
      WRITE (6,3210) PVID(IDPVR), TC(NN), MC(NN), TSUB(NN), MS(NN)
              ISTJ = STJ(NN)
      WRITE (6,3090) ISTJ
      WRITE (6,3100) WL
      WRITE (6,3220) PLF(NN, 13)
      WRITE (6,3140) CSP(NN), CC(NN), CSB(NN), CR(NN), CJ(NN)
      WRITE (6,3150) CTB(NN)
      WRITE (6,3230) CI(NN), CM(NN)
      WRITE (6,3180) CSR(NN)
         IF (CA(NN) .NE. 0.0) WRITE (6,3190) CA(NN)
      WRITE (6,3240) TCT(NN), KANAL
 1440    CONTINUE
         IF (NR2 .LT. NREQ) NREQ = NR2
              TCTMM = -1.0
         DO 1460 J = 1, NREQ
              TCTMIN = 10.0**10.
         DO 1450 I = 1, NREQ
         IF (TCT(I) .GT. TCTMIN) GO TO 1450
         IF (TCT(I) .LE. TCTMM) GO TO 1450
              NMB(J) = I
              TCTMIN = TCT(I)
 1450    CONTINUE
              TCTMM = TCTMIN
 1460    CONTINUE
              MPGE = NREQ/6
              MXTRA = NREQ-6*MPGE
              ML = 0
         IF (MPGE .EQ. 0) GO TO 1880
              II = 6
 1465          ML = ML + 1
         IF (ML - MPGE)  1468, 1468, 1475
 1468         MM = 1+6*(ML-1)
              MMF = 6+6*(ML-1)
              IM = 7I
 1470         IZ = NREQ
              MCA = NREQ+1
              KTY = NREQ+6
         DO 1480 I = MCA, KTY
         DO 1480 K = 3, 12
 1480         PLF(I, K) = 0.0
         DO 1490 I = MM, MMF
              IZ = IZ+1
              KZ = NMB(I)
              IP(IZ) = IP(KZ)
              IO(IZ) = IO(KZ)
              IR(IZ) = IR(KZ)
              MC(IZ) = MC(KZ)
              MS(IZ) = MS(KZ)
              TC(IZ) = TC(KZ)
              TSUB(IZ) = TSUB(KZ)
              STJ(IZ) = STJ(KZ)
```

```
            CSP(I7) = CSP(KZ)
            CC(IZ) = CC(KZ)
            CSH(I7) = CSB(KZ)
            CR(IZ) = CR(KZ)
            CJ(IZ) = CJ(KZ)
            CTH(I7) = CTB(KZ)
            CI(IZ) = CI(KZ)
            CO(IZ) = CO(KZ)
            CT(IZ) = CT(KZ)
            CM(IZ) = CM(KZ)
            CSR(I7) = CSR(KZ)
            CA(TZ) = CA(KZ)
            TCT(I7) = TCT(KZ)
            TCT(I7) = TCT(KZ)
            JNR(I7) = JNR(KZ)
            MLR(I7) = MLR(KZ)
            JMR(I7) = JMR(KZ)
            MTR(I7) = MTR(KZ)
            MTR(I7) = MTB(KZ)
            JPR(I7) = JPR(KZ)
            NPPN = NPP(KZ)
            NPL = NPP(KZ)+1
            NPP(I7) = NPP(KZ)
            PLF(I7, 13) = PLF(KZ, 13)
        DO 1485 IK7=2,NPPN
        IF (IO(KZ).EQ.3)  TO(KZ,2) = 0.0
            TO(IZ, IKZ) = TO(KZ, IKZ) + THLEV
1485    CONTINUE
        DO 1490 IK7 = 2, NPL
            PLF(I7, IKZ) = PLF(KZ, IKZ)
1490    CONTINUE
      WRITF (6,I920) NPROB, TITLE
      WRITE (6,3250) (MX, MX = MM, MMF)
      WRITE (6,3260) (STAR, MX = 1, IM)
        DO 1500 I = I, II
            INP = IP(NREQ+I)
            PVNAM(I) = PVID(INP)
            INO = TO(NREQ+I)
            OVNAM(I) = OVID(INO)
            INR = IR(NREQ+I)
1500        RNFNAM(I) = RNFID(INR)
      WRITE (6,3270) (PVNAM(I), I = 1, II)
      WRITF (6,3280) (OVNAM(I), I = 1, II)
      WRITF (6,3290) (RNFNAM(I), I = 1, II)
            IN = NREQ+I
            I6 = IN+II-1
      WRITE (6,3300) (MC(I), I = IN, I6)
      WRITF (6,3310) (MS(I), I = IN, I6)
      WRITE (6,3260) (STAR, I3 = 1, IM)
      WRITE (6,3320) (TC(I), I = IN, I6)
      WRITE (6,3330) (TSUR(I), I = IN, I6)
      WRITE (6,3420)
            LMAX = 0
        DO 1510 I = IN, I6
1510    IF (NPP(I) .GT. LMAX) LMAX = NPP(I)
        IF (LMAX .EQ. 1) GO TO 1600
        DO 1590 J = 2, LMAX
            J1 = J-I
      WRITF (6,3340) J1
          DO 1580 I = IN, I6
          IF (NPP(I) .LT. J) GO TO 1580
              II = I-NREQ
          GO TO (1520,1530,1540,1550,1560,1570), II
1520  WRITE (6,3350) (TO(I, J))
          GO TO 1580
1530  WRITF (6,3360) (TO(I, J))
          GO TO 1580
1540  WRITF (6,3370) (TO(I, J))
          GO TO 1580
1550  WRITF (6,3380) (TO(I, J))
          GO TO 1580
1560  WRITE (6,3390) (TO(I, J))
          GO TO 1580
1570  WRITF (6,3400) (TO(I, J))
1580      CONTINUE
1590      CONTINUE
C         PERFORMANCE PERIODS
1600  WRITF (6,3410) (PLF(I, 2), I = IN, I6)
      WRITF (6,3420)
          IF (LMAX.EQ.1)  GO TO 1685
          DO 1680 J = 2, LMAX
              J2 = J-1
      WRITF (6,3430) J2
          DO 1670 I = IN, I6
          IF (NPP(I) .LT. J) GO TO 1670
              II = I-NREQ
          GO TO (1610,1620,1630,1640,1650,1660), II
1610  WRITF (6,3350) (PLF(I, J+1))
          GO TO 1670
1620  WRITF (6,3360) (PLF(I, J+I))
          GO TO 1670
1630  WRITF (6,3370) (PLF(I, J+1))
          GO TO 1670
1640  WRITF (6,3380) (PLF(I, J+1))
          GO TO 1670
1650  WRITF (6,3390) (PLF(I, J+1))
          GO TO 1670
1660  WRITE (6,3400) (PLF(I, J+1))
1670      CONTINUF
1680      CONTINUF
1685  WRITF (6,3440) (PLF(I, 13), I = IN, I6)
C
      WRITE (6,3450) (STJ(I), I = IN, I6)
      WRITF (6,3460) (WL, I = IN, I6)
      WRITF (6,3260) (STAR, I3 = 1, IM)
      WRITF (6,3470) (CSP(I), I = IN, I6)
      WRITE (6,3480) (CC(I), I = IN, I6)
      WRITF (6,3490) (CSR(I), I = IN, I6)
      WRITF (6,3500) (CR(I), I = IN, I6)
      WRITE (6,3510) (CJ(I), I = IN, I6)
      WRITF (6,3520) (CTR(I), I = IN, I6)
      WRITF (6,3530) (CI(I), I = IN, I6)
      WRITF (6,3540) (CO(I), I = IN, I6)
      WRITE (6,3550) (CT(I), I = IN, I6)
      WRITF (6,3560) (CM(I), I = IN, I6)
      WRITE (6,3570) (CSR(I), I = IN, I6)
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```
          DO 1690 I = IN, I6
          IF (CA(I) .NE. 0.0) GO TO 1700
 1690     CONTINUE
          GO TO 1710
 1700 WRITE (6,3590) (CA(I), I = IN, I6)
 1710     CONTINUE
      WRITE (6,3420)
      WRITE (6,3260) (STAR, MX = I, IM)
      WRITE (6,3600) (TCT(I), I = IN, I6)
      WRITE (6,3260) (STAR, MX = I, IM)
          IF (PSNI .NE. 0.0) GO TO 1870
      WRITE (6,1920) NPROB, TITLE
      WRITE (6,3610)
          DO 1820 IX = IN, I6
                JMRN = JMR(IX)
                JPRN = JPR(IX)
                MTRN = MTR(IX)
                MTRN = MTR(IX)
                JNRN = JNR(IX)
                MLRN = MLR(IX)
                MTRN4 = MTR(IX)-4
                MY = NM+IX-NREQ-1
                MU = NMB(MY)
          DO 1720 I = 1, JNRN
                RLN(IX, I) = RLN(MU, I)
 1720           RLS(IX, I) = RLS(MU, I)
          DO 1730 I = 1, JMRN
                RTN(IX, I) = RTN(MU, I)
 1730           RTS(IX, I) = RTS(MU, I)
          DO 1740 I = 1, JPRN
                TBN(IX, I) = TBN(MU, I)
 1740           TBSP(IX, I) = TBSP(MU, I)
      WRITE (6,3620) MY
          IF (IR(IX) .EQ. 2) GO TO 1780
          IF (JNRN) 1760,1750,1760
 1750 WRITE (6,2990)
          GO TO 1770
 1760 WRITE (6,3630) (RLN(IX, IY), IY = 1, JNRN)
      WRITE (6,3640) MLRN, (NAMEBS(MLRN, I), I = 1, 3)
      WRITE (6,3650) (RLS(IX, I), I = 1, JNRN)
 1770 WRITE (6,3660) (RTN(IX, I), I = 1, JMRN)
      WRITE (6,3640) MTRN4, (NAMEBS(MTRN, I), I = 1, 3)
      WRITE (6,3650) (RTS(IX, I), I = 1, JMRN)
          IF (CTB(IX) .EQ. 0.0)  GO TO 1820
      WRITE (6,3670) (RTN(IX, I), I = 1, JMRN)
      WRITE (6,3640) MTRN4, (NAMEBS(MTRN, I), I = 1, 3)
      WRITE (6,3650) (RTS(IX, I), I = 1, JMRN)
          GO TO 1820
 1780     IF (JNRN) 1800,1790,1800
 1790 WRITE (6,3000)
          GO TO 1810
 1800 WRITE (6,3680) (RLS(IX, I), I = 1, JNRN)
      WRITE (6,3640) MLRN, (NAMEWS(MLRN, I), I = 1, 3)
      WRITE (6,3690) (RLN(IX, I), I = 1, JNRN)
 1810 WRITE (6,3700) (RTS(IX, I), I = 1, JMRN)
      WRITE (6,3640) MTRN, (NAMEWS(MTRN, I), I = 1, 3)
      WRITE (6,3590) (RTN(IX, I), I = 1, JMRN)
      WRITE (6,3670) (TBN(IX, I), I = 1, JPRN)
      WRITE (6,3640) MTRN, (NAMETS(MTRN, I), I = 1, 3)
      WRITE (6,3650) (TBSP(IX, I), I = 1, JPRN)
 1820     CONTINUE
 1870     GO TO 1465
 1875     IF (MMF .EQ. NREN) GO TO 1890
                MM = MM+6
                MMF = MM+MXTRA-1
          IF (MXTRA .EQ. 0) GO TO 1890
                II = MXTRA
                IM = 25+8*MXTRA
          GO TO 1470
 1880           MM = 1
                MMF = MXTRA
                II = MMF
                IM = 25+8*MXTRA
                ML = ML + 1
          GO TO 1470
 1890     CONTINUE
                NORTH = NOIN-KREJ
                KOIN = KSUB+KREJ
                KAP = NOIN-KOIN
                KFD = KLIF-KFUND
                JOIN = KFUND-KANAL
      WRITE (6,1920) NPROB, TITLE
      WRITE (6,3750)  NOIN, KREJ, NORTH, KAP, KSUB, KLIFE, KLIF,
     1        KFD, KFUND, KANAL, JOIN
          IF (JOIN .EQ. 0) GO TO 10
      WRITE (6,3760) (I, I = 1, LM)
      WRITE (6,3770) (NIHT(I), I = 1, LM)
      WRITE (6,3780) (NTMT(I), I = 1, LM)
      WRITE (6,3790) (NOLT(I), I = 1, LM)
      WRITE (6,3800) (LFT(I), I = 1, LM)
      WRITE (6,3810) (MANT(I), I = 1, LM)
      WRITE (6,3820) (NTOCT(I), I = 1, LM)
      WRITE (6,3830) (NCNT(I), I = 1, LM)
      WRITE (6,3831) (NODE(I), I = 1, LM)
      WRITE (6,3840) (NTOT(I), I = 1, LM)
      WRITE (6,3850) NNT, NNH, NNC
 1920 FORMAT  ( 1H1,///,4X,1H1,7X,29HRIGID  PAVEMENT  SYSTEM  3
     1          27HCENTER FOR HIGHWAY RESEARCH,2X, 10HDEC 1974  ,
     1          3X,7HRPFC III,2X,
     2          10H1-----TRIM,/12X, 5HPROB ,A4, 6X, 15A4)
 2940 FORMAT   ( /,20X,45H*********************************************
     1           /,20X,45H*                                           *
     2           /,20X,45H*     OUT OF ALL COMBINATIONS TRIED         *
     3           /,20X,45H*           NO  INITIAL DESIGN              *
     4           /,20X,45H*         MEETS THE REQUIREMENTS            *
     5           /,20X,45H*                                           *
     6           /,20X,45H*           PROGRAM TERMINATED              *
     7           /,20X,45H*********************************************)
 2950 FORMAT   ( /,20X,45H*********************************************
     1           /,20X,45H*                                           *
     2           /,20X,45H*     OUT OF ALL OVERLAY STRATEGIES         *
     3           /,20X,45H*             THAT WERE TRIED               *
     4           /,20X,45H*         NO  OVERLAY  STRATEGY             *
     5           /,20X,45H*         MEETS THE REQUIREMENTS            *
     6           /,20X,45H*                                           *
     7           /,20X,45H*   PROGRAM PARTIALLY CONTINUED             *
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      8         /,20X,45H*********************************************)
 2940 FORMAT   ( /,20X,45H*********************************************
      1         /,20X,45H*                                           *
      2         /,20X,45H*          NO INITIAL DESIGN POSSIBLE       *
      3         /,20X,45H*            FOR THIS COMBINATION           *
      4         /,20X,45H*                                           *
      5         /,20X,45H*          PROGRAM WILL BE  CONTINUED       *
      6         /,20X,45H*          FOR THE OTHER COMBINATIONS       *
      7         /,20X,45H*********************************************)
 2970 FORMAT   ( /,20X,45H*********************************************
      1         /,20X,45H*                                           *
      2         /,20X,45H*         NO OVERLAY STRATEGY POSSIBLE      *
      3         /,20X,45H*             FOR THIS COMBINATION          *
      4         /,20X,45H*                                           *
      5         /,20X,45H*          PROGRAM WILL BE  CONTINUED       *
      6         /,20X,45H*          FOR THE OTHER COMBINATIONS       *
      7         /,20X,45H*********************************************)
 2980 FORMAT  (/, 15X, 16HMOST ECONOMICAL , A3, 21H PAVEMENT DESIGN WITH
      1         ,A4, 9H OVERLAY, //, 10X, 22HINITIAL CONSTRUCTION. ,
      2         10H LIFE IS , F7.3, 6H YEARS, //, 13X, 9HMATERIALS, 43X,
      3         11HDESCRIPTION , /, 61X, 8HMATERIAL, 4X, 8HMATERIAL , /,
      4         62X, 4HNUMBER, 7X, 4HNAME, //, 13X, 8HCONCRETE, 4X, F8.2,
      5         7H INCHES, 25X, I1, /, 13X, 7HSUBBASE, 5X, F8.2,
      6         7H INCHES, 25X, I1 )
 2990 FORMAT  (13X,49HLONG.REINF. BAR SPACING NOT AVAILABLE DUE TO BOND)
 3000 FORMAT  (13X,48HLONG. REINF. MESH DIAMETER NOT AVAILABLE DUE TO ,
      1         4HBOND )
 3010 FORMAT  (13X,23HLONG. REINF.    BAR NO., 4F6.0)
 3020 FORMAT  (29X, 7HSPACING, 4F6.1)
 3030 FORMAT  (1H+, 54X, I1, 5X, 2A4, A2)
 3040 FORMAT  (13X,23HTRAN. REINF.    BAR NO., 4F6.0)
 3050 FORMAT  (13X, 23HLONG.REINF.MESH SPACING, 4F6.1)
 3060 FORMAT  (23X,  13HMESH DIAMETER,  4F6.2)
 3070 FORMAT  (13X, 23HTRAN.REINF.MESH SPACING, 4F6.1)
 3080 FORMAT  (13X, 23HTIE BARS      BAR NUMBER, 4F6.0)
 3090 FORMAT(/,25X,24HTRANSVERSE JOINT SPACING,15X,I5,5H FEET)
 3095 FORMAT(/,25X,37HTRANSVERSE CONSTRUCTION JOINT SPACING,2X,I5,
      1       5H FEET)
 3100 FORMAT(25X,26HLONGITUDINAL JOINT SPACING,13X,F5.0,5H FEET)
 3110 FORMAT   (//, 10X, 23HSUBSEQUENT CONSTRUCTION)
 3120 FORMAT   (13X, I1, 28H  OVERLAY AND LEVEL UP WITH ,F5.2,
      1          11H INCHES OF , A4,  7H AFTER , F7.3, 6H YEARS)
 3121 FORMAT   ( /16X, 22HEVERY OVERLAY INCLUDES, F5.2,
      1          19H INCHES OF LEVEL UP)
 3130 FORMAT   (/, 15X, 24HTOTAL OVERLAY THICKNESS , F6.2,  7H INCHES,
      1          15H    TOTAL LIFE , F7.3,  6H YEARS)
 3140 FORMAT   (//, 10X, 39HCOST ANALYSIS   DOLLARS PER SQUARE YARD, /,
      1          15X, 20HINITIAL CONSTRUCTION, /, 18X, 16HCOST OF SUBGRADE
      2          12H PREPARATION, 16X, F6.3, /, 18X,
      4          16HCOST OF CONCRETE, 28X, F6.3, /, 18X,
      4          15HCOST OF SUBBASE, 29X, F6.3, /,  18X,
      5          22HCOST OF REINFORCEMENT ,22X, F6.3, /,
      6          18X, 14HCOST OF JOINTS, 30X, F6.3)
 3150 FORMAT   (18X,16HCOST OF TIE BARS, 28X, F6.3, /)
 3160 FORMAT   (15X, 31HTOTAL INITIAL CONSTRUCTION COST,  16X, F6.3, /,
      1          15X, 31HTOTAL OVERLAY CONSTRUCTION COST,  16X, F6.3, /,
      2          15X, 39HTOTAL T.D. COST DURING OV. CONSTRUCTION, 08X,
      3          F6.3, /, 15X, 22HTOTAL MAINTENANCE COST,  25X, F6.3)
 3170 FORMAT  (15X, 43HTOTAL SEAL COAT COST AFTER OV. CONSTRUCTION, 4X,
      1         F6.3)
 3180 FORMAT  (15X, 15HSALVAGE RETURNS, 32X, F6.3)
 3190 FORMAT  (15X, 29HANY ADDITIONAL COST SPECIFIED, 18X, F6.3)
 3200 FORMAT  (/, 14X, 18HTOTAL OVERALL COST, 30X, F6.3, //,10X,
      1         15HDESIGN ANALYSIS, /, 13X,  5HTOTAL, I4, 12H INITIAL DES
      2         , 33HIGNS WERE EXAMINED, OUT OF WHICH,, /, 18X, I4,
      3         45H DESIGNS WERE REJECTED DUE TO USER RESTRAINTS, /, 18X,
      4         I4, 36H REMAINING INITIAL DESIGNS PRODUCED, 2X, I3,
      5         19H OVERLAY STRATEGIES)
 3210  FORMAT (/, 15X, 45HMOST ECONOMICAL INITIAL DESIGN LASTING THE AN,
      1         13HALYSIS PERIOD, //, 13X, 17HPAVEMENT TYPE IS , A3, //,
      2         54X,  8HMATERIAL, /, 55X,  6HNUMBER, /, 13X,  8HCONCRETE,
      3         4X, F8.2,  7H INCHES, 18X, I1, /, 13X,  7HSUBBASE, 5X,
      4         F8.2,  7H INCHES, 18X, I1 )
 3220 FORMAT  (//, 13X, 22HLIFE OF THE DESIGN IS , F7.3,  6H YEARS)
 3230 FORMAT  (15X, 31HTOTAL INITIAL CONSTRUCTION COST, 16X, F6.3, /,
      1         15X, 22HTOTAL MAINTENANCE COST, 25X, F6.3 )
 3240 FORMAT  (/, 14X, 18HTOTAL OVERALL COST, 30X, F6.3, //, 10X,
      1         15HDESIGN ANALYSIS, /, 20X,25HTHIS IS THE MOST OPTIMAL ,
      2         06HDESIGN, /, 20X,  7HOUT OF , I4, 19H ACCEPTABLE DESIGNS
      3         , /, 20X, 12HOF THIS KIND)
 3250 FORMAT  (//, 21X, 42HSUMMARY OF DESIGNS IN INCREASING ORDER OF ,
      1         10HTOTAL COST, //, 12X, 13HDESIGN NUMBER, 12X, 6I8)
 3260 FORMAT  (12X, 73A1)
 3270 FORMAT  (12X, 13HPAVEMENT TYPE, 12X, 6(5X,A3))
 3280 FORMAT  (12X, 13HOVERLAY  TYPE, 12X, 6(4X,A4))
 3290 FORMAT  (12X, 18HREINFORCEMENT TYPE, 7X, 6(4X, A4))
 3300 FORMAT  (/, 12X, 13HCONCRETE TYPE, 12X, 6I8)
 3310 FORMAT  (12X, 13HSUBBASE  TYPE,12X, 6I8)
 3320 FORMAT  (/, 12X, 14HSLAB THICKNESS, 11X, 6F8.2)
 3330 FORMAT  (12X,  17HSUBBASE THICKNESS, 8X, 6F8.2)
 3340 FORMAT  (12X, 18HOVERLAY + LEVEL UP, I2 )
 3350 FORMAT  (1H+, 36X, F8.2)
 3360 FORMAT  (1H+, 44X, F8.2)
 3370 FORMAT  (1H+, 52X, F8.2)
 3380 FORMAT  (1H+, 60X, F8.2)
 3390 FORMAT  (1H+, 68X, F8.2)
 3400 FORMAT  (1H+, 74X, F8.2)
 3410 FORMAT  (/, 12X, 12HINITIAL LIFE, 13X, 6F8.2)
 3420 FORMAT  (10X)
 3430 FORMAT  (12X,16HPERFORMANCE LIFE ,  I2)
 3440 FORMAT  (/, 12X, 22HTOTAL PERFORMANCE LIFE, 3X, 6F8.2)
 3450 FORMAT  (//, 12X, 21HSPACING TRANS. JOINTS, 4X, 6F8.2)
 3460 FORMAT  ( 12X, 20HSPACING LONG. JOINTS, 5X, 6F8.2)
 3470 FORMAT  (/, 12X, 25HCOST OF SUBG. PREPARATION, 6F8.3)
 3480 FORMAT  (12X, 16HCOST OF CONCRETE, 9X, 6F8.3)
 3490 FORMAT  (12X, 15HCOST OF SUBBASE, 10X, 6F8.3)
 3500 FORMAT  (12X, 21HCOST OF REINFORCEMENT, 4X, 6F8.3)
 3510 FORMAT  (12X, 14HCOST OF JOINTS, 11X, 6F8.3)
 3520 FORMAT  (12X, 16HCOST OF TIE BARS, 9X, 6F8.3)
 3530 FORMAT  (/, 12X, 19HINITIAL CONST. COST, 6X, 6F8.3)
 3540 FORMAT  (12X, 19HOVERLAY CONST. COST, 6X, 6F8.3)
 3550 FORMAT  (12X,18HTRAFFIC DELAY COST, 7X, 6F8.3)
 3560 FORMAT  (12X, 16HMAINTENANCE COST, 9X, 6F8.3)
 3570 FORMAT  (12X, 15HSALVAGE RETURNS, 10X, 6F8.3)
 3590 FORMAT  (12X, 19HANY ADDITIONAL COST, 6X, 6F8.3)
 3600 FORMAT  (12X, 22HTOTAL COST PER SQ YARD, 3X, 6F8.3)
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3610 FORMAT  (/, 36X, 20HREINFORCEMENT DESIGN, /, 13X, 06HDESIGN, 05X,
    1         25HREINFORCEMENT DESCRIPTION, 17X, 18HMATERIAL  MATERIAL,
    2         /, 13X,  6HNUMBER, 48X, 15HNUMBER      NAME, /)
3620 FORMAT  (/, 14X, I2)
3630 FORMAT  (1H+, 18X, 23HLONG. REINF.     BAR NO., 4F6.0)
3640 FORMAT  (1H+, 62X, I1, 4X, 2A4, A2)
3650 FORMAT  (35X,  7HSPACING, 4F6.1)
3660 FORMAT  (19X, 23HTRAN. REINF.     BAR NO., 4F6.0)
3670 FORMAT  (19X,  8HTIE BARS, 5X, 10HBAR NUMBER, 4F6.0)
3680 FORMAT  (1H+, 18X, 23HLONG.REINF.MESH SPACING, 4F6.1)
3690 FORMAT  (29X, 13HMESH DIAMETER, 4F6.2)
3700 FORMAT  (19X, 23HTRAN.REINF.MESH SPACING, 4F6.1)
3750 FORMAT  (4(/), 33X, 23HINITIAL DESIGN ANALYSIS, //, 17X,
     1        17HOUT OF A TOTAL OF, I5, 26H INITIAL POSSIBLE DESIGNS,,
     2        /, 23X, I4, 42H WERE REJECTED DUE TO MAX. INITIAL THICKNE
     3        12HSS RESTRAINT, /, 17X,  6HOUT OF, I4, 14H DESIGNS THUS
     4        ,4HLEFT, /, 23X, I4, 29H DESIGNS WERE REJECTED SINCE ,
     5        23HTHEY ARE OVERDESIGNS OF, /, 27X, 14HINITIAL DESIGN
     6        32HS WHICH LAST THE ANALYSIS PERIOD, /, 17X,  6HOUT OF,
     7        I4, 19H DESIGNS THUS LEFT.,/, 23X, I4, 14H DESIGNS WERE ,
     7        39HREJECTED DUE  TO THEIR LIVES BEING LESS, /,  27X,
     8        53HTHAN THE MINIMUM ALLOWABLE TIME  TO THE FIRST OVERLAY,
     9        /, 17X,  6HOUT OF, I4, 19H DESIGNS THUS LEFT.,/, 23X, I4,
     1        54H DESIGNS WERE REJECTED DUE TO THE RESTRAINT OF MAXIMUM
     2        , /, 27X, 23HINITIAL FUNDS AVAILABLE, /, 17X,  6HOUT OF,
     3        I4, 19H DESIGNS THUS LEFT.,/, 23X, I4, 14H DESIGNS WERE ,
     4        38HACCEPTABLE  INITIAL DESIGNS WITH LIVES, /, 27X,
     5        29HMORE THAN THE ANALYSIS PERIOD,  /, 17X,  8HAND THUS,
     6        3X, I4, 45H DESIGNS WERE PASSED TO THE OVERLAY SUBSYSTEM,
     7        04H  TO, /, 32X, 31HFORMULATE THE POSSIBLE OVERLAY ,
     8        10HSTRATEGIES)
3760 FORMAT  (3(/), 32X, 26HOVERLAY SUBSYSTEM ANALYSIS, //, 10X,
     1        25HDESIGN COMBINATION NUMBER, 26X, 4I5)
3770 FORMAT  (/, 10X, 45HNUMBER WHEN MAX. OV. THICKNESS RESTRAINT WAS ,
     1        3HHIT, 3X, 4I5)
3780 FORMAT  (10X, 49HNUMBER WHEN MIN TIME BETWEEN OV RESTRAINT WAS HIT
     1        , 2X, 4I5)
3790 FORMAT  (10X, 48HNUMBER WHEN OVERLAYS NEEDED WERE MORE THAN EIGHT,
     1        3X, 4I5)
3800 FORMAT  (10X, 48HNUMBER OF TIMES  SUBROUTINE * AGE *  WAS  CALLED,
     1        3X, 4I5)
3810 FORMAT  (10X, 48HNUMBER OF TIMES  SUBROUTINE *MANCE*  WAS  CALLED,
     1        3X, 4I5)
3820 FORMAT  (10X, 48HNUMBER OF TIMES  SUBROUTINE * TDC *  WAS  CALLED,
     1        3X, 4I5)
3830 FORMAT  (10X, 48HNUMBER OF  POSSIBLE OVERLAY STRATEGIES  OBTAINED,
     1        3X, 4I5)
3831 FORMAT  (10X, 30HNUMBER OF OVERDESIGNS OBTAINED, 21X, 4I5)
3840 FORMAT  (/, 10X, 17HOUT OF A TOTAL OF, 34X, 4I5)
3850 FORMAT  (3(/), 21X, 33HTHUS FOR THE ENTIRE DESIGN SYSTEM, /,
     1        21X, 26HOUT OF AN OVERALL TOTAL OF, I6,  9H OVERLAY ,
     2        10HSTRATEGIES, /, 25X, I5, 22H WERE REJECTED DUE TO ,
     3        20HDIFFERENT RESTRAINTS, /, 21X,  4HAND , I5,
     4        42H WERE CONSIDERED FOR  OPTIMIZATION PROCESS)
  10 RETURN
     END
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THE AUTHORS

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B. Frank McCullough is an Associate Professor of Civil Engineering at The University of Texas at Austin. He has strong interests in pavements and pavement design and has developed design methods for continuously reinforced concrete pavements currently used by the Texas Highway Department, U. S. Steel Corporation, and others. During nine years with the Texas Highway Department he was active in a variety of research and design activities. He participates in many national committees and is chairman of the Rigid Pavement Design Committee of the Transportation Research Board.