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16. Abstract

This report supplies the instructions necessary for the use of computer program RPS2. This program is one of a continuing set of programs of the Rigid Pavement Design System developed by Research Project 123. The program uses over 100 input variables to generate a set of rigid pavement design strategies. The program optimizes these strategies on a cost per square yard basis and outputs the most economical strategies in order of increasing cost up to a total of 23 available designs. This report provides a complete input guide for the program, a sample input and output, and a discussion of common errors which occur in the program's use.

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RIGID PAVEMENT DESIGN SYSTEM
INPUT GUIDE
FOR COMPUTER PROGRAM RPS2

by

Robert F. Carmichael
B. F. McCullough

Research Report 123-21

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

Highway Design Division
Texas Highway Department

Texas Transportation Institute
Texas A&M University

Center for Highway Research
The University of Texas at Austin

May 1974

PREFACE

This report is an interim step in the ultimate goal of providing a detailed User's Manual for the Rigid Pavement Design System. This report contains an Input Guide for Program RPS2 and will help to document completely RPS2 usage. It will also serve as an implementation report for anyone desiring to use RPS2.

A newer version of Rigid Pavement System, RPS3, is in the development stages and will be documented by a more complete report which will in essence be a User's Manual with complete instructions to the designer

Robert F. Carmichael
B. F. McCullough

May 1974

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 Users 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.

ABSTRACT

This report supplies the instructions necessary for the use of computer program RPS2. This program is one of a continuing set of programs of the Rigid Pavement Design System developed by Research Project 123. The program uses over 100 input variables to generate a set of rigid pavement design strategies. The program optimizes these strategies on a cost per square yard basis and outputs the most economical strategies in order of increasing cost up to a total of 23 available designs. This report provides a complete input guide for the program, a sample input and output, and a discussion of common errors which occur in the program's use.

KEY WORDS: Input Guide, User's Manual, rigid pavement, design system, user errors.

SUMMARY

This report has provided for the user one of the most complete input guides to date for a Rigid Pavement Design System program. The input guide clearly indicates to the user all the options available and attempts to steer the user away from making erroneous inputs. The report has also included samples of typical input coding sheets and the computer output obtained from these inputs. The program also documents the types of errors most frequently made by users and discusses how these errors may be corrected.

The input guide is very straight forward and should be easily used.

The report finally preserves intact and documents one of the programs in the development chain of the programs designed for a better Rigid Pavement Design System.

IMPLEMENTATION

This research report should be implemented as soon as possible to allow Texas Highway Department personnel time to familiarize themselves with the program. The modified version of RPS and RPS3 will be implemented on a formal basis and the input guide used will be very similar to the input guide included in this report. A familiarity with this report would make the implementation of RPS3 easier and more simplified.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

This report is an interim step in an overall effort to implement the Rigid Pavement Design System into use by personnel of the Texas Highway Department. Background reports directly relating to this report are

(1) 123-1, "A Systems Approach Applied to Pavement Design and Research,"

(2) 123-2, "A Recommended Texas Highway Department Pavement Design System User's Manual,"

(3) 123-5, "A Systems Analysis of Rigid Pavement Design," and

(4) 32-11, "A Systems Approach to the Flexible Pavement Design Problem."

Basically, the report serves as a final documentation of Rigid Pavement Design System computer program RPS2. The report contains a complete input guide, including all variables and their units, certain recommendations to the user on determination of input variable values, and comments for use of Program RPS2. Also included in the report are the coding sheets for a sample problem, the output from the sample problem, and a discussion of the most common errors made by users.

Computer program RPS1 was modified into IBM language for the Texas Highway Department Design Division. It was later replaced by RPS2 which is currently in use by Texas Highway Department and the Center for Highway Research. Changes made to RPS1 to develop RPS2 have been outlined to the Texas Highway Department. To provide a better understanding of theoretical models and their development, Research Report 123-5 completely documents the development of program RPS1, the initial Rigid Pavement Design System program.

CHAPTER 2. OBJECTIVES AND APPROACH

The objective of this report is to provide the Texas Highway Department and other users with a simple input guide to use until the next version of RPS, RPS3, can be completed. In the interim time while improvements are being made on the current RPS2 program, this input guide will provide for the implementation of the Rigid Pavement System to continue. This approach was adopted for three basic reasons.

(1) The modifications which are being made upon the system will take a considerable amount of time to complete and it was felt that during this modification, the Texas Highway Department designers could use this input guide to continue implementation of the system.

(2) The information available on RPS2 was not completely documented and it was decided that RPS2 should be left as a separate program in the building block process of obtaining Rigid Pavement Design systems.

(3) The use of this input guide would produce feedback so that the input guide for the modified program, RPS3, could be made easier to use based upon the descrepancies discovered in this interim guide.

The approach utilized, was to make a card by card input guide using the input guide for RPS1 as a reference and supplementing it with the new characteristics of RPS2. All units were added for the variables. The program was then run to design a hypothetical pavement and 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 true sense, this input guide is more rudimentary and simplistic than the "User's Manual" to be prepared in conjunction with the new rigid pavement system program. Later efforts will be directed at making the design system program more modular, at characterizing the input information, changing models to more adequately describe specific design features, and final implementation of the Rigid Pavement Design System.

Before the publication of the User's Manual for the RPS3 program version, more variable limits will be established. A final User's Manual with all necessary value ranges for variables and more detailed explanation is the ultimate goal of the work. The main objective of this report is, therefore, the formulation of a stepping-stone toward the final User's Manual.

CHAPTER 3. GENERAL CODING INSTRUCTIONS

Coding instructions presented in this chapter are for the Rigid Pavement Design System program RPS2, currently in use by the Design Division of the Texas Highway Department. Included with the basic format information for coding problems are general statements which attempt to guide the program user and some limited suggestions on certain input variable values. A summary of some of the most common errors made by users is also provided and will document the nature of these errors, and how they may be corrected. The input guide has been used by various persons unfamiliar with the program to ascertain their objections and problems. In this fashion, the input guide has been tested for its clarity.

GENERAL STATEMENT ON INPUT GUIDE USE

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 1 shows the arrangement of the data cards. As Fig 1 indicates, 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 upon the cards symbolize where the decimal is to be punched. If there is no decimal point, then the user is directed on how to input the number.

When entering material properties in the program, expected values should be used, not values with factors of safety added. The program takes care of this 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 .

On the subgrade and subbase cards, the user has the option of indicating either k-value or Texas Triaxial Class Value. If only one of the values is

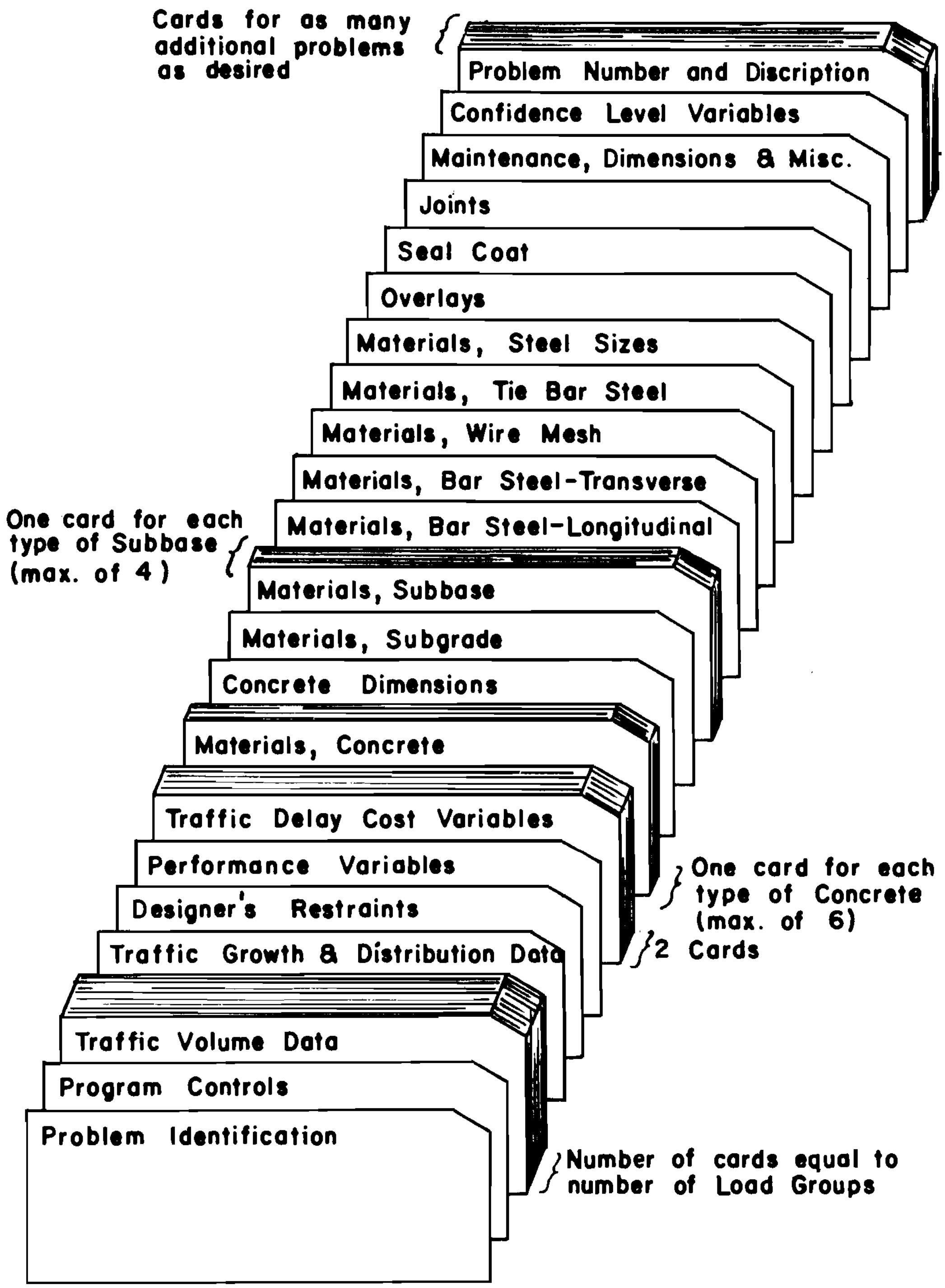


Fig 1. Assembly order for RPS2 data.

input into the program, then the other is not necessary and may 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, so for example, he should not input the concrete overlay parameters when he has called for asphalt overlays only to be designed. It is advisable therefore, to roughly plan the facility to be designed and then to list the necessary data inputs on paper before proceeding with the computer input.

INPUT GUIDE

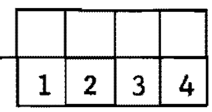
The following section is the input guide to be used with program RPS2. If any problems are encountered, it will be helpful to examine the sample problem included in Chapter 4 and the summary of common errors included in this chapter. The sample problem is helpful as a practice run before actual use of the program for design and the error summary gives examples which will help the user diagnose his errors.

TEXAS HIGHWAY DEPARTMENT

RIGID PAVEMENT DESIGN SYSTEM

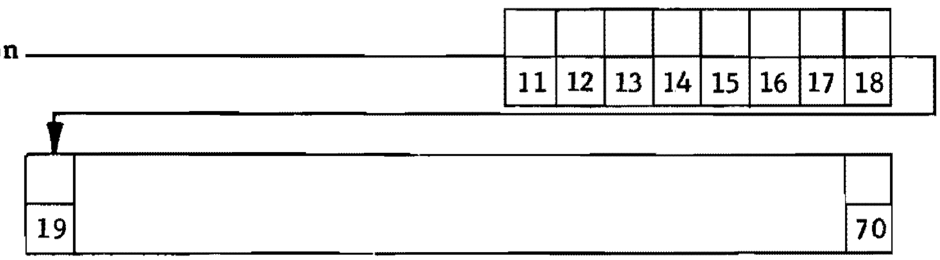
PROBLEM IDENTIFICATION
CARD NO. 1

1.1 Problem Number



(Any combination of letters and/or numbers)

1.2 Problem Description



(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 Form of Traffic Data Input ______ [60]

= 1 if input is two-directional 18-kip equivalent single axle wheel loads for the analysis period

= blank if load groups to be input

2.6 Number of Designs for the Output (< 24) ______ [78 79 80 •]

= blank for twelve designs (six per page)

TRAFFIC VOLUME DATA

CARD(S) NO. 3

(Use these card(s) only when input 2.5 is blank)

3.1 Number of Load Groups

1	2	3	4	5	6	7	8	9	10

(Place last digit of number in column 10)

Include this input only on the first card*

3.2 Range of Axle Loads

Lower value in pounds

11	12	13	14	15	16	17	18	19	20

(Place last digit of number in column 20)

Upper value in pounds

21	22	23	24	25	26	27	28	29	30

(Place last digit of number in column 30)

3.3 Axle Code

	●
39	40

= 1 indicates single axle inputs

= 2 indicates tandem axle inputs

3.4 Number of Axles in Specified Range in Both Directions Per Day

41	42	43	44	45	46	47	48	49	50

(Place last digit of number in column 50)

* An additional card including only items 3.2 through 3.4 should be added for each load range group (one card for each load range).

TRAFFIC GROWTH AND DISTRIBUTION DATA
CARD NO. 4

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

							•		
1	2	3	4	5	6	7	8	9	10

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

							•		
11	12	13	14	15	16	17	18	19	20

4.3 Directional Distribution Factor (percent)

							•		
31	32	33	34	35	36	37	38	39	40

4.4 Lane Distribution Factor (percent)

							•		
41	42	43	44	45	46	47	48	49	50

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

							•		
61	62	63	64	65	66	67	68	69	70

4.6 Total 18-kip Axles for Analysis Period in Both Directions

									•
71	72	73	74	75	76	77	78	79	80

(Include this input only if 2.5 is equal to 1)

* The initial ADT expected in one direction should not be large enough so as to exceed the practical capacity of 1500 veh/hr/lane.

DESIGNER'S RESTRAINTS
CARD NO. 5

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

							•		
1	2	3	4	5	6	7	8	9	10

5.2 Maximum Allowable Thickness, Slab Plus Subbase (inches)

							•		
11	12	13	14	15	16	17	18	19	20

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

							•		
21	22	23	24	25	26	27	28	29	30

5.4* Minimum Allowable Time Between Overlays (years)

							•		
31	32	33	34	35	36	37	38	39	40

5.5* Maximum Total Asphalt Concrete Overlay Thickness (inches)

			•	
41	42	43	44	45

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

			•	
46	47	48	49	50

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

			•	
51	52	53	54	55

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

			•	
56	57	58	59	60

5.9 Length of Analysis Period (years)

							•		
61	62	63	64	65	66	67	68	69	70

* See explanation following completion of this card.

5.10** Average Level Up Thickness (inches) ______ [•] 71 72 73 74 75

5.11 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. 5

5.3-5.8* Overlay Inputs

If no overlay is planned for the facility 5.3 should be (at least) equal to the analysis period while items 5.4, 5.5, 5.6, 5.7, and 5.8 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.

5.10** 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. 6

6.1 Initial Serviceability Index (expected)

							●		
1	2	3	4	5	6	7	8	9	10

6.2 Terminal Serviceability Index (accepted)

							●		
11	12	13	14	15	16	17	18	19	20

6.3 Serviceability Index After an Overlay (expected)

							●		
21	22	23	24	25	26	27	28	29	30

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

							●		
31	32	33	34	35	36	37	38	39	40

6.5** Swelling Rate Constant

							●		
41	42	43	44	45	46	47	48	49	50

6.6*** 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. 6

6.4* 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.

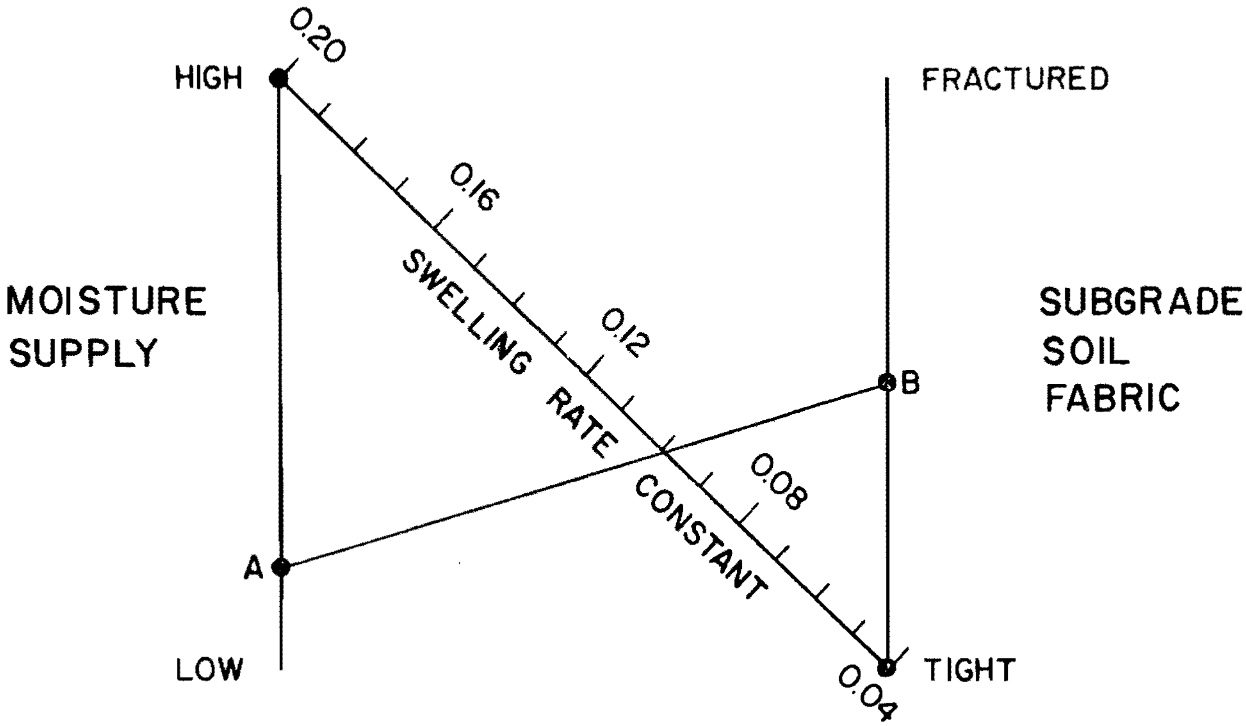
6.5** Swelling Rate Constant

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 6.1 gives a method of selecting this input based upon the judgement of the designer of local soil and moisture conditions.

Figure 6.2 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.

The designer should also give consideration to future modifications or construction practices to be used which might lower both variable 6.4 and 6.5. Encapsulated embankments, drainage systems, ponding techniques, or other



NOTES: (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 6.1. Nomograph for selecting swelling rate constant.

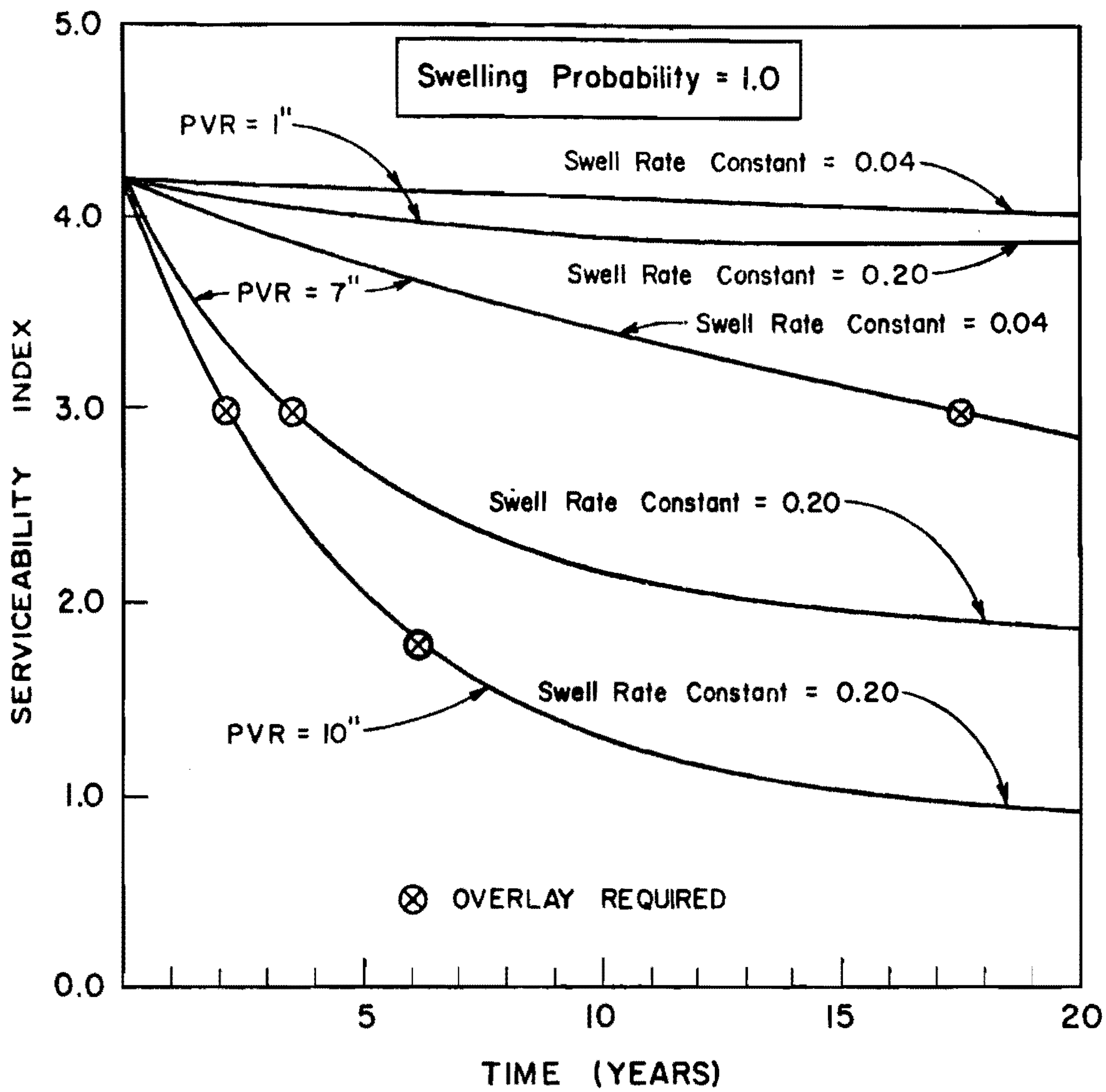


Fig 6.2. Performance curves illustrating serviceability loss not caused by traffic.

subgrade treatment techniques would reduce the swelling rate constant or swelling probability. These methods would at least delay the swelling soil problems.

6.6*** 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. PVR can either be estimated in a particular locality from the total amount of differntial 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 swelling rate constant which was discussed in the previous section. Figure 6.3 provides a multiplier (ratio) to apply to the original PVR if the swelling rate constant and age of an existing road are known.

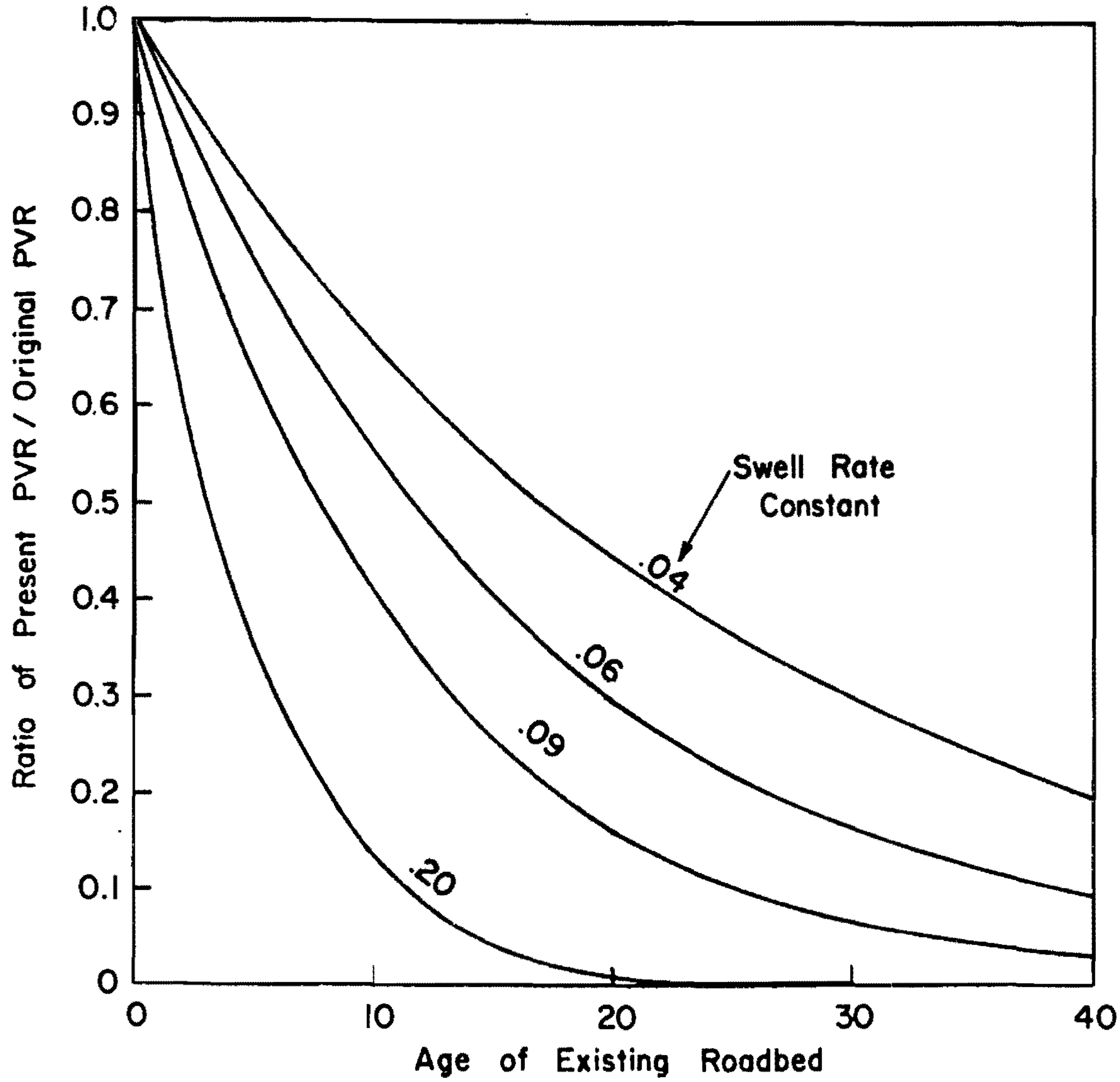


Fig 6.3. Chart for estimating PVR for an existing road.

TRAFFIC DELAY COST VARIABLES
CARD NO. 7A

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

							•		
1	2	3	4	5	6	7	8	9	10

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

							•		
11	12	13	14	15	16	17	18	19	20

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

							•		
21	22	23	24	25	26	27	28	29	30

7.4 Percent of ADT Arriving Each Hour of Construction

							•		
31	32	33	34	35	36	37	38	39	40

7.5 Number of Hours Per Day that Overlay Construction Takes Place

							•		
41	42	43	44	45	46	47	48	49	50

7.6* Number of Open Lanes in Restricted Zone in Overlay Direction [55]

7.7* Number of Open Lanes in Restricted Zone in Non-Overlay Direction [60]

7.8 Type of Road [80]

= 1 indicates rural roads

= 2 indicates urban roads

* See item 7.16 before filling in these values.

TRAFFIC DELAY COST VARIABLES
CARD NO. 7B

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

							•		
1	2	3	4	5	6	7	8	9	10

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

							•		
11	12	13	14	15	16	17	18	19	20

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

							•		
21	22	23	24	25	26	27	28	29	30

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

							•		
31	32	33	34	35	36	37	38	39	40

7.13 Average Approach Speed to Overlay Area (mph)

							•		
41	42	43	44	45	46	47	48	49	50

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

							•		
51	52	53	54	55	56	57	58	59	60

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

							•		
61	62	63	64	65	66	67	68	69	70

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

80

** See explanation on following page.

EXPLANATION OF SPECIFICALLY INDICATED TRAFFIC DELAY COST VARIABLES ON CARD NO. 7B

7.16** 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 7.3; 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 7.6 and 7.7; the Number of Open Lanes in Restricted Zone in Overlay Direction and Non-Overlay Direction respectively should neither be greater than three lanes.

The maximum speed which the program can handle is 60 mph. Also the product of Variable 7.4, Percent of ADT Arriving Each Hour of Construction; and Variable 7.5; Number of Hours Per Day that Overlay Construction takes Place; must be less than 100.

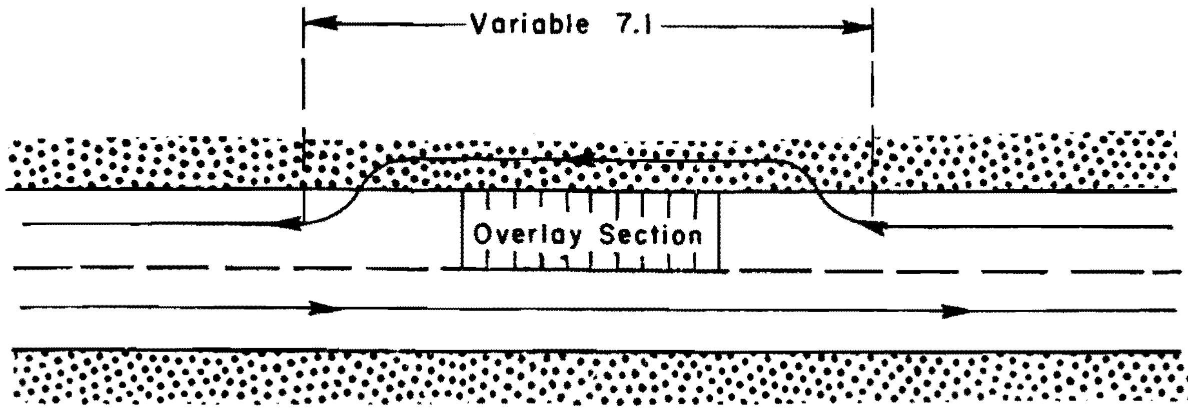


Fig 7.1. Detour model No. 1.

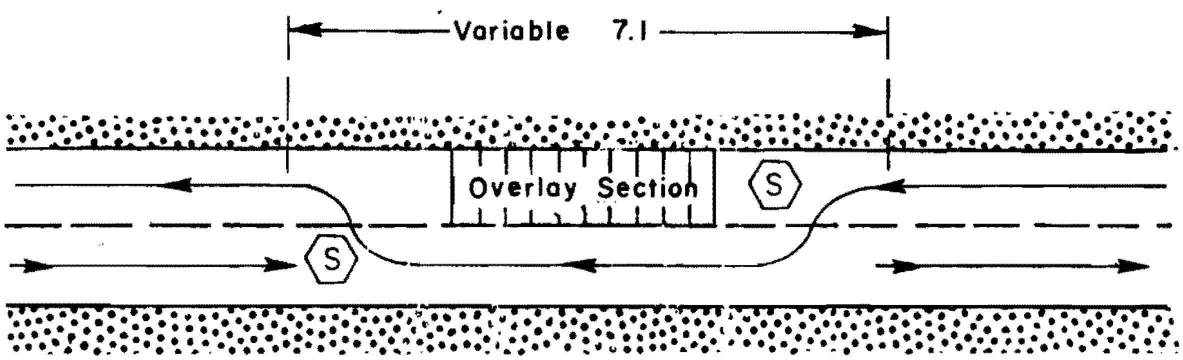


Fig 7.2. Detour model No. 2.

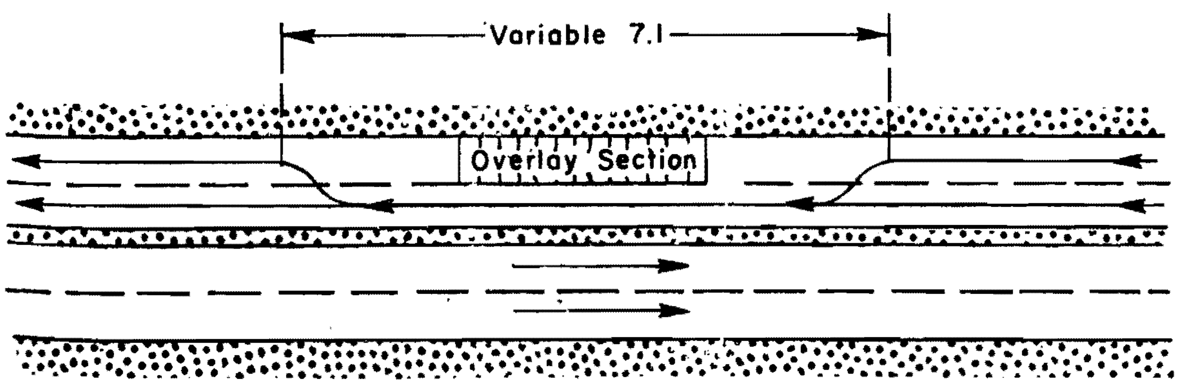


Fig 7.3. Detour model No. 3.

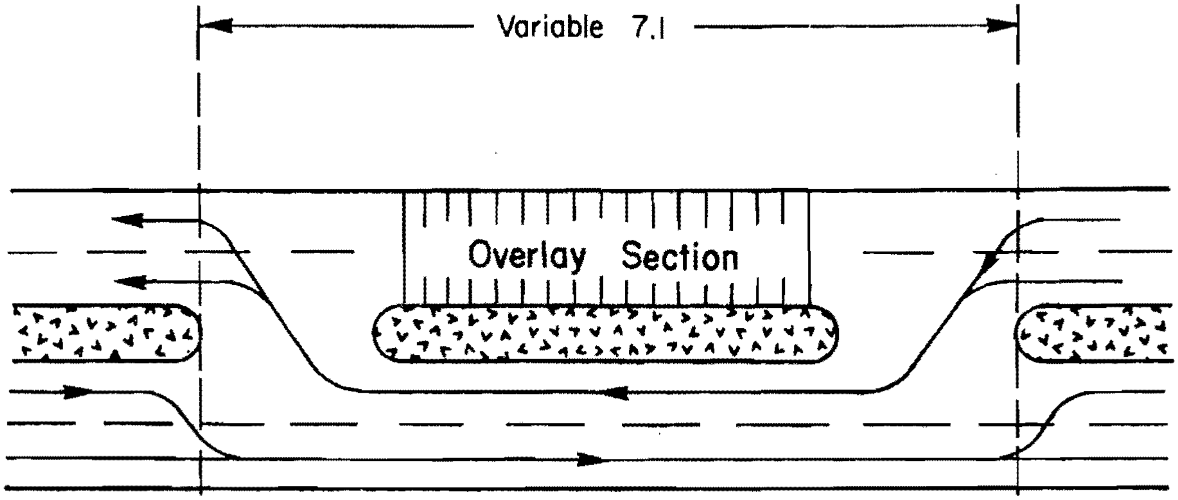


Fig 7.4. Detour model No. 4

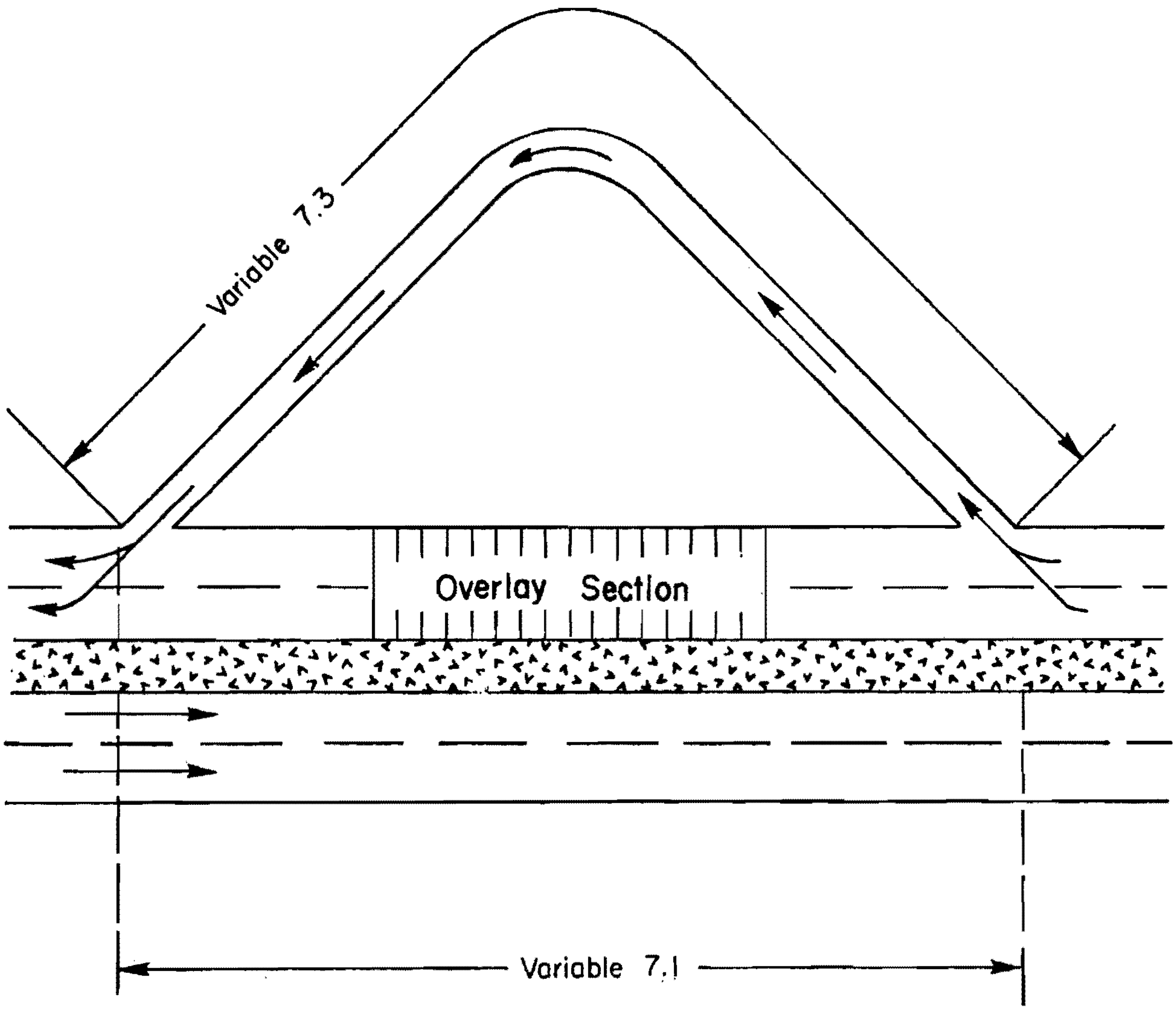


Fig 7.5. Detour model No. 5.

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 (Gross) (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.

*** See explanation on following page.

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

10.1* Subgrade k-value (pci)

The subgrade k-value is a "gross k" as defined in the AASHO Interim Guide. This variable is often referred to as a "modulus of subgrade reaction" and it is expressed as the pounds per square inch per inch of deflection or pounds per cubic inch modulus of the subgrade.

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 32, and the same estimation technique should be used for obtaining the subgrade erodability 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 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 factos 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.

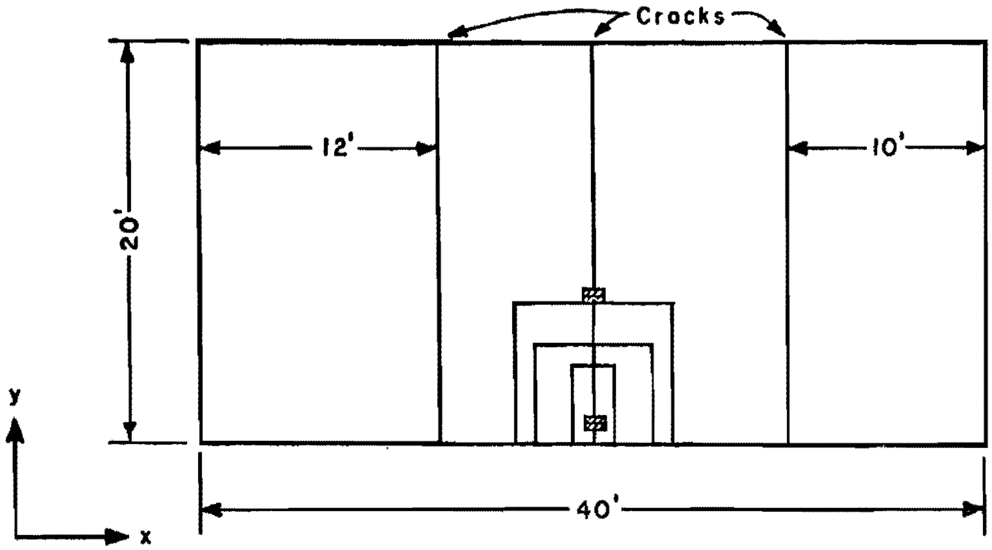
The erodability factor will approach the zero value or at least one if erosion is reduced by such design considerations as concrete shoulders, curb and gutter sections, high strength stabilized subbases, and rumble strips such as those utilized by the Houston Urban office of the Texas highway Department. The erodability factor described here is the same for both subbases and/or subgrade characterization.

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.



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

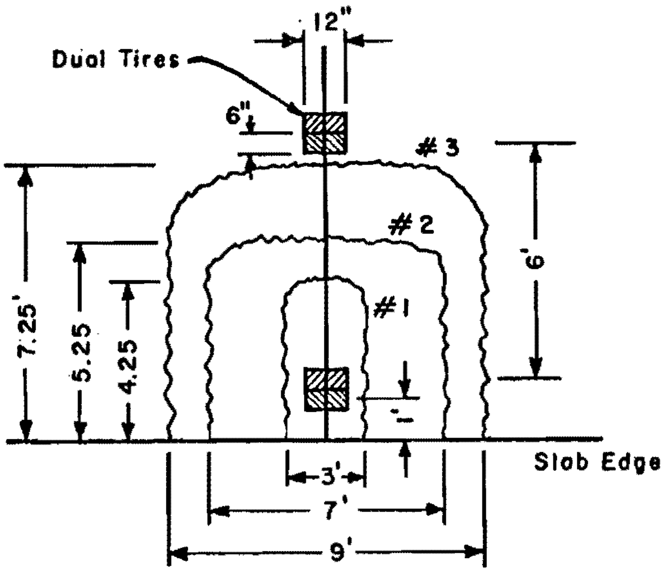
SLAB PROPERTIES

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
	0.0	0
# 1	1.6	1
# 2	4.6	2
# 3	8.2	3

+ Reduced to nearest tenth

Fig 11.1. Slab and support conditions for erodability analysis.

TABLE II.1

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

MATERIALS, BAR STEEL - <u>LONGITUDINAL</u>
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 - TRANSVERSE
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
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

SEAL COAT
CARD NO. 18

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

18.1 Minimum Time to First Seal Coat After an Asphalt Concrete Overlay (years)

							•		
1	2	3	4	5	6	7	8	9	10

18.2 Minimum Time Between Seal Coats (years)

							•		
11	12	13	14	15	16	17	18	19	20

18.3 Cost Per Lane Mile of a Seal Coat (dollars)

							•		
21	22	23	24	25	26	27	28	29	30

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
<u>20.4* Cost of Materials</u>

These variables may be specifically calculated using the procedure outlined by Highway Research Board 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

SUMMARY OF COMMON USER ERRORS

An effort is herewithin made to document the most common errors made by users of the Rigid Pavement Design System program RPS2 so that the user will be able to diagnose his 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 assoicated 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 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. This causes the program to give the type of output shown in Figs 2 and 3. The ADT, in one direction should not be large enough so as 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 give negative answers for the traffic delay cost as shown in Fig 2. Sometimes in combination with these negative results, the program will begin to print the type of erroneous output shown in Fig 3 with characteristic "BAN" message printed at the top of the design column. An example of how the problem arises is as follows:

Given ADT initial = 30,000 vehicle per day on direction

GF - ADT growth factor = 8 percent

PAPH - Percent of ADT arriving per hour of construction = 10 percent

TN = Time of overlay = 8 years

Model for overlay = 3

Number of open lanes in overlay direction = 2

Number of open lanes in nonoverlay direction = 3

```
RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER        JAN 1973
PROB    4      HOUSTON STUDY IH45 CAVELCADE - PATTON  RFC  10-2-73
```

SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER	1	2	3	4	5	6
PAVEMENT TYPE	JCP	JCP	CRC	CRC	JCP	CRC
OVERLAY TYPE	AC	AC	AC	AC	NONE	NONE
REINFORCEMENT TYPE	BARS	BARS	BARS	BARS	BARS	BARS
CONCRETE TYPE	1	1	1	1	1	1
SUBBASE TYPE	1	1	1	1	1	1
SLAB THICKNESS	9.00	9.50	7.00	7.50	10.00	8.00
SUBBASE THICKNESS	8.00	6.00	10.00	6.00	8.00	8.00
OVERLAY + LEVEL UP 1	3.00	3.00	3.00	3.00		
INITIAL LIFE	20.17	23.32	21.17	22.51	30.99	31.78
PERFORMANCE LIFE 1	35.68	40.34	39.18	40.04		
TOTAL PERFORMANCE LIFE	35.68	40.34	39.18	40.04	30.99	31.78
SPACING TRANS. JOINTS	30.00	30.00	R	R	30.00	R
SPACING LONG. JOINTS	12.00	12.00	12.00	12.00	12.00	12.00
COST OF SUBG. PREPARATION	.192	.192	.192	.192	.192	.192
COST OF CONCRETE	8.551	8.829	7.440	7.718	9.107	7.996
COST OF SUBBASE	.752	.585	.919	.585	.752	.752
COST OF REINFORCEMENT	1.672	1.765	5.762	6.174	1.858	6.586
COST OF JOINTS	.589	.589	.174	.174	.589	.174
COST OF TIE BARS	.161	.170	.125	.134	.179	.143
INITIAL CONST. COST	11.916	12.129	14.611	14.976	12.676	15.841
OVERLAY CONST. COST	.299	.242	.279	.255	0.000	0.000
TRAFFIC DELAY COST	-5.821	-4.542	-5.373	-4.838	0.000	0.000
MAINTENANCE COST	1.194	1.588	1.311	1.480	2.569	2.569
SALVAGE RETURNS	-.267	-.271	-.230	-.228	-.245	-.201
SEAL COAT COST	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL COST PER SQ YARD	7.322	9.146	10.599	11.646	15.000	18.209

Fig 2. Negative traffic delay cost error example.

```
RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER          JAN 1973
PROB  RFC      REFERENCE DESIGN DATA                  NOVEMBER 14, 1973

          SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER                       13      14      15      16      17      18
**********************************************************************************
PAVEMENT TYPE
OVERLAY  TYPE
REINFORCEMENT TYPE                 BAN     BAN     BAN     BAN     BAN     BAN

CONCRETE TYPE                        0       0       0       0       0       0
SUBBASE  TYPE                        0       0       0       0       0       0
**********************************************************************************

SLAB THICKNESS                    0.00    0.00    0.00    0.00    0.00    0.00
SUBBASE THICKNESS                 0.00    0.00    0.00    0.00    0.00    0.00

OVERLAY + LEVEL UP 1

INITIAL LIFE                      0.00    0.00    0.00    0.00    0.00    0.00

PERFORMANCE LIFE 1

TOTAL PERFORMANCE LIFE            0.00    0.00    0.00    0.00    0.00    0.00


SPACING TRANS. JOINTS             0.00    0.00    0.00    0.00    0.00    0.00
SPACING LONG. JOINTS             12.00   12.00   12.00   12.00   12.00   12.00
**********************************************************************************

COST OF SUBG. PREPARATION        0.000   0.000   0.000   0.000   0.000   0.000
COST OF CONCRETE                 0.000   0.000   0.000   0.000   0.000   0.000
COST OF SUBBASE                  0.000   0.000   0.000   0.000   0.000   0.000
COST OF REINFORCEMENT            0.000   0.000   0.000   0.000   0.000   0.000
COST OF JOINTS                   0.000   0.000   0.000   0.000   0.000   0.000
COST OF TIE BARS                 0.000   0.000   0.000   0.000   0.000   0.000

INITIAL CONST. COST              0.000   0.000   0.000   0.000   0.000   0.000
OVERLAY CONST. COST              0.000   0.000   0.000   0.000   0.000   0.000
TRAFFIC DELAY COST               0.000   0.000   0.000   0.000   0.000   0.000
MAINTENANCE COST                 0.000   0.000   0.000   0.000   0.000   0.000
SALVAGE RETURNS                  0.000   0.000   0.000   0.000   0.000   0.000
SEAL COAT COST                   0.000   0.000   0.000   0.000   0.000   0.000
ANY ADDITIONAL COST               .000    .000    .000    .000    .000    .000

**********************************************************************************
TOTAL COST PER SQ YARD           0.000   0.000   0.000   0.000   0.000   0.000
**********************************************************************************
```

Fig 3. "BAN" error caused by excessive traffic.

Assuming the program is trying to overlay the facility the VPH , vehicles per hour, is calculated as follows:

$$VPH = ADTT\ (PAPH)$$

where ADTT is the ADT at the time of the overlay calculated by the equation:

$$ADTT = ADT\ (1 + GF \times TN)$$

For the example ADTT = 49200 vehicles per day in one direction and therefore the VPS = 4920 vehicles arriving at the overlay per hour. Clearly if model 3 is used, this leaves only 2 lanes in the overlay direction open to carry this 4920 vehicles per hour or 2460 vehicles per hour per lane, which is clearly in violation of the 1500 vehicles per hour per lane capacity level. The user would not have realized the subtle error because the input of 30,000 vehicles per day in one direction is a reasonable amount of traffic for a three lane facility.

Therefore, when the user encounters an error of the type shown in Fig 2 or Fig 3, he should re-input the ADT, average daily traffic, PAH, percent of ADT arriving per hour of overlay construction, and GF, ADT growth rate. The TN variable is simply the initial life of each design and is not an input.

Errors caused by Decisions or Constraints

The inputs which reflect the designers 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 had chosen a confidence level of 80 percent which is less restrictive, then the program would have computed the strategies easier and 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 tell why the largest proportion of his 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 constraints, 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 design 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 dump on a fatal loader error of time limit. To correct this, the designer needs to put a number "1" in column five on the subbase information card and leave the remainder of the card blank. A correct output will look like Fig 4. The negative zeros shown on Fig 4 should not worry the user, they are acceptable and the output is correct.

Errors Caused by Overlay Variables

The RPS2 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

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
SEAL COAT COST	.047	.106	.116	0.000
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 4. Correct design of slab on subgrade.

Army Corp of Engineers concrete coefficient is the one main variable which causes errors. It has a minimum value limit of .35 and a maximum value limit of 1.0.

Errors Caused by Seal Coat Variables

The basic error caused by the seal coat data is if the card is excluded when there is an asphaltic-concrete overlay. The program will search for the information and will give a time limit error when unable to find it. The program will also fail to function if this card is included and the designer is using only portland cement-concrete overlays.

Errors Caused by Joint Information

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

CHAPTER 4. SAMPLE RPS2 PROBLEM

This chapter explains the sample problem coding sheets in Appendix 1, the computer output produced by this input in Appendix 2, and gives an interpretation of the meaning of the output.

The purpose of this information is to give the user a complete example of what the program input and output look like and to help familiarize the user with the program's use. The example is also helpful to the user as a reference guide for coding a problem and using the program.

CODING SHEETS

The coding sheets shown in Appendix 1 are all that is necessary for one complete problem. The hypothetical example problem is for a six-lane urban freeway. The example problem has allowed the program to design this project at a 95 percent confidence level for an analysis period of 20 years. The example uses all the different combinations; CRCP and JCP, PCC and AC overlays, deformed bar and wire mesh reinforcement, and more than one concrete type. Additional problems may be coded and placed together in one computer run. A blank card at the end of the last problem will terminate the program.

PROBLEM OUTPUT

The computer output produced by the analysis of a sample problem using the data as coded in Appendix 1 is shown in Appendix 2. First, the ouput prints the entire list of inputs with the exception of the confidence level variables which are not printed out until the very end of the output. Next, the most economical pavement of each combination is given. For example, in the sample problem, the most economical JCP, jointed concrete pavement with an AC, asphalt overlay, was printed out on a sheet by itself. The design lasted 5.032 years before an overlay and it had a performance life of 29.107 for the overall analysis period with two overlays. The total cost per cubic yard of this design is $10.12. Had the output been printed out in short form, This information would have been deleted and only the summary tables would have been printed. Appendix 2 is an example of the long form of output option which is available to the user.

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 number of designs listed is dependent upon the designer's input with a maximum number of 23. There are six designs per page with all the lives and costs printed out. Another page follows each of the design sheets with corresponding reinforcement designs and seal coat schedules.

The final page of the output is an analysis of the problem for the user. It gives the user information on why his designs were rejected. This is helpful to the designer so that he may change certain variables which have been unnecessarily restritive to the design or to analyze other variables. The sheet summaries rejects first in the initial design stage, then in the overlay design stage. The sheet also gives the total number of designs which were optimized to produce the number of economical outputs desired by the user. The set of numbers below the analysis table are the confidence level variables. They are in the same order as when they were input with the exception that the standard deviations of the flexural strength are printed out instead of the coefficients of variation for each concrete type.

It is common for the designer input the command for the design of both CRCP and JCP and have the program print only JCP or only CRCP in the summary list. This occurs because the program is only giving the 23 most economical designs, and these may only be one type of pavement.

The total cost of each design is per square yard and is a present worth value of all the initial and future costs. The design summary lists the pavement type, overlay type, reinforcement type, concrete type, subbase type, thicknesses, overlay schedule, and performance lives.

CHAPTER 5. SUMMARY AND IMPLEMENTATION

This report gives a formal input guide for the Rigid Pavement Design System program RPS2. In conjunction with this input guide, it also provides sample computer coding sheets and the output produced from a computer run. It cites the most common errors made by users of the RPS2 program, and explains how these errors may be corrected.

The feedback and comments concerning this input guide will be helpful in the formulation of later attempts at making RPS easier to use by the design personnel of the Texas Highway Department. This may well be the most important feature of the report. Also the documentation of the RPS2 program is important in that the program will be retained as an important stepping-stone in the overall attempt to implement a Rigid Pavement Design System. There are certain features of this particular program which future users may prefer to use instead of newer developments.

Finally, this input guide will be instrumental in allowing for the implementation to continue. Until the new version of RPS is developed and introduced to the Texas Highway Districts, this input guide will allow for the design engineers to become familiar with the Rigid Pavement Design System in general. The implementation of the program into other highway departments is also feasible with this formal input guide.

APPENDIX 1

COMPUTER CODING SHEETS OF A SAMPLE PROBLEM

IDENTIFICATION Coding Sheet RPS2 CODED BY (RFC) DATE May 15, 1974 PAGE 1 OF 2

```
CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT          RFC
                                                           1                  23
       2.0       3.0                50.0      60.0              35000. 40000000.
      16.0      24.0       5.0       5.0  6.0  2.0  6.0  2.0     20.     1.0   0
       4.3       3.0       4.2       .80       .14       7.0
       2.0       0.5       1.0       3.0       9.0    2    3                   2
       2.0       0.0       .01       0.0      60.0      40.0      55.0         3
    2 28 1500.            140.  3500000.300.   1000.        8.50    950.  60.
      28 1600.            145.  3750000.360.   1000.        9.00    950.  60.
                 8.0      12.0       1.0
    150.0                                                     .90 2.0    1500.
    2GRANULAR   1.0  1.5         30000.   2000.        2.5030.0  6.0 12.0  2.0
     ASPH. STAB 0.0  1.8        100000.   2000.        4.0045.0  6.0 12.0  2.0
A-615,GR6565000  .19A-609,GR6060000  .19
A-15GR40  33000  .17A-15GR40  35000  .18
ASTM,A-49770000  .18A-649     60000  .17
```

IDENTIFICATION Coding Sheet RPS2 CODED BY (R7C) DATE May 15, 1974 PAGE 2 OF 2

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80
A-615GR40		40000	.18												
3.	4.	5.		5.0	12.0	6.0	14.0	7.0	15.0	8.0	18.0	2.	3.	4.	
	1000.		10.0		40.		200000.		175.		40.0		1.0		3.00
	5.0		5.0		10.0										
	1.40		1.20				15.0		90.0		15.0		2		
	10.0		2.50		3.00		2.00		9.00				12.00		6
	20.0				20000.		20.0		0.0		0.3		0.3		0.3

APPENDIX 2

COMPUTER PROGRAM OUTPUT FROM SAMPLE PROBLEM

```
RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER        JAN 1973
PROB CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC
```

TRAFFIC GROWTH AND DISTRIBUTION

AXLE GROWTH	2.00
ADT GROWTH RATE	3.00
DIRECTIONAL DISTRIBUTION FACTOR	50.00
LANE DISTRIBUTION FACTOR	60.00
INITIAL AVERAGE DAILY TRAFFIC	35000.00
TOTAL 18 KIP AXLES FOR ANAYLSIS PERIOD	40000000

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

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	16.00
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	4.30
TERMINAL SERVICEABILITY INDEX	3.00
SERVICEABILITY INDEX AFTER AN OVERLAY	4.20
PROBABILITY OF CONJUNCTION OF BAD SOIL AND SITE	.80
EXPONENTIAL EXPONENT FOR SWELLING CLAY DETERIORATION	.14
SWELLING ACTIVITY, ESTIMATED DIFFERENTIAL MOVEMENT	7.00

TRAFFIC DELAY COST VARIABLES

DISTANCE OVER WHICH TRAFFIC IS SLOWED,	OV.DIRECTION	2.00
	N.OV.DIRECTION	.50
NO. OF OPEN LANES IN RESTRICTED ZONE,	OV.DIRECTION	2
	N.OV.DIRECTION	3
PERCENT VEHICLES STOPPED BY ROAD EQUIP,	OV.DIRECTION	2.00
	N.OV.DIRECTION	0.00
AVG DELAY CAUSED BY ROAD EQUIP, HOURS ,	OV.DIRECTION	.01
	N.OV.DIRECTION	0.00
AVG SPEED THROUGH OVERLAY ZONE, MPH ,	OV.DIRECTION	40.00
	N.OV.DIRECTION	55.00
AVERAGE APPROACH SPEED TO OVERLAY AREA		60.00
DETOUR DISTANCE AROUND OVERLAY ZONE		1.00
ADT ARRIVING EACH HOUR OF CONSTRUCTION		3.00
NO. OF HOURS/DAY OVERLAY CONSTRUCTION OCCURS		9.00
TRAFFIC MODEL USED IN THE ANALYSIS		3
ROAD LOCATION		URBAN

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

MATERIALS, CONCRETE

CONCRETE MIX DESIGN NUMBER	1	2
AGE OF TESTING CONCRETE	28	28
MEASURING POINT	CENTER	CENTER
FLEXURAL STRENGTH	500.00	600.00
TENSILE STRENGTH	300.00	360.00
ELASTIC MODULUS	3500000	3750000
WEIGHT	140.00	145.00
CONSTRUCTION EQUIPMENT COST	1000.00	1000.00
COST PER CUBIC YARD	8.50	9.00
COST OF SURFACING CONCRETE	950.00	950.00
SALVAGE PERCENT OF CONCRETE	60.00	60.00

MINIMUM ALLOWABLE CONCRETE THICKNESS	8.00
MAXIMUM ALLOWABLE CONCRETE THICKNESS	12.00
PRACTICAL INCREMENT FOR POURING CONCRETE	1.00

MATERIALS, STEEL

	1	2		
BARS				
LONGITUDINAL				
BAR STEEL ASTM DESIG	A-615,GR65	A-609,GR60		
TENSILE YIELD PT STR	65000.00	60000.00		
COST/LB OF BAR STEEL	.190	.190		
TRANSVERSE				
BAR STEEL ASTM DESIG	A-15GR40	A-15GR40		
TENSILE YIELD PT STR	33000.00	35000.00		
COST/LB OF BAR STEEL	.170	.180		
BAR NOS. TO BE TRIED	3	4	5	
WIRE MESHES				
WIRE MESH ASTM DESIG	ASTM,A-497	A-649		
TENSILE YIELD PT STR	70000.00	60000.00		
COST/LB OF WIRE MESH	.180	.170		
MESH SIZES TO BE TRIED				
LONG. WIRE SPACING	5.00	6.00	7.00	8.00
TRAN. WIRE SPACING	12.00	14.00	15.00	18.00
TIE BARS USED WITH W. MESH				
TIE BAR ASTM DESIG.	A-615GR40			
TENSILE YIELD PT STR	40000.00			
COST /LB OF TIE BARS	.180			
TIE BAR NOS TO BE TRIED	2	3	4	

```
 RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER        JAN 1973
PROB CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC
```

MATERIALS, SUBGRADE

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

MATERIALS, SUBBASE

SUBBASE TYPE	GRANULAR	ASPH. STAB
ERODABILITY FACTOR	1.00	0.00
FRICTION FACTOR	1.50	1.80
ELASTIC MODULUS	30000	100000
CONSTR EQUIPMENT COST	2000.00	2000.00
COST/COMPACTED CU YD	2.50	4.00
SALVAGE PERCENT VALUE	30.00	45.00
MIN ALLOWED THICKNESS	6.00	6.00
MAX ALLOWED THICKNESS	12.00	12.00
INCREMENT FOR SUBBASE	2.00	2.00

OVERLAY

INITIAL COST PER LANE MILE OF EQUIPMENT FOR OVERLAYS	1000.00
COST/CU YD OF IN PLACE COMPACTED ASPHALT CONCRETE	10.00
SALVAGE PERCENT VALUE OF ASPHALT CONCRETE	40.00
ASPHALT CONCRETE MODULUS VALUE	200000
PRODUCTION RATE OF COMPACTED ASPHALT CONCRETE	175.00
CONCRETE PRODUCTION RATE	40.00
CONCRETE COEFFICIENT	1.00
RANDOM ADDITIONAL COST/SQ YD FOR ANYTHING	3.00

SEAL COATS

TIME TO FIRST SEAL COAT AFTER AC OVERLAY	5.00
TIME BETWEEN SEAL COATS	5.00
COST PER LANE MILE OF A SEAL COAT	10.00

JOINTS

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

MAINTENANCE, DIMENSIONS AND MISCELLANEOUS

DAYS OF FREEZING TEMPERATURE PER YEAR	10.00
COMPOSITE LABOR WAGE FOR MAINTENANCE OPERATIONS	2.50
COMPOSITE EQUIPMENT RENTAL RATE FOR MAINT. OPERATION	3.00
COST OF MATERIALS FOR MAINTENANCE OPERATIONS	2.00
WIDTH OF EACH LANE	12.00
TOTAL NUMBER OF LANES IN BOTH DIRECTIONS	6
RATE OF INTEREST OR TIME VALUE OF MONEY	9.00

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RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER          JAN 1973
PROB CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC

   MOST ECONOMICAL JCP PAVEMENT DESIGN WITH  AC OVERLAY,

INITIAL CONSTRUCTION,   LIFE IS   5.032 YEARS

  MATERIALS                                                DESCRIPTION
                                                       MATERIAL    MATERIAL
                                                        NUMBER       NAME

  CONCRETE         12.00 INCHES                            2
  SUBBASE           6.00 INCHES                            2
  LONG.REINF.MESH SPACING   5.0    6.0    7.0    8.0       1       ASTM,A-497
            MESH DIAMETER   .20    .22    .24    .25
  TRAN.REINF.MESH SPACING  12.0   14.0   15.0   18.0       1       ASTM,A-497
            MESH DIAMETER   .34    .36    .38    .41
  TIE BARS      BAR NUMBER    2      3      4              1       A-615GR40
                   SPACING  3.8    8.5   15.0

            TRANSVERSE JOINT SPACING     30 FEET
            LONGITUDINAL JOINT SPACING   12 FEET


SUBSEQUENT CONSTRUCTION
  1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER   5.032 YEARS
  2  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER  13.547 YEARS

    EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

   TOTAL OVERLAY THICKNESS   4.00 INCHES    TOTAL LIFE  29.107 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
   INITIAL CONSTRUCTION
      COST OF SUBGRADE PREPARATION                       .213
      COST OF CONCRETE                                  3.277
      COST OF SUBBASE                                    .951
      COST OF REINFORCEMENT                              .904
      COST OF JOINTS                                    1.020
      COST OF TIE BARS                                   .060

   TOTAL INITIAL CONSTRUCTION COST                      6.425
   TOTAL OVERLAY CONSTRUCTION COST                       .936
   TOTAL T.D. COST DURING OV. CONSTRUCTION               .060
   TOTAL MAINTENANCE COST                                .156
   TOTAL SEAL COAT COST AFTER OV. CONSTRUCTION           .001
   SALVAGE RETURNS                                      -.454
   ANY ADDITIONAL COST SPECIFIED                        3.000

  TOTAL OVERALL COST                                   10.123

DESIGN ANALYSIS
  TOTAL  80 INITIAL DESIGNS WERE EXAMINED, OUT OF WHICH,
         76 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          4 REMAINING INITIAL DESIGNS PRODUCED   21 OVERLAY STRATEGIES
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RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER          JAN 1973
PROB CFHR       EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC

   MOST ECONOMICAL JCP PAVEMENT DESIGN WITH  CC OVERLAY,

INITIAL CONSTRUCTION,   LIFE IS   5.032 YEARS

   MATERIALS                                                   DESCRIPTION
                                                           MATERIAL    MATERIAL
                                                            NUMBER       NAME

   CONCRETE        12.00 INCHES                               2
   SUBBASE          6.00 INCHES                               2
   LONG.REINF.MESH SPACING   5.0    6.0    7.0    8.0         1      ASTM,A-497
             MESH DIAMETER   .20    .22    .24    .25
   TRAN.REINF.MESH SPACING  12.0   14.0   15.0   18.0         1      ASTM,A-497
             MESH DIAMETER   .34    .36    .38    .41
   TIE BARS      BAR NUMBER    2      3      4                1      A-615GR40
                    SPACING  3.8    8.5   15.0

               TRANSVERSE JOINT SPACING      30 FEET
               LONGITUDINAL JOINT SPACING    12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   CC AFTER   5.032 YEARS
   2  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   CC AFTER  13.973 YEARS

     EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

     TOTAL OVERLAY THICKNESS   4.00 INCHES    TOTAL LIFE  34.530 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
     INITIAL CONSTRUCTION
        COST OF SUBGRADE PREPARATION                      .213
        COST OF CONCRETE                                 3.277
        COST OF SUBBASE                                   .951
        COST OF REINFORCEMENT                             .904
        COST OF JOINTS                                   1.020
        COST OF TIE BARS                                  .060

     TOTAL INITIAL CONSTRUCTION COST                     6.425
     TOTAL OVERLAY CONSTRUCTION COST                      .974
     TOTAL T.D. COST DURING OV. CONSTRUCTION              .259
     TOTAL MAINTENANCE COST                               .165
     SALVAGE RETURNS                                     -.482
     ANY ADDITIONAL COST SPECIFIED                       3.000

    TOTAL OVERALL COST                                  10.341

DESIGN ANALYSIS
   TOTAL  80 INITIAL DESIGNS WERE EXAMINED, OUT OF WHICH,
          76 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
           4 REMAINING INITIAL DESIGNS PRODUCED   24 OVERLAY STRATEGIES
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RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER         JAN 1973
PROB CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC

   MOST ECONOMICAL CRC PAVEMENT DESIGN WITH  AC OVERLAY,

INITIAL CONSTRUCTION,   LIFE IS   5.324 YEARS

   MATERIALS                                                 DESCRIPTION
                                                         MATERIAL    MATERIAL
                                                          NUMBER       NAME

   CONCRETE        11.00 INCHES                             1
   SUBBASE          6.00 INCHES                             2
   LONG.REINF.MESH SPACING  5.0   6.0                        1       ASTM,A-497
             MESH DIAMETER  .61   .67
   TRAN.REINF.MESH SPACING 12.0  14.0  15.0  18.0           1       ASTM,A-497
             MESH DIAMETER  .32   .34   .36   .39
   TIE BARS     BAR NUMBER    2     3     4                 1       A-615GR40
                   SPACING  4.2   9.6  17.0

             TRANSVERSE JOINT SPACING      0 FEET
             LONGITUDINAL JOINT SPACING   12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER   5.324 YEARS
   2  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   AC AFTER  15.090 YEARS

    EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

    TOTAL OVERLAY THICKNESS   4.00 INCHES    TOTAL LIFE  33.998 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
    INITIAL CONSTRUCTION
       COST OF SUBGRADE PREPARATION                  .213
       COST OF CONCRETE                             2.874
       COST OF SUBBASE                               .951
       COST OF REINFORCEMENT                        4.345
       COST OF JOINTS                                .605
       COST OF TIE BARS                              .053

    TOTAL INITIAL CONSTRUCTION COST                 9.041
    TOTAL OVERLAY CONSTRUCTION COST                  .882
    TOTAL T.D. COST DURING OV. CONSTRUCTION          .057
    TOTAL MAINTENANCE COST                           .193
    TOTAL SEAL COAT COST AFTER OV. CONSTRUCTION      .001
    SALVAGE RETURNS                                 -.411
    ANY ADDITIONAL COST SPECIFIED                   3.000

   TOTAL OVERALL COST                              12.763

DESIGN ANALYSIS
   TOTAL  80 INITIAL DESIGNS WERE EXAMINED, OUT OF WHICH,
          48 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          32 REMAINING INITIAL DESIGNS PRODUCED  103 OVERLAY STRATEGIES
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 RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER         JAN 1973
 PROB CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC

    MOST ECONOMICAL CRC PAVEMENT DESIGN WITH  CC OVERLAY,

INITIAL CONSTRUCTION,   LIFE IS   5.324 YEARS

   MATERIALS                                                   DESCRIPTION
                                                          MATERIAL    MATERIAL
                                                           NUMBER       NAME

   CONCRETE        11.00 INCHES                              1
   SUBBASE          6.00 INCHES                              2
   LONG.REINF.MESH SPACING   5.0    6.0                      1       ASTM,A-497
            MESH DIAMETER   .61    .67
   TRAN.REINF.MESH SPACING  12.0   14.0   15.0   18.0        1       ASTM,A-497
            MESH DIAMETER   .32    .34    .36    .39
   TIE BARS      BAR NUMBER   2      3      4                1       A-615GR40
                    SPACING  4.2    9.6   17.0

               TRANSVERSE JOINT SPACING      0 FEET
               LONGITUDINAL JOINT SPACING   12 FEET


SUBSEQUENT CONSTRUCTION
   1  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   CC AFTER   5.324 YEARS
   2  OVERLAY AND LEVEL UP WITH  3.00 INCHES OF   CC AFTER  15.736 YEARS

     EVERY OVERLAY INCLUDES 1.00 INCHES OF LEVEL UP

    TOTAL OVERLAY THICKNESS   4.00 INCHES    TOTAL LIFE  42.030 YEARS


COST ANALYSIS   DOLLARS PER SQUARE YARD
    INITIAL CONSTRUCTION
       COST OF SUBGRADE PREPARATION                        .213
       COST OF CONCRETE                                   2.874
       COST OF SUBBASE                                     .951
       COST OF REINFORCEMENT                              4.345
       COST OF JOINTS                                      .605
       COST OF TIE BARS                                    .053

    TOTAL INITIAL CONSTRUCTION COST                       9.041
    TOTAL OVERLAY CONSTRUCTION COST                        .877
    TOTAL T.D. COST DURING OV. CONSTRUCTION                .246
    TOTAL MAINTENANCE COST                                 .218
    SALVAGE RETURNS                                       -.433
    ANY ADDITIONAL COST SPECIFIED                         3.000

   TOTAL OVERALL COST                                    12.949

DESIGN ANALYSIS
   TOTAL  80 INITIAL DESIGNS WERE EXAMINED, OUT OF WHICH,
          48 DESIGNS WERE REJECTED DUE TO USER RESTRAINTS
          32 REMAINING INITIAL DESIGNS PRODUCED   67 OVERLAY STRATEGIES
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RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

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	CC	AC	CC	AC	CC
REINFORCEMENT TYPE	MESH	MESH	MESH	MESH	MESH	MESH
CONCRETE TYPE	2	2	2	2	2	2
SUBBASE TYPE	2	2	2	2	2	2
SLAB THICKNESS	12.00	12.00	12.00	12.00	12.00	12.00
SUBBASE THICKNESS	6.00	6.00	8.00	8.00	10.00	10.00
OVERLAY + LEVEL UP 1	3.00	3.00	3.50	3.50	4.00	4.00
OVERLAY + LEVEL UP 2	3.00	3.00	3.00	3.00	3.00	3.00
INITIAL LIFE	5.03	5.03	5.13	5.13	5.22	5.22
PERFORMANCE LIFE 1	13.55	13.97	14.49	15.17	15.51	16.53
PERFORMANCE LIFE 2	29.11	34.53	32.57	39.86	36.48	45.93
TOTAL PERFORMANCE LIFE	29.11	34.53	32.57	39.86	36.48	45.93
SPACING TRANS. JOINTS	30.00	30.00	30.00	30.00	30.00	30.00
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	3.277	3.277	3.277	3.277	3.277	3.277
COST OF SUBBASE	.951	.951	1.173	1.173	1.395	1.395
COST OF REINFORCEMENT	.904	.904	.904	.904	.904	.904
COST OF JOINTS	1.020	1.020	1.020	1.020	1.020	1.020
COST OF TIE BARS	.060	.060	.060	.060	.060	.060
INITIAL CONST. COST	6.425	6.425	6.647	6.647	6.870	6.870
OVERLAY CONST. COST	.936	.974	.996	1.018	1.055	1.061
TRAFFIC DELAY COST	.060	.259	.065	.278	.069	.297
MAINTENANCE COST	.156	.165	.179	.202	.212	.257
SALVAGE RETURNS	-.454	-.482	-.482	-.513	-.510	-.544
SEAL COAT COST	.001	0.000	.001	0.000	.001	0.000
ANY ADDITIONAL COST	3.000	3.000	3.000	3.000	3.000	3.000
TOTAL COST PER SQ YARD	10.123	10.341	10.405	10.633	10.698	10.941

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

REINFORCEMENT DESIGN

DESIGN NUMBER	REINFORCEMENT DESCRIPTION						MATERIAL NUMBER	MATERIAL NAME
1	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
2	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
3	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
4	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
5	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
6	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			

SEAL COAT SCHEDULE

DESIGN NUMBER		
1	10.03	18.55
3	10.13	19.49
5	10.22	15.22

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER	7	8	9	10	11	12
PAVEMENT TYPE	JCP	JCP	JCP	JCP	JCP	JCP
OVERLAY TYPE	CC	AC	CC	CC	CC	AC
REINFORCEMENT TYPE	MESH	MESH	MESH	MESH	MESH	MESH
CONCRETE TYPE	2	2	2	2	2	2
SUBBASE TYPE	2	2	2	2	2	2
SLAB THICKNESS	12.00	12.00	12.00	12.00	12.00	12.00
SUBBASE THICKNESS	6.00	12.00	8.00	12.00	12.00	12.00
OVERLAY + LEVEL UP 1	6.50	4.50	6.00	4.50	5.50	7.00
OVERLAY + LEVEL UP 2		3.00		3.00		
INITIAL LIFE	5.03	5.31	5.13	5.31	5.31	5.31
PERFORMANCE LIFE 1	20.98	16.64	20.38	18.03	20.40	20.12
PERFORMANCE LIFE 2		40.91		52.76		
TOTAL PERFORMANCE LIFE	20.98	40.91	20.38	52.76	20.40	20.12
SPACING TRANS. JOINTS	30.00	30.00	30.00	30.00	30.00	30.00
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	3.277	3.277	3.277	3.277	3.277	3.277
COST OF SUBBASE	.951	1.617	1.173	1.617	1.617	1.617
COST OF REINFORCEMENT	.904	.904	.904	.904	.904	.904
COST OF JOINTS	1.020	1.020	1.020	1.020	1.020	1.020
COST OF TIE BARS	.060	.060	.060	.060	.060	.060
INITIAL CONST. COST	6.425	7.092	6.647	7.092	7.092	7.092
OVERLAY CONST. COST	1.233	1.113	1.142	1.105	1.046	1.321
TRAFFIC DELAY COST	.358	.074	.328	.316	.298	.087
MAINTENANCE COST	.472	.259	.464	.370	.451	.451
SALVAGE RETURNS	-.522	-.537	-.526	-.575	-.549	-.547
SEAL COAT COST	0.000	.001	0.000	0.000	0.000	.001
ANY ADDITIONAL COST	3.000	3.000	3.000	3.000	3.000	3.000
TOTAL COST PER SQ YARD	10.966	11.001	11.055	11.307	11.337	11.404

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

REINFORCEMENT DESIGN

DESIGN NUMBER	REINFORCEMENT DESCRIPTION						MATERIAL NUMBER	MATERIAL NAME
7	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
8	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
9	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
10	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
11	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			
12	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.20	.22	.24	.25		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.34	.36	.38	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.8	8.5	15.0			

SEAL COAT SCHEDULE

DESIGN NUMBER		
8	10.31	15.31
12	10.31	15.31

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER	13	14	15	16	17	18
PAVEMENT TYPE	CRC	CRC	CRC	CRC	CRC	CRC
OVERLAY TYPE	AC	CC	AC	AC	CC	CC
REINFORCEMENT TYPE	MESH	MESH	MESH	MESH	MESH	MESH
CONCRETE TYPE	1	1	2	1	2	1
SUBBASE TYPE	2	2	2	2	2	2
SLAB THICKNESS	11.00	11.00	10.00	11.00	10.00	11.00
SUBBASE THICKNESS	6.00	6.00	6.00	8.00	6.00	6.00
OVERLAY + LEVEL UP 1	3.00	3.00	3.00	3.50	3.00	5.00
OVERLAY + LEVEL UP 2	3.00	3.00	3.00	3.00	3.00	
INITIAL LIFE	5.32	5.32	5.40	5.44	5.40	5.32
PERFORMANCE LIFE 1	15.09	15.74	15.59	16.27	16.50	20.26
PERFORMANCE LIFE 2	34.00	42.03	36.02	38.42	46.73	
TOTAL PERFORMANCE LIFE	34.00	42.03	36.02	38.42	46.73	20.26
SPACING TRANS. JOINTS	R	R	R	R	R	R
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	2.874	2.874	2.777	2.874	2.777	2.874
COST OF SUBBASE	.951	.951	.951	1.173	.951	.951
COST OF REINFORCEMENT	4.345	4.345	4.675	4.345	4.675	4.345
COST OF JOINTS	.605	.605	.605	.605	.605	.605
COST OF TIE BARS	.053	.053	.050	.053	.050	.053
INITIAL CONST. COST	9.041	9.041	9.270	9.263	9.270	9.041
OVERLAY CONST. COST	.882	.877	.867	.937	.893	.921
TRAFFIC DELAY COST	.057	.246	.056	.061	.241	.270
MAINTENANCE COST	.193	.218	.209	.236	.248	.450
SALVAGE RETURNS	-.411	-.433	-.400	-.439	-.428	-.433
SEAL COAT COST	.001	0.000	.001	.001	0.000	0.000
ANY ADDITIONAL COST	3.000	3.000	3.000	3.000	3.000	3.000
TOTAL COST PER SQ YARD	12.763	12.949	13.004	13.061	13.224	13.250

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

REINFORCEMENT DESIGN

DESIGN NUMBER	REINFORCEMENT DESCRIPTION						MATERIAL NUMBER	MATERIAL NAME
13	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.61	.67				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.32	.34	.36	.39		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.2	9.6	17.0			
14	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.61	.67				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.32	.34	.36	.39		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.2	9.6	17.0			
15	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.64	.70	.76	.81		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.31	.33	.34	.38		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.5	10.2	18.1			
16	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.61	.67				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.32	.34	.36	.39		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.2	9.6	17.0			
17	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.64	.70	.76	.81		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.31	.33	.34	.38		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.5	10.2	18.1			
18	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.61	.67				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.32	.34	.36	.39		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.2	9.6	17.0			

SEAL COAT SCHEDULE

DESIGN NUMBER		
13	10.32	
15	10.40	15.40
16	10.44	15.44

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

SUMMARY OF DESIGNS IN INCREASING ORDER OF TOTAL COST

DESIGN NUMBER	19	20	21	22	23
PAVEMENT TYPE	CRC	CRC	CRC	CRC	CRC
OVERLAY TYPE	CC	AC	AC	AC	AC
REINFORCEMENT TYPE	MESH	MESH	MESH	MESH	MESH
CONCRETE TYPE	1	1	2	1	1
SUBBASE TYPE	2	2	2	1	2
SLAB THICKNESS	11.00	12.00	10.00	12.00	11.00
SUBBASE THICKNESS	8.00	6.00	8.00	6.00	10.00
OVERLAY + LEVEL UP 1	3.50	3.00	3.50	3.00	4.00
OVERLAY + LEVEL UP 2	3.00		3.00	3.00	3.00
INITIAL LIFE	5.44	6.22	5.52	5.71	5.54
PERFORMANCE LIFE 1	17.34	21.28	16.91	16.81	17.57
PERFORMANCE LIFE 2	49.17		41.12	37.41	43.43
TOTAL PERFORMANCE LIFE	49.17	21.28	41.12	37.41	43.43
SPACING TRANS. JOINTS	R	R	R	R	R
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	2.874	3.110	2.777	3.110	2.874
COST OF SUBBASE	1.173	.951	1.173	.701	1.395
COST OF REINFORCEMENT	4.345	4.740	4.675	4.933	4.345
COST OF JOINTS	.605	.605	.605	.605	.605
COST OF TIE BARS	.053	.058	.050	.048	.053
INITIAL CONST. COST	9.263	9.677	9.493	9.610	9.485
OVERLAY CONST. COST	.912	.571	.920	.826	.992
TRAFFIC DELAY COST	.263	.035	.060	.054	.066
MAINTENANCE COST	.287	.392	.263	.250	.294
SALVAGE RETURNS	-.463	-.397	-.428	-.405	-.466
SEAL COAT COST	0.000	.001	.001	.001	.001
ANY ADDITIONAL COST	3.000	3.000	3.000	3.000	3.000
TOTAL COST PER SQ YARD	13.262	13.279	13.308	13.336	13.372

RIGID PAVEMENT SYSTEM 2 RAMESH KHER JAN 1973
PROB CFHR EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT RFC

REINFORCEMENT DESIGN

DESIGN NUMBER	REINFORCEMENT DESCRIPTION						MATERIAL NUMBER	MATERIAL NAME
19	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.61	.67				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.32	.34	.36	.39		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.2	9.6	17.0			
20	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.64	.70				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.33	.36	.37	.41		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	3.9	8.8	15.6			
21	LONG.REINF.MESH	SPACING	5.0	6.0	7.0	8.0	1	ASTM,A-497
		MESH DIAMETER	.64	.70	.76	.81		
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.31	.33	.34	.38		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.5	10.2	18.1			
22	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.66	.72				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.30	.33	.34	.37		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.7	10.5	18.7			
23	LONG.REINF.MESH	SPACING	5.0	6.0			1	ASTM,A-497
		MESH DIAMETER	.61	.67				
	TRAN.REINF.MESH	SPACING	12.0	14.0	15.0	18.0	1	ASTM,A-497
		MESH DIAMETER	.32	.34	.36	.39		
	TIE BARS	BAR NUMBER	2	3	4		1	A-615GR40
		SPACING	4.2	9.6	17.0			

SEAL COAT SCHEDULE

DESIGN NUMBER		
20	11.22	16.22
21	10.52	15.52
22	10.71	15.71
23	10.54	15.54

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RIGID  PAVEMENT  SYSTEM  2   RAMESH KHER         JAN 1973
PROB CFHR      EXAMPLE RIGID PAVEMENT DESIGN SYSTEM INPUT FORMAT  RFC


                     INITIAL DESIGN ANALYSIS

     OUT OF A TOTAL OF  160 INITIAL POSSIBLE DESIGNS,
              0 WERE REJECTED DUE TO MAX. INITIAL THICKNESS RESTRAINT
     OUT OF 160 DESIGNS THUS LEFT
              0 DESIGNS WERE REJECTED SINCE THEY ARE OVERDESIGNS OF
               INITIAL DESIGNS WHICH LAST THE ANALYSIS PERIOD
     OUT OF 160 DESIGNS THUS LEFT,
            124 DESIGNS WERE REJECTED DUE  TO THEIR LIVES BEING LESS
               THAN THE MINIMUM ALLOWABLE TIME  TO THE FIRST OVERLAY
     OUT OF  36 DESIGNS THUS LEFT,
              0 DESIGNS WERE REJECTED DUE TO THE RESTRAINT OF MAXIMUM
               INITIAL FUNDS AVAILABLE
     OUT OF  36 DESIGNS THUS LEFT,
              0 DESIGNS WERE ACCEPTABLE  INITIAL DESIGNS WITH LIVES
               MORE THAN THE ANALYSIS PERIOD
     AND THUS     36 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        18    4   11    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        56   48  185  102
NUMBER OF TIMES  SUBROUTINE *MANCE*  WAS  CALLED        56   48  185  102
NUMBER OF TIMES  SUBROUTINE * TDC *  WAS  CALLED        56   48  185  102
NUMBER OF  POSSIBLE OVERLAY STRATEGIES  OBTAINED         5    7   63   46
NUMBER OF OVERDESIGNS OBTAINED                          16   17   40   21

OUT OF A TOTAL OF                                       39   28  114   67


          THUS FOR THE ENTIRE DESIGN SYSTEM
          OUT OF AN OVERALL TOTAL OF   248 OVERLAY STRATEGIES
                33 WERE REJECTED DUE TO DIFFERENT RESTRAINTS
          AND   215 WERE CONSIDERED FOR  OPTIMIZATION PROCESS



  0.0   20000  20.0  0.00   .30   .30   .30
  0.0
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THE AUTHORS

Robert F. Carmichael is a Research Engineer at the Center for Highway Research at The University of Texas at Austin. He is currently pursuing a Masters of Science Degree in Civil Engineering, with a specialty in highway design and transportation planning. His experience includes employment with the Center for Highway Research as an undergraduate research assistant for three years and with the Texas Highway Department as a field assistant engineering aid for three summers. His major involvements currently are the implementation of the Rigid Pavement Design System and the modification of the computer program which performs this rigid pavement design.

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.