

FLEXIBLE PAVEMENT SYSTEM COMPUTER PROGRAM DOCUMENTATION

by

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A System Analysis of Pavement Design
and Research Implementation

Research Project 1-8-69-123

conducted

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U. S. Department of Transportation
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PREFACE AND LISTING OF PREVIOUS REPORTS

This is the eleventh report issued under Research Study 1-8-69-123, A Systems Analysis of Pavement Design and Research Implementation. The study is being conducted by principal investigators and their staffs in three agencies--The Texas Highway Department at Austin, The Center for Highway Research at Austin and the Texas Transportation Institute at College Station--as part of a cooperative research program with the Department of Transportation, Federal Highway Administration.

Previous reports emanating from Study 123 are the following:

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.

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.

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 clay parameter used in pavement design system.

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.

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.

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 W. M. Moore, describes a computer program which will serve as a subsystem of a future Flexible Pavement System founded on linear elastic theory.

Report No. 123-6A, "Calculation of the Elastic Moduli of a Two-Layer Pavement System from Measured Surface Deflections, Part II," is a supplement to Report 123-6, prepared by the same authors (in publication).

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.

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.

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 nomograph for the field engineer to use to eliminate aggregates which would not provide adequate skid resistance performance (in publication).

Report No. 123-10, "Flexible Pavement System - Second Generation, Incorporating Fatigue and Stochastic Concepts," by Surenda 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.

The author is indebted to Mr. Frank Scrivner for the performance equation and to Dr. Frank McFarland for the updated user cost tables implemented in the computer program and documented in this report.

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification or regulation. Reference to specific makes or models of computer equipment is made for identification only and does not imply endorsement by the sponsors of this report.

Abstract

This report gives the documentation of the computer program FPS-9 used for implementation of the flexible pavement design system. This documentation is also in machine readable form to make possible a continuing documentation system for updates and improvements in the Flexible Pavement System (FPS) series of computer programs.

Included in this report are:

1. Cross Reference tables,
2. Input data formats,
3. Flowcharts,
4. Documentation of mathematical and user cost formulas,
5. Results of timing tests for computer CPU time on example data,
6. A variable name dictionary,
7. Documentation aids, including "TEXLIS" a computer program for printing the body of the report.

Key Words

Computer Program Documentation, Flexible Pavement System, Pavement Design, Systems Analysis, Optimization, Pavement Economics, Highway User Costs.

Summary

As part of a Systems Analysis of Pavement Design and Research, a computer program FPS, for Flexible Pavement System, was developed and tested. This study provides documentation and an easily updated documentation system for the latest version of the computer program FPS-9. The text listing program used to implement the documentation system may be of interest for other similar projects.

Implementation Statement

This documentation is planned for immediate implementation in the research project for Systems Analysis and Research in maintaining the FPS series of computer programs. To aid in this implementation the body of the report is available in machine readable form with the text editing program "TEXLIS" as well as the "FPS-9" computer program.

It is expected that this report will aid future research for improving portions of the pavement design system by aiding integration of new or revised program modules into the FPS computer program used to implement the research results.

The published version of this report may be obtained by addressing your request as follows:

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Research & Development Committee
Texas Highway Department - File D-8
11th and Brazos
Austin, Texas 78701 (Phone 512/475-2971)

The following portions of the report are available on 80 character cards or tape from the address given on page one of the body of the report for the cost of reproduction and mailing. If a tape copy is desired, enclose tape and indicate whether 7 or 9 track and whether 200, 556, or 800 BPI. The tape will be 80 character card image records blocked 10 records per block unless otherwise specified.

TEXLIS

The program given in Appendix III of the report for producing an edited text listing together with the data to reproduce Appendix III.

FPS9

The FPS-9 computer program which is flowcharted in Appendix IV.

FPS9 DOCU

The data for TEXTLIS which will reproduce the body of this report giving FPS-9 documentation.

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FPS-9
FLEXIBLE PAVEMENT SYSTEM
COMPUTER PROGRAM DOCUMENTATION

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THIS PAGE AND THE REMAINDER OF THE BODY OF THIS REPORT ARE
AVAILABLE ON TAPE OR 80 CHARACTER CARDS FROM THE ABOVE ADDRESS
FOR USE IN MAINTAINING AN INDEPENDENT DOCUMENTATION USING THE
'TEXLIS' PROGRAM IN THE APPENDIX 'TEXT LISTING PROGRAM DOCUMENTATION'.

FPS-9 PROGRAM DOCUMENTATION

THE FPS-9 COMPUTER PROGRAM IS ONE OF A SERIES OF COMPUTER PROGRAMS IMPLEMENTING THE SYSTEMS APPROACH TO PAVEMENT DESIGN. THE ORIGINAL FPS BY G. R. CAREY HAS BEEN MODIFIED AND CHANGED TO INCORPORATE THE RESULTS OF LATER RESEARCH AND TO MEET THE NEEDS OF USERS OF THE FPS COMPUTER PROGRAM.

A NUMBERING CONVENTION FOR THE SUFFIX, SUCH AS THE '9' IN FPS-9, WAS ADOPTED BY THE RESEARCH AGENCIES, BEGINNING WITH FPS-3. FPS-1 AND FPS-2 WERE THE ORIGINAL AND FIRST REVISION, RESPECTIVELY, OF THE FPS COMPUTER PROGRAM, EACH OF WHICH UTILIZED PAVEMENT DEFLECTION EQUATIONS FOR PREDICTING PAVEMENT PERFORMANCE (REFERENCES 1 AND 2). AT THE TIME OF THE PUBLICATION OF REPORT 123-1 'A SYSTEMS APPROACH APPLIED TO PAVEMENT DESIGN' (REFERENCE 3), A NUMBERING CONVENTION WAS ADOPTED TO BE USED FOR LATER REVISIONS OF FPS. THE PAVEMENT DEFLECTION METHOD SERIES OF PROGRAMS WERE TO USE ODD NUMBERS FOR LATER REVISIONS (3, 5, 7, . . .). THE PROGRAMS BASICALLY SIMILAR BUT USING THE AASHO BASED EQUATION FOR PREDICTING PAVEMENT PERFORMANCE WERE TO USE EVEN NUMBERS (4, 6, 8, . . .). EACH PROGRAM AS IT EVOLVED WOULD USE A FURTHER SUFFIX WHILE IN THE DEVELOPMENT, DEBUGGING, EVALUATION, AND TESTING STAGES (FPS-5-TTI, FPS-6-CFHR, AND FPS-11-THD AS EXAMPLES) UNTIL APPROVED FOR PUBLICATION BY THE COOPERATING AGENCIES, AT WHICH TIME THE SUFFIX WOULD BE DROPPED.

SEVERAL CHANGES IN PROGRAM STRUCTURE AND VARIABLE NAMES WERE IMPLEMENTED IN THE FPS-9 COMPUTER PROGRAM TO IMPROVE THE UNDERSTANDING OF THE PROGRAM AND THIS DOCUMENTATION. HOWEVER, A COMPREHENSIVE REVISION OF THE FPS COMPUTER PROGRAM WOULD HAMPER THOSE FAMILIAR WITH EARLIER VERSIONS. AS A RESULT FEW MAJOR PROGRAM MODIFICATIONS HAVE BEEN MADE, BUT PRIMARILY AN EASILY MAINTAINED SYSTEM OF CONTINUING PROGRAM DOCUMENTATION HAS BEEN IMPLEMENTED. WITH THESE AIDS IT IS ANTICIPATED THAT FUTURE IMPROVEMENT, MODIFICATION, AND MAINTENANCE OF THE FLEXIBLE PAVEMENT SYSTEM SERIES OF PROGRAMS MAY BE UNDERTAKEN BY USING AGENCIES. TO ASSIST IN THIS GOAL PORTIONS OF THE PROGRAM WERE SEGMENTED TO AID IN PROGRAM MODIFICATION EFFORTS.

THE INTENDED AUDIENCE OF THIS REPORT IS THE SYSTEMS ANALYST OR PROGRAMMER WHO IS EXPECTED TO MAKE FUTURE CHANGES AND UPDATES OF THE FPS SERIES OF PROGRAMS. A SIMILAR PUBLICATION IS NEEDED FOR EACH VERSION OF FPS, AND SO DOCUMENTATION AIDS ARE INCLUDED TO ENABLE THE ANALYST TO MAINTAIN A COMPLETELY UPDATED DOCUMENTATION.

THE PRIMARY AID FOR CONTINUING DOCUMENTATION IS THE 'TEXLIS' PROGRAM USED TO PRODUCE AN EDITED LISTING OF A DOCUMENTATION DECK. THIS METHOD HAS THE ADVANTAGE THAT CHANGES IN THE PROGRAM MAY BE DOCUMENTED BY SIMPLE REPLACEMENT, REMOVAL, OR INSERTION OF CARDS IN THE DOCUMENTATION DECK AND A PRINTING OF THE LATEST VERSION BY A RUN OF THE 'TEXLIS' PROGRAM. LATER IT IS ANTICIPATED THAT THIS DOCUMENTATION MAY BE IMPLEMENTED ON AN ON-LINE TERMINAL SYSTEM.

A BRIEF DEFINITION OF THE FOLLOWING TERMS IS GIVEN BELOW TO AID IN UNDERSTANDING THIS DOCUMENTATION AND THE OUTPUT OF FPS-9.

1. PROBLEM

A PROBLEM IS DEFINED BY ONE SET OF DATA AS INPUT FOR THE FPS-9 COMPUTER PROGRAM AND ON OUTPUT BY CONSECUTIVELY NUMBERED PAGES WITH THE SAME HEADING. A COMPUTER RUN MAY CONSIST OF ONE OR MORE PROBLEMS.

2. DESIGN TYPE

WITHIN A PROBLEM, A UNIQUE SET OF INITIAL DESIGN MATERIALS IS A DESIGN TYPE. EACH DESIGN TYPE PRODUCES AN OPTIMUM DESIGN ON OUTPUT OR A STATEMENT THAT NO DESIGN WAS POSSIBLE FOR THAT DESIGN TYPE.

3. INITIAL DESIGN

WITHIN EACH DESIGN TYPE, EACH COMBINATION OF DIFFERENT LAYER THICKNESS POSSIBLE WITH THE GIVEN LIMITS ON THICKNESSES AND INCREMENTS MAKES AN INITIAL DESIGN. IF THE INITIAL DESIGN MEETS ALSO CONSTRAINTS OF COST AND TOTAL INITIAL DESIGN THICKNESS, IT IS A FEASIBLE INITIAL DESIGN. IN THIS VERSION OF FPS A FEASIBLE DESIGN IS NOT 'CONSIDERED' IF WITHIN THE SAME DESIGN TYPE THERE IS AN INITIAL DESIGN OF LOWER COST WHICH IS OF EQUAL OR BETTER STRENGTH.

4. FEASIBLE

THE WORD FEASIBLE USUALLY SHOULD BE COMBINED WITH A MODIFIER SUCH AS 'FEASIBLE INITIAL DESIGN', 'FEASIBLE OVERLAY', OR 'FEASIBLE OVERLAY POLICY'. IF A DESIGN OR POLICY IS FEASIBLE, IT HAS MET ONE OR MORE CONSTRAINTS. IT MAY BE REJECTED IF WHEN COMPARED TO OTHER FEASIBLE DESIGNS IT IS OF HIGHER COST.

5. BEST OVERLAY POLICY

FOR A GIVEN INITIAL DESIGN, THE OPTIMUM OVERLAY POLICY OBTAINED BY COMPARING COSTS BETWEEN ALL FEASIBLE OVERLAYS IS KNOWN AS THE BEST OVERLAY POLICY WITH A PARTICULAR INITIAL DESIGN.

5. UNITS OF MEASURE

INPUT AND OUTPUT OF DATA MAY BE IN ANY UNITS CONVENIENT TO THE USER, BUT AS AN AID TO MODULARIZATION, IN COMMON OR AS SUBROUTINE ARGUMENTS, THE FOLLOWING UNITS ARE CONSISTENT THROUGHOUT THE PROGRAM.

PAVEMENT OR PAVEMENT MATERIALS

YARDS, SQUARE YARDS, OR CUBIC YARDS AS APPLICABLE.

DISTANCES RELATED TO USER COSTS

MILES.

VEHICLE SPEEDS

MILES PER HOUR.

TIME

YEARS WHEN RELATED TO PAVEMENT PERFORMANCE, HOURS WHEN RELATED TO USER COSTS.

PROPORTIONS AND INTEREST RATES

ALWAYS AS A DECIMAL PROPORTION EQUAL TO (PERCENTAGE/100.0).

TRAFFIC

AVERAGE DAILY TRAFFIC AT A GIVEN POINT IN TIME.

TRUCK AXLE LOADS

MILLIONS OF 18 KIP AXLE EQUIVALENTS FROM THE TIME OF CONSTRUCTION TO A GIVEN POINT IN TIME.

INPUT DATA FOR FPS-9 IS ONE OR MORE SETS OF CARDS, ONE SET FOR EACH PROBLEM. AFTER THE LAST PROBLEM THERE SHOULD BE ONE OR MORE BLANK CARDS.

EACH PROBLEM IS DESCRIBED BY TEN OR MORE CARDS AS A SET. A SET OF CARDS IS COMPOSED OF EIGHT CARDS IN ORDER FOLLOWED BY A GROUP OF MATERIAL PROPERTY CARDS, ONE FOR EACH MATERIAL TO BE CONSIDERED FOR THE PROBLEM AND ONE FOR THE SUB-GRADE CHARACTERISTICS.

THE INFORMATION ON THE INPUT CARDS IS GIVEN BELOW. ALTHOUGH THE FORMATS APPEAR TO BE COMPLEX, WITH THE EXCEPTION OF THE HEADER CARD AND THE MATERIAL PROPERTY CARDS, EACH VARIABLE IS IN A 10 CHARACTER FIELD. IF THE 'REAL' VARIABLES (BEGINNING WITH LETTERS A-H, O-Z) ARE PUNCHED WITH A DECIMAL AND 'INTEGER' VARIABLES (BEGINNING WITH LETTERS I THROUGH N) ARE RIGHT JUSTIFIED IN THEIR FIELDS, THE FORMATS OF CARDS TWO THROUGH EIGHT MAY BE IGNORED.

SOME VARIABLES HAVE BEEN RENAMED FROM EARLIER VERSIONS OF THE PROGRAM SO THAT A CAREFUL DISTICTION COULD BE MADE BETWEEN THOSE VALUES WHICH ARE INPUT IN UNITS CONVENIENT FOR THE USER AND THE VALUES WHICH ARE IN UNITS CONVENIENT FOR CALCULATION IN THE REMAINDER OF THE FPS COMPUTER PROGRAM.

*****CARD 1*****
HEADER CARD FORMAT(A4, 6X, 16A4)

NPROB - PROBLEM NUMBER, ANY CHARACTERS IDENTIFYING THE PROBLEM
COLUMNS 1-4 *

AN2 - PROBLEM DESCRIPTION, ADDITIONAL PROBLEM IDENTIFICATION.
COLUMNS 11-74 *

* NOTE - A BLANK CARD (NPROB AND FIRST FOUR CHARACTERS OF AN2 AS
BLANKS) AS A HEADER CARD WILL FLAG THE END OF DATA.

*****CARD 2*****
MISCELLANEOUS INPUTS FORMAT(2I10, 2F10.2, I10)

NMB-THE NUMBER OF OUTPUT PAGES FOR THE SUMMARY TABLE(8 DESIGNS/PAGE).
NMB CAN ONLY HAVE THE VALUE 1, 2, OR 3.
COLUMN 10

NM-THE TOTAL NUMBER OF MATERIALS AVAILABLE, EXCLUDING SUBGRADE.
NM AS AN INPUT VALUE IS NOT REQUIRED AND IS IGNORED IN THIS
VERSION OF FPS, IT IS OBTAINED INSTEAD BY COUNTING THE MATERIAL
PROPERTY CARDS.
COLUMNS 11-20 IGNORED

CL-THE LENGTH OF THE ANALYSIS PERIOD IN YEARS.
COLUMNS 21-30

FPS-9 PROGRAM DOCUMENTATION

XLW-THE WIDTH OF EACH LANE(FEET).
COLUMNS 31-40

NL-THE NUMBER OF LANES ON THE HIGHWAY, BOTH DIRECTIONS
COLUMNS 41-50

*****CARD 3*****
PERFORMANCE EQUATION VARIABLES FORMAT(5F10.2, 2F10.4)

ALPHA-THE DISTRICT OR REGIONAL TEMPERATURE CONSTANT.
COLUMNS 1-10

PSI-THE SERVICEABILITY INDEX OF THE INITIAL STRUCTURE.
COLUMNS 11-20

P1-THE BEGINNING SERVICEABILITY INDEX OF THE PAVEMENT
AFTER AN OVERLAY. SET THE SAME AS PSI IN FPS-9.
COLUMNS 21-30

P2-THE MINIMUM ALLOWED VALUE OF THE SERVICEABILITY INDEX
(POINT AT WHICH AN OVERLAY MUST BE APPLIED).
COLUMNS 31-40

P2P-NON-TRAFFIC DETERIORATION PARAMETER-THE LOWER BOUND ON THE
SERVICEABILITY INDEX WHICH WOULD BE ACHIEVED IN INFINITE
TIME WITH NO TRAFFIC.
COLUMNS 41-50

B ONE - A NON-TRAFFIC DETERIORATION PARAMETER, THE CONSTANT WHICH
DETERMINES THE EFFECT THAT SWELLING CLAY WILL HAVE UPON THE
SERVICEABILITY LOSS OF THE PAVEMENT DURING A FINITE
TIME INTERVAL.
COLUMNS 51-60

GAMMA - A SWELLING CLAY PARAMETER, THE DECREASE IN SERVICEABILITY
INDEX WHICH IS EXPECTED TO OCCUR EACH YEAR AT A CONSTANT RATE.
COLUMNS 61-70

*****CARD 4*****
THE TRAFFIC VARIABLES FORMAT(3F10.0, F10.2, I10)

R0 - ONE-DIRECTION AVERAGE DAILY TRAFFIC AT THE BEGINNING OF THE
ANALYSIS PERIOD.
COLUMNS 1-10

R20 - ONE-DIRECTION AVERAGE DAILY TRAFFIC 20 YEARS AFTER
CONSTRUCTION.
COLUMNS 11-20

XN20 - THE 20 YEAR ACCUM. 18-KIP AXLE EQUIV.
COLUMNS 21-30

PROPCT - PERCENT OF ADT WHICH WILL PASS THROUGH THE OVERLAY ZONE
DURING EACH HOUR WHILE OVERLAYING TAKES PLACE (NORMALLY ABOUT
6 PERCENT FOR RURAL AREAS, 5.5 PERCENT FOR URBAN AREAS, AND
ABOUT 4.2 IF TRAFFIC IS EVENLY DISTRIBUTED DURING THE 24 HOURS).
COLUMNS 31-40

ITYPE - IS A CODE FOR THE TYPE OF ROAD UNDER CONSIDERATION.
ITYPE=1 DESIGNATES A RURAL ROAD AND ITYPE=2 DESIGNATES AN
URBAN ROAD. ALL OTHER VALUE ARE INVALID.
COLUMN 50

*****CARD 5*****
THE VALUES OF THE CONSTRAINT VARIABLES FORMAT(4F10.1, 4F10.2)

XTTO - THE MINIMUM ALLOWED TIME TO THE FIRST OVERLAY.
COLUMNS 1-10

XTBO - THE MINIMUM ALLOWED TIME BETWEEN OVERLAYS PERMITTED.
COLUMNS 11-20

TTSC - THE TIME TO THE FIRST SEAL COAT AFTER INITIAL OR OVERLAY
CONSTRUCTION.
COLUMNS 21-30

TBSC - THE TIME BETWEEN SEAL COATS.
COLUMNS 31-40

CMAX - THE MAXIMUM COST PER SQUARE YARD THAT IS TO BE ALLOWED FOR
INITIAL CONSTRUCTION.
COLUMNS 41-50

TMAXIN - THE MAXIMUM ALLOWABLE TOTAL THICKNESS OF INITIAL
CONSTRUCTION.
COLUMNS 51-60

OMININ - THE MINIMUM THICKNESS OF AN INDIVIDUAL OVERLAY.
COLUMNS 61-70

OMAXIN - THE ACCUMULATED MAXIMUM THICKNESS OF ALL OVERLAYS.
COLUMNS 71-80

*****CARD 6*****
OVERLAY PARAMETERS ASSOCIATED WITH USER COSTS FORMAT(6F10.2, 2I10)

ACPR - ASPHALTIC CONCRETE PRODUCTION RATE (TONS PER HOUR)
COLUMNS 1-10

ACCD-ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/COMPACTED CY).
COLUMNS 11-20

XLSD-THE DISTANCE, MEASURED ALONG THE C.L., OVER WHICH TRAFFIC IS
SLOWED IN THE OVERLAY DIRECTION (LSD IN USER COST TABLES
APPENDIX).
COLUMNS 21-30

XLSDN-THE DISTANCE, MEASURED ALONG THE C.L., OVER WHICH TRAFFIC IS
SLOWED IN THE NON-OVERLAY DIRECTION (LSN IN USER COST
TABLES APPENDIX).
COLUMNS 31-40

XLSD-THE DISTANCE, MEASURED ALONG THE DETOUR, AROUND THE OVERLAY
ZONE. THIS VARIABLE IS USED ONLY FOR MODEL=5 (LSD IN USER
COST TABLES APPENDIX).
COLUMNS 41-50

HPD-THE NUMBER OF HOURS PER DAY THAT OVERLAY CONSTRUCTION TAKES
PLACE. THE PRODUCT (HPD*PROPCT) SHOULD NOT BE GREATER THAN
100 PERCENT, HOWEVER IF THE STRIP IS UNDER CONSTRUCTION
TWENTY-FOUR HOURS A DAY, (HPD*PROPCT) WILL EQUAL 100.
COLUMNS 51-60

NLRO-THE NUMBER OF OPEN LANES IN THE OVERLAY DIRECTION IN THE
RESTRICTED ZONE.
COLUMN 70

NLRN-THE NUMBER OF OPEN LANES IN THE NON-OVERLAY DIRECTION IN THE
RESTRICTED ZONE.
COLUMN 80

*****CARD 7*****
ADDITIONAL PARAMETERS ABOUT USER COSTS ASSOCIATED WITH OVERLAYS
JRMAT(2F10.2, 2F10.4, 3F10.2, I10)

PPO2 - PERCENT OF VEHICLES THAT WILL BE STOPPED IN THE OVERLAY
DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT.
COLUMNS 1-10

PPN2 - PERCENT OF VEHICLES THAT WILL BE STOPPED IN THE
NON-OVERLAY DIRECTION BECAUSE OF PERSONNEL OR EQUIPMENT.
COLUMNS 11-20

DO2-THE AVERAGE DELAY PER VEHICLE STOPPED IN THE OVERLAY DIRECTION
BECAUSE OF MOVEMENT OF OVERLAY PERSONNEL AND EQUIPMENT IN THE
RESTRICTED ZONE.
COLUMNS 21-30

DN2-THE AVERAGE DELAY PER VEHICLE STOPPED IN THE NON-OVERLAY
DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT.
COLUMNS 31-40

AAS-THE AVERAGE APPROACH SPEED TO THE OVERLAY AREA, WILL BE THE SAME FOR BOTH DIRECTIONS. (MILES PER HOUR) *
COLUMNS 41-50

ASO-THE AVERAGE SPEED THROUGH THE OVERLAY AREA, IN THE OVERLAY DIRECTION. (MILES PER HOUR) *
COLUMNS 51-60

ASN-THE AVERAGE SPEED THROUGH THE OVERLAY AREA, IN THE NON-OVERLAY DIRECTION. (MILES PER HOUR) *
COLUMNS 61-70

MODEL-THE MODEL NUMBER WHICH DESCRIBES THE TRAFFIC SITUATION. (ONLY NUMBERS 1, 2, 3, 4, OR 5 ARE VALID)
COLUMN 80

* NOTE ALTHOUGH SPEEDS MAY BE INPUT AS ANY VALUE, THEY WILL BE ROUNDED TO THE NEAREST 10 MPH WITHIN THE TABLE LIMITS OF 60 MPH AS GIVEN IN THE APPENDIX ON USER COSTS.

*****CARD 8*****
MAINTENANCE COSTS, SEAL COAT COSTS, TIME VALUE OF MONEY
FORMAT(4F10.2)

CM1-ANNUAL ROUTINE MAINTENANCE COST PER LANE MILE FOR THE FIRST YEAR AFTER CONSTRUCTION OR AN OVERLAY.
COLUMNS 1-10

CM2-ANNUAL INCREMENTAL INCREASE IN ROUTINE MAINTENANCE COST PER LANE MILE.
COLUMNS 11-20

SC -THE COST OF A SEAL COAT PER LANE MILE.
COLUMNS 21-30

PCTRAT - THE INTEREST RATE OR TIME VALUE OF MONEY, IN PERCENT.
COLUMNS 31-40

 MATERIAL PROPERTY CARDS (TWO TO ELEVEN CARDS STARTING WITH CARD 9)

 CONSTRUCTION MATERIALS, THEIR PROPERTIES, AND ASSOCIATED CONSTRAINTS.
 FORMAT(3X, I1, 3X, A1, 3X, 6A3, F6.2, 4F8.2)

THE COLUMN DESCRIPTIONS ARE AS FOLLOWS--

FIRST FIELD--1 COLUMN - ILAYER - THE LAYER NUMBER IN WHICH THE MATERIAL MAY BE USED. (MUST NOT BE GREATER THAN 6)
 NOTE THAT THE FIRST FIELD MUST BE BLANK OR ZERO FOR SUBGRADE.
 COLUMN 4

SECOND FIELD--1 COLUMN--CODE LETTER OF THE MATERIAL.
 THE CODE LETTER IS NOT APPLICABLE FOR THE SUBGRADE.
 COLUMN 8

THIRD FIELD--18 COLUMNS--THE NAME OF THE TYPE OF MATERIAL.
 COLUMNS 12-29

FOURTH FIELD--6 COLUMNS--THE IN-PLACE COST PER COMPACTED CUBIC YARD.
 THIS FIELD NOT APPLICABLE FOR THE SUBGRADE.
 COLUMNS 30-35

FIFTH FIELD--8 COLUMNS--THE STRENGTH COEFFICIENT OF THE MATERIAL.
 COLUMNS 36-43

SIXTH FIELD--8 COLUMNS--THE MINIMUM LAYER THICKNESS ALLOWED.
 THIS FIELD NOT APPLICABLE FOR THE SUBGRADE.
 COLUMNS 44-51

SEVENTH FIELD--8 COLUMNS--THE MAXIMUM LAYER THICKNESS ALLOWED.
 THIS FIELD NOT APPLICABLE FOR THE SUBGRADE.
 COLUMNS 52-59

EIGHTH FIELD--8 COLUMNS--SALVAGE VALUE PERCENTAGE OF THE MATERIAL.
 THIS FIELD NOT APPLICABLE FOR THE SUBGRADE.
 COLUMNS 60-67

----- NOTES ...

THE MATERIAL PROPERTY CARDS MUST BE IN ASCENDING SORTED ORDER BY THE FIRST FIELD, AND THE SUBGRADE CARD MUST BE LAST. IN OTHER WORDS, ALL LAYER 1 CARDS MUST BE FIRST, FOLLOWED BY ALL OF THE LAYER 2 CARDS, . . . , AND LAST MUST BE THE SUBGRADE CARD WITH THE ILAYER FIELD BLANK OR ZERO. THERE MUST BE AT LEAST ONE MATERIAL FOR EACH LAYER.

LAYER 1 IS THE SURFACE LAYER, ASPHALTIC CONCRETE.

OVERLAYS WILL BE ASSUMED TO BE CONSTRUCTED OF THE SAME MATERIAL AS THE SURFACE LAYER.

THE FPS-9 PROGRAM IS VERY FLEXIBLE. IN ADDITION TO THE MORE OBVIOUS PROBLEMS, THE FOLLOWING SETS OF INPUT DATA ILLUSTRATE HOW SPECIAL PROBLEMS MAY BE CONSIDERED.

EACH EIGHTY CHARACTER CARD IS SHOWN ON TWO LINES, COLUMNS ONE THROUGH 60 ON THE FIRST LINE, FOLLOWED BY DASHES, COLUMN 61-80 ON THE SECOND LINE, PRECEDED BY DASHES, OTHERWISE IT IS THE EXACT DATA USED FOR THE TIMING EXPERIMENTS AND TO PRODUCE THE EXAMPLE OUTPUT IN THE APPENDIX. COMMENTS ON THE FOUR SAMPLE DATA PROBLEMS ARE ALSO INCLUDED IN THIS SECTION.

PROBLEM T-1

		COLUMN NUMBERS									
	1	2	3	4	5	6	7	8			
.....	5.....	0.....	5.....	0.....	5.....	0.....	5.....	0.....	5.....	0.....	
										5.....0.....5.....0	

T-1		TEST DATA SIMILAR TO 123-1 REPORT ON FPS-3					
3		20.0	12.0	4			
30.0	4.2	4.2	3.0	1.50	0.07		
12000.	18000.	2.0E06	6.0	1	0.02		
2.0	5.0	5.0	3.0	5.0	36.0		
75.0	1.80	0.5	0.5		0.5	8.0	
2.0	0.0	0.1	0.1	60.0	10.0		
50.0	20.0	1500.0	5.0		1	2	
1	A	ASPHALTIC CONCRET	10.0	.82	1.00	45.0	
2	L	CR. LIMESTONE-1	5.0	.55	6.00	75.0	
2	G	GRAVEL-1	3.0	0.35	6.00	100.0	
3	G	GRAVEL-1	3.0	0.35	6.00	100.0	
SUBGRADE		0.22					

THIS PROBLEM WAS PREPARED TO BE SIMILAR TO THE TEST DATA IN REPORT 123-1 (REFERENCE 3). THE VALUES OF SWELLING CLAY WERE CHANGED TO REFLECT THE NEW MODEL AND THE SERVICEABILITY INDEX AFTER OVERLAY WAS MADE THE SAME AS THE SERVICEABILITY INDEX AFTER INITIAL CONSTRUCTION FOR THE FPS-9 PERFORMANCE EQUATION. THE MATERIAL 'GRAVEL-1' WAS INCLUDED FOR EITHER LAYER 1 OR LAYER 2 TO ILLUSTRATE THE ADVANTAGE OF THIS CAPABILITY IN FPS-9.

IF THE INPUT VALUE OF THE MAXIMUM THICKNESS OF ASPHALTIC CONCRETE HAD BEEN LESS, A SAVING IN COMPUTER TIME WOULD HAVE RESULTED SINCE ONLY THE ONE LAYER DESIGN WOULD HAVE BEEN AFFECTED IN THE OPTIMUM DESIGNS OUTPUT. IT MAY BE NOTED THAT ALL OTHER DESIGNS USING MORE THAN ONE LAYER WERE OF MUCH LOWER COST AND HAD ASPHALTIC CONCRETE LAYER THICKNESS IN THE OPTIMUM DESIGNS OF 1.0 TO 4.50 INCHES IN DEPTH.

COLUMN NUMBERS

T-2		EXISTING BASE USED AS EITHER 2ND OR 3RD LAYER					
		3	3	20	12	4	
		22	4.2	4.0	3.0	1.50	0.0600
		1600.	3200.	800000.	5.0	1	0.05
		5.0	5.0	22.	22.	7.50	24.00
		80	2.00	1.0	1.0	0.0	0.50 4.5
		1.00	1.00	0.01	0.01	60	10 1
		50.00	20.00	0.00	7.0		1 20
							30 5
1	A			ACP 16.00	0.95	1.50	2.00
2	B			ASPH STAB BASE 11.00	0.85	2.00	8.50
2	X			EXISTING BASE 0.00	0.46	14.00	14.00
3	X			EXISTING BASE 0.00	0.46	14.00	14.00
						100.0	
						100.0	
				SUBGRADE	0.24		

ALTHOUGH THE NUMBER OF MATERIALS WAS AS GREAT AS IN PROBLEM T-1, NOTE THAT PROBLEM T-2 REQUIRED LESS THAN 20 PERCENT OF THE COMPUTER TIME AS THE PREVIOUS PROBLEM PRIMARILY BECAUSE OF THE LESSER NUMBER

PROBLEM T-4

COLUMN NUMBERS							
1	2	3	4	5	6	7	8
.....5.....0.....5.....0.....5.....0.....5.....0.....5.....0.....							
-----						5.....0.....5.....0	

T-4 SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. -----

1	2	20.0	12.0	6		
26.00	4.20	4.20	3.0	1.50	0.08	
					0.03	
15000.	25000.	3.45E+06	5.5	2		
2.0	5.0	30.0	30.0	100.	26.	
					0.5	10.
75.0	2.0	1.00	0.	1.10	8.	
					2	3
10.0	0.0	.0167	0.0	50.0	30.0	
					50.0	5
25.0	10.0	1500.0	6.0			
1	A	ASPHALTIC CONCRETE	24.0	0.90	1.0	1.0
					25.0	
1	A	ASPHALTIC CONCRETE	24.0	0.90	6.0	6.0
					25.0	
2	S	CRUSHED STONE	4.0	0.65	4.0	4.00
					100.0	
2	S	CRUSHED STONE	4.0	0.65	20.	20.0
					100.0	
3	G	GRAVEL-1	3.0	0.35	20.	20.
					80.0	
3	G	GRAVEL-1	3.0	0.35	6.0	6.0
					80.0	
		SUBGRADE		0.240		

THIS SET OF DATA, SIMILAR TO PROBLEM T-3, SHOWS A METHOD OF OBTAINING INFORMATION ON A WIDE RANGE OF PAVEMENT MATERIAL THICKNESSES. THIRTY PAGES OF OUTPUT WERE PRODUCED BY THIS SET OF DATA COVERING EXTREMES IN MATERIAL THICKNESSES AT A COST IN COMPUTER TIME OF LESS THAN FIVE SECONDS.

SLIGHTLY MORE INFORMATION WOULD HAVE BEEN OBTAINED AT A LOW COST IF THE MAXIMUM AND MINIMUM THICKNESSES, INSTEAD OF BEING IDENTICAL ON EACH MATERIAL CARD, HAD A DIFFERENCE OF AT LEAST ONE INCREMENT. THE CONSTRAINT MESSAGES WOULD THEN HAVE INDICATED WHETHER THE OPTIMUM LAY BETWEEN THE THICK LAYER AND THE THIN LAYER.

THE FOLLOWING TWO CROSS-REFERENCE TABLES ARE DESIGNED TO AID THE PROGRAMER OR ANALYST TO ALTER ONE PORTION OF THE PROGRAM WITHOUT CAUSING UNKNOWN OR DISASTROUS EFFECTS ON OTHER PORTIONS OF THE PROGRAM.

1. SUBPROGRAM AND MAIN CROSS REFERENCE TABLE.

EACH SUBROUTINE AND FUNCTION CALL IS LISTED DOWN THE LEFT WITH AN 'X' UNDER THE COLUMN FOR THE MAIN OR SUBPROGRAM WHICH REFERENCES THAT SUBPROGRAM WHICH WAS CALLED.

THE FORTRAN LANGUAGE ALSO IMPLIES CERTAIN FUNCTION CALLS AND THEIR NAMES MAY DIFFER DEPENDING ON THE COMPUTER SYSTEM. THE NAMES SHOWN ARE THOSE BY THE IBM OS/360 SYSTEM. IBCOM IS THE IBM FORTRAN INPUT-OUTPUT SUBPROGRAM. FRXPI AND FRXPR ARE IMPLICIT FUNCTIONS CALLED FOR FLOATING POINT AND INTEGER EXPONENTIALS RESPECTIVELY.

2. COMMON VARIABLES CROSS REFERENCE TABLE.

THIS TABLE LISTS EACH OF THE VARIABLES IN COMMON AND IDENTIFIES THE PROGRAM OR PROGRAMS WHICH USE THOSE VARIABLES AND WHETHER THEY ARE JUST REFERENCED (FETCHED) AND/OR IF THE PROGRAM STORES A NEW VALUE. SUBROUTINE CALLING ARGUMENTS WHICH ARE ALSO IN COMMON ARE IDENTIFIED.

BELOW IS A TABLE SHOWING THE EXTERNAL REFERENCES OF EACH OF THE PROGRAMS.

```
*****
*                                CALLING PROGRAM NAME
*
CALLED *****
EXTERNAL*
NAME      *      I      S      O      O      S      H      L
          *      O      O      U      V      U      E      A
          *      M      N      L      T      R      C      U      T      P      S      M      A      Y
          *      A      P      V      P      L      A      S      I      W      E      A      D      I
          *      I      U      E      U      A      L      E      M      R      A      R      N      D
          *      N      T      Z      T      Y      C      R      E      M      L      Y      G      X
*****
```

INPUT X

SOLVE2 X

OUTPUT X

OVLAY X

CALC X X

USER X

TIME X

PWRM X

SEAL X

SUMARY X

HEADNG X X X

LAYIDX X

----- REFERENCES TO COMMON -----

BLANK X X X X X X X X

----- EXPLICIT FORTRAN AND LIBRARY REFERENCES -----

EXP X X X

SQRT X

----- I B M IMPLIED FORTRAN LIBRARY REFERENCES -----

FRXPI X X X X

FRXPR X X

IBCOM X X X X X X

F = FETCH FOR COMPUTATION OR PRINTING
 S = STORE A NEW VALUE IN CORE
 A = CALLING ARGUMENT USED IN A SUBROUTINE CALL

VARI-	*	PROGRAM NAME							
ABLES	*****	*****							
IN	*			S	O	O			
COM-	*		I	O	U	V			
MON	*	M	N	L	T	R	C	U	T
	*	A	P	V	P	L	A	S	I
	*	I	U	E	U	A	L	E	M
	*	N	T	2	T	Y	C	R	E

A	S	---	---	---	---	F	---	---	---
AAS	---	SF	---	---	---	---	F	---	---
ACCD	---	SF	---	---	---	---	F	---	---
ACPR	---	SF	---	---	---	---	F	---	---
ALPHA	---	SF	---	F	---	---	---	---	F
AN2	A	SFA	---	A	---	---	---	---	---
ASN	---	SF	---	---	---	---	F	---	---
ASO	---	SF	---	---	---	---	F	---	---
B	SF	---	---	---	---	F	---	---	---
BB	SF	---	---	---	---	---	---	---	---
B ONE	---	SF	---	---	F	---	---	---	---
CINT	S	---	---	---	---	F	---	---	---
CL	---	SF	F	---	AF	---	---	---	F
CMAx	---	SF	F	---	---	---	---	---	---
COST	S	---	F	---	F	---	---	---	---
C1	---	S	---	---	A	---	---	---	---
C2	---	S	---	---	A	---	---	---	---

VARI-	*	PROGRAM NAME							
ABLES	*****	*****							
IN	*			S	O	O			
COM-	*		I	O	U	V			
MON	*	M	N	L	T	R	C	U	T
	*	A	P	V	P	L	A	S	I
	*	I	U	E	U	A	L	E	M
	*	N	T	2	T	Y	C	R	E

DATA	F	SF	---	F	---	---	---	---	---
DN2	---	SF	---	---	---	---	F	---	---
DO2	---	SF	---	---	---	---	F	---	---
DMAX	S	---	F	F	---	---	---	---	---
DMIN	S	---	F	F	---	---	---	---	---
DOVER	---	---	SF	SF	FS	F	---	---	---
GAMMA	---	SF	---	---	---	---	---	F	---
HPD	---	SF	---	---	---	---	F	---	---
INDEX	SF	---	---	F	---	---	---	---	---
IPAGE	A	SA	---	A	---	---	---	---	---
ITYPE	---	SF	---	---	---	---	F	---	---
KT	S	---	SF	F	SF	---	---	---	---
LAYER	SF	---	F	F	F	F	---	---	---
MATYPE	SF	---	---	---	---	---	---	---	---
MODEL	---	SF	---	---	---	---	F	---	---
NLO	---	SF	---	---	---	---	F	---	---
NLRN	---	SF	---	---	---	---	F	---	---
NLRO	---	SF	---	---	---	---	F	---	---
NM	F	SF	---	F	---	---	---	---	---
NMB	FA	SF	---	---	F	---	---	---	---
NPROB	A	SFA	---	A	---	---	---	---	---

VARI-	*	PROGRAM NAME							
ABLES	*****	*****							
IN	*			S	O	O			
COM-	*		I	O	U	V			
MON	*	M	N	L	T	R	C	U	T
	*	A	P	V	P	L	A	S	I
	*	I	U	E	U	A	L	E	M
	*	N	T	2	T	Y	C	R	E

OV COST	---	S	---	---	F	---	---	---	
OV INC	---	S	---	---	F	---	---	---	
OV MAX	---	SF	---	F	F	---	---	---	
OV MIN	---	SF	---	---	F	---	---	---	
OVSALV	---	S	---	---	F	---	---	---	
OVSTR	---	S	---	---	F	---	---	---	SEE NOTE
PN2	---	SF	---	---	---	---	F	---	
PO2	---	SF	---	---	---	---	F	---	
PROP	---	SF	---	---	---	---	F	---	
PSI	---	SF	---	---	F	---	---	---	
PSVGE	S	---	---	---	F	---	---	---	
P1	---	SF	---	---	F	---	---	F	
P2	---	SF	---	---	---	---	---	F	
P2P	---	SF	---	---	---	---	---	F	
RATE	---	SF	---	---	AF	---	F	---	
RC	---	SF	---	---	F	---	---	F	
RO	---	SF	---	---	F	---	---	F	
SC	---	SF	---	---	---	---	---	---	
SCC	---	S	---	---	A	---	---	---	

NOTE

OVSTR IS REFERENCED ONLY FOR PRINTING IN FPS-9 BUT IS INCLUDED IN COMMON FOR PLANNED FUTURE CHANGES IN FPS. FPS-9 AND EARLIER VERSIONS OF FPS USE THE STRENGTH OF THE FIRST LAYER AS THE OVERLAY STRENGTH COEFFICIENT.

VARI-	PROGRAM NAME								
ABLES	*****								
IN	*			S	O	O			
COM-	*		I	O	U	V			
MON	*	M	N	L	T	R	C	U	T
	*	A	P	V	P	L	A	S	I
	*	I	U	E	U	A	L	E	M
	*	N	T	Z	T	Y	C	R	E

TBSC	---	S	---	A	---	---	---	---	---
TCKMAX	---	SF	F	F	---	---	---	---	---
TMIN	---	S	---	---	A	---	---	---	---
TT	---	---	---	---	SAF	---	---	---	---
TTSC	---	S	---	A	---	---	---	---	---
UPLEVL	---	S	---	F	F	---	F	---	---
XINC	S	---	FS	F	---	---	---	---	---
XLSD	---	SF	---	---	---	---	F	---	---
XL SN	---	SF	---	---	---	---	F	---	---
XL SO	---	SF	---	---	---	---	F	---	---
XNC	---	SF	---	---	---	---	---	F	---
XTBO	---	SF	---	---	---	---	---	F	---
XTTO	---	SF	---	F	---	---	---	F	---
Z	---	---	S	F	---	---	---	---	---

THE NAME DICTIONARY DOCUMENTS EACH OF THE VARIABLES IN COMMON AND THOSE PASSED AS SUBROUTINE ARGUMENTS. VARIABLES LOCAL ONLY TO A GIVEN SUBPROGRAM MAY BE MORE EASILY DOCUMENTED WITH COMMENT CARDS IN THE PROGRAM LISTING.

SIGNIFICANT DIFFERENCES IN THE USE OF A VARIABLE IN THIS AND PREVIOUS VERSIONS OF FPS ARE NOTED.

THE UNITS, SUCH AS FEET OR YEARS, WHICH EACH VARIABLE IS ASSUMED IN THE PROGRAM ARE GIVEN WITH A NOTATION IF DIFFERENT FROM EARLIER VERSIONS OF THE FPS PROGRAM. THE SECTION ON DEFINITION OF TERMS MAY BE USED FOR GENERAL INFORMATION OF THE UNITS OF MEASURE FOR THE VARIABLES.

- A AN ARRAY OF STRENGTH COEFFICIENTS FOR EACH MATERIAL IN A DESIGN SELECTED FROM THE DATA ARRAY USING THE INDEX ARRAY IN 'MAIN' FOR USE BY 'CALC'.
- AAS THE AVERAGE APPROACH SPEED TO THE OVERLAY AREA, ASSUMED TO BE THE SAME FOR BOTH DIRECTIONS (MILES PER HOUR).
- ACCD ASPHALTIC CONCRETE COMPACTED DENSITY (TONS PER COMPACTED CUBIC YARD).
- ACPR ASPHALTIC CONCRETE OVERLAY MATERIAL PRODUCTION RATE (TONS PER HOUR)
- ADT ONE-DIRECTION AVERAGE DAILY TRAFFIC AT A GIVEN POINT IN TIME, CALCULATED IN 'OVRLAY', FOR 'USER' SUBROUTINE.
- ALPHA THE DISTRICT OR REGIONAL TEMPERATURE CONSTANT.
- AMINCT THE PRESENT WORTH OF THE TOTAL COST FOR THE BEST OVERLAY POLICY FOR AN INITIAL DESIGN.
- AN2 AN ARRAY(16 WORDS) OF ALPHANUMERIC CHARACTERS ASSOCIATED WITH THE PAVEMENT SYSTEM, USED FOR PAGE HEADINGS.
- ASN THE AVERAGE SPEED THROUGH THE OVERLAY AREA, IN THE NON-OVERLAY DIRECTION. (MILES PER HOUR)
- ASO THE AVERAGE SPEED THROUGH THE OVERLAY AREA, IN THE OVERLAY DIRECTION. (MILES PER HOUR)
- B AN ARRAY OF TERMS FOR THE SCI EQUATION, SELECTED FROM ARRAY BB IN 'MAIN' FOR USE BY 'CALC'.
- BB AN ARRAY, ONE TERM OF THE SCI EQUATION FOR EACH MATERIAL.
- BCOST THE CALCULATED COST PER SQUARE YARD OF THE BEST OVERLAY POLICY WITH EACH DESIGN.

BDEXT AN ARRAY OF OVERLAY THICKNESSES FOR THE BEST OVERLAY POLICY.

BI SWELLING CLAY TERM FOR THE PERFORMANCE EQUATION, CALCULATED IN 'OVLAY' AND 'OUTPUT', USED IN 'TIME'.

BIP ACCUMULATED SURFACE CURVATURE TERM DUE TO SWELLING CLAY, CALCULATED IN 'TIME', USED IN 'OUTPUT' AND 'OVLAY' TO CALCULATE THE NEXT BI TERM.

BONE NON-TRAFFIC DETERIORATION PARAMETER, THE CONSTANT WHICH DETERMINES THE EFFECT THAT SWELLING CLAY WILL HAVE UPON THE SERVICEABILITY LOSS OF THE PAVEMENT DURING A FINITE TIME INTERVAL.

BPOCCT PRESENT WORTH OF OVERLAY CONSTRUCTION COST FOR THE BEST OVERLAY POLICY FOR A GIVEN INITIAL DESIGN.

BPRM THE PRESENT WORTH VALUE OF THE ROUTINE MAINTENANCE FOR THE BEST OVERLAY POLICY (PRESENT VALUE DOLLARS PER SQUARE YARD).

BPTUC THE PRESENT WORTH VALUE OF TOTAL USER-COSTS FOR THE BEST OVERLAY POLICY. (PRESENT WORTH DOLLARS PER SQUARE YARD).

BPWSCC THE PRESENT WORTH VALUE OF SEAL COAT COSTS FOR THE BEST OVERLAY POLICY (PRESENT VALUE DOLLARS PER SQUARE YARD).

BSAL THE PRESENT WORTH OF THE SALVAGE VALUE TO BE SUBTRACTED FROM OTHER COSTS FOR THE BEST OVERLAY POLICY OF A DESIGN.

BTSC AN ARRAY OF TIME PERIODS BETWEEN SEAL COATS FOR THE BEST OVERLAY POLICY (YEARS).

BTT AN ARRAY OF PERFORMANCE TIME PERIODS (SET EQUAL CORRESPONDING TT ITEM) FOR THE BEST OVERLAY POLICY (YEARS).

CINT THE FIRST TERM IN THE SCI EQUATION, CALCULATED IN 'MAIN' AND USED BY 'CALC'.

CL THE LENGTH OF THE ANALYSIS PERIOD IN YEARS.

CMAX THE MAXIMUM COST PER SQUARE YARD THAT IS TO BE ALLOWED FOR INITIAL CONSTRUCTION (DOLLARS).

CM1 ANNUAL ROUTINE MAINTENANCE COST PER LANE MILE FOR THE FIRST YEAR AFTER CONSTRUCTION OF AN OVERLAY (VERSION 9, SEE C1).

CM2 ANNUAL INCREMENTAL INCREASE IN ROUTINE MAINTENANCE COST PER LANE MILE(VERSION 9, SEE C2).

CODE AN ALPHABETIC CODE LETTER, FOR DATA, ASSOCIATED WITH EACH LAYER OF THE CURRENT DESIGN.

COST THE COST PER UNIT OF THICKNESS OF THE JTH LAYER. COST(J) DETERMINED FROM DATA(,9) USING INDEX AND ILAYER.

- C1 FIRST YEAR MAINTENANCE COST PER SQUARE YARD FOR THE FIRST YEAR AFTER CONSTRUCTION OF AN OVERLAY, CALCULATED FROM CM1.
- C2 ANNUAL INCREMENTAL INCREASE IN ROUTINE MAINTENANCE COST PER SQUARE YARD.
- DATA AN ARRAY WITH A ROW(1ST SUBSCRIPT) FOR EACH MATERIAL. SEE ALSO ILAYER.
SOME VERSIONS OF FPS DIFFER IN THE USE OF THE DATA ARRAY.
DATA(,1) IS THE INCREMENT IN THICKNESS OF THE MATERIAL.
DATA(,2) IS A ONE CHARACTER ALPHANUMERIC PRINTED OUT FOR REFERENCE IN 'SUMARY'.
DATA(,3), THRU ,DATA(,8) IS 18 ALPHANUMERIC CHARACTERS ASSOCIATED WITH EACH MATERIAL.
DATA(,9) THE IN-PLACE COST PER COMPACTED CUBIC YARD.
DATA(,10) THE STRENGTH COEFFICIENT FOR THE THIS MATERIAL.
DATA(,11) THE MINIMUM LAYER THICKNESS.
DATA(,12) THE MAXIMUM LAYER THICKNESS.
DATA(,13) THE SALVAGE VALUE PERCENTAGE FOR THIS MATERIAL.
- DELD THE OVERLAY THICKNESS (YARDS, EARLIER VERSIONS INCHES).
- DDN2 THE SAME AS DN2, SOME VERSIONS OF FPS.
- DDO2 THE SAME AS DO2, SOME VERSIONS OF FPS.
- DMAX AN ARRAY, ONE MAXIMUM LAYER THICKNESS PER LAYER, FOR THE CURRENT DESIGN (YARDS, EARLIER VERSIONS INCHES).
- DMIN AN ARRAY, ONE MINIMUM LAYER THICKNESS PER LAYER, FOR THE CURRENT DESIGN (YARDS, EARLIER VERSIONS INCHES).
- DN2 AVERAGE TIME STOPPED (IN HOURS) OF VEHICLES TRAVELING IN THE NON-OVERLAY DIRECTION BY OVERLAY EQUIPMENT AND PERSONNEL.
- DOVER AN ARRAY OF CALCULATED LAYER THICKNESSES FOR A DESIGN (YARDS, EARLIER VERSIONS INCHES).
- DO2 AVERAGE TIME STOPPED (IN HOURS) OF VEHICLES TRAVELING IN THE OVERLAY DIRECTION BY OVERLAY EQUIPMENT AND PERSONNEL IN THE RESTRICTED ZONE.
- GAMMA A SWELLING CLAY PARAMETER USED BY 'TIME' IN CALCULATION OF SERVICEABILITY LOSS OVER TIME.
- HPD THE NUMBER OF HOURS PER DAY THAT OVERLAY CONSTRUCTION TAKES PLACE.
- I THE NUMBER OF PERFORMANCE PERIODS AS USED IN 'OVRLAY', 'TIME', AND PORTIONS OF 'OUTPUT'.
- IBT THE NUMBER OF PERFORMANCE PERIODS OF THE BEST OVERLAY POLICY.

ICOST A FLAG WHICH IS CHANGED FROM ZERO TO ONE IN 'SOLVE2' IF AN INITIAL DESIGN IS MORE EXPENSIVE THAN CMAX (MAXIMUM ALLOWABLE COST FOR INITIAL DESIGN).

IDUMMY A TEMPORARY ARRAY USED TO PRINT VALUES FROM THE POLICY ARRAY IN INTEGER FORM.

ILAYER AN ARRAY, ASSOCIATED WITH A MATERIAL PROPERTY IN THE DATA ARRAY, WHICH IS THE LAYER NUMBER IN WHICH THE MATERIAL MAY BE USED. (LAYER 1 IS THE TOP LAYER)

INDEX AN ARRAY USED FOR LAYER INDEXING AND POINTS TO THE MATERIAL IN THE DATA ARRAY FOR EACH LAYER USED IN A DESIGN.

IPAGE A PAGE COUNTER USED FOR HEADINGS.

IPOSS AN ARRAY OF NMDGN(THE DESIGN NUMBER) OF DESIGN TYPES WHICH HAVE AN OPTIMUM DESIGN (ONE OR MORE FEASIBLE COMPLETE DESIGNS).

ISKIP A FLAG WHICH IS CHANGED FROM ZERO TO ONE BY 'SOLVE2' IF AN INITIAL DESIGN IS THICKER THAN TCKMAX (TOTAL THICKNESS ALLOWED).

ISW A FLAG SET NON-ZERO IN 'TIME' TO INDICATE AN OVERLAY OR INITIAL DESIGN LIFE LESS THAN THE MINIMUM TIME TO THE NEXT OVERLAY.

ISWOV A FLAG SET EQUAL ISW IN 'OVLAY' IF ANY OVERLAY OF THE CURRENT DESIGN WAS INCREASED IN DEPTH BECAUSE OF ISW. THIS FLAG IS USED TO DETERMINE CONSTRAINTS OF THE BEST DESIGN.

ITIME INTEGER OF TPRIM, ROUNDED TO THE NEAREST YEAR.

ITYPE A CODE FOR THE TYPE OF ROAD (RURAL OR URBAN) FOR THIS DESIGN.
ITYPE=1 DESIGNATES A RURAL ROAD
ITYPE=2 DESIGNATEA AN URBAN ROAD

KNTOL WITHIN A PROBLEM, THE NUMBER OF COMPLETED FEASIBLE DESIGNS (FEASIBLE INITIAL DESIGNS WITH A FEASIBLE OVERLAY POLICY), INITIALIZED IN 'MAIN', COUNTED IN 'OUTPUT'.

KOUNT A COUNTER WHICH DEEPS TRACK OF THE NUMBER OF FEASIBLE INITIAL DESIGNS FOR A GIVEN DESIGN TYPE.

KT AN ARRAY OF COUNTERS, INITIALIZED FOR EACH DESIGN TYPE, USED IN THE OUTPUT OF THE PROGRAM ACTIVITY REPORT IN FPS-9.
KT(1) INITIAL DESIGNS
KT(2) FEASIBLE INITIAL DESIGNS
KT(3) OVERLAYS
KT(4) FEASIBLE OVERLAYS
KT(5) OVERLAY POLICIES
KT(6) FEASIBLE OVERLAY POLICIES

KT(7) FEASIBLE COMPLETE DESIGNS.

- LAST A FLAG WHICH IS SET NON-ZERO BY SUBROUTINE 'INPUT' TO SIGNAL THE END OF DATA.
- LAYER A COUNTER USED FOR THE NUMBER OF LAYERS (EXCLUDING SUBGRADE) FOR EACH DESIGN. THE MAXIMUM VALUE OF LAYER EQUAL MATYPE.
- LP1 THE NUMBER OF LAYERS IN A DESIGN PLUS ONE, THE SUBGRADE SUBSCRIPT VALUE.
- MATYPE A LIMIT, USED IN 'MAIN', ON THE NUMBER OF LAYERS IN A DESIGN, THE VALUE OF THE LAST LAYER UNDER CONSIDERATION AT THIS STEP (EXCLUDING SUBGRADE).
- MODEL THE MODEL NUMBER WHICH DESCRIBES THE TRAFFIC SITUATION.
- NBSC THE NUMBER OF SEAL COATS FOR THE BEST OVERLAY POLICY.
- NDP THE NUMBER OF DESIGNS PER SUMMARY PAGE.
- NK THE NUMBER OF DESIGN TYPES WITH AN OPTIMUM DESIGN (ONE OR MORE FEASIBLE COMPLETE DESIGNS).
- NLO NUMBER OF LANES IN ONE-DIRECTION (NORMAL OPERATION). USED FOR TRAFFIC MODELS 3, 4, AND 5 IN 'USER'. FOR THESE MODELS NLO MUST RANGE BETWEEN 2 AND 6 LANES (INCLUSIVE). EARLIER VERSIONS OF FPS ASSUMED NLO TO BE NLRO+1.
- NLRN THE NUMBER OF OPEN LANES IN THE NON-OVERLAY DIRECTION IN THE RESTRICTED ZONE. MUST NOT BE LESS THAN 1 NOR GREATER THAN 6.
- NLRO THE NUMBER OF OPEN LANES IN THE OVERLAY DIRECTION IN THE RESTRICTED ZONE.
- NM THE TOTAL NUMBER OF MATERIALS AVAILABLE, EXCLUDING SUBGRADE.
- NMB THE NUMBER OF OUTPUT PAGES FOR THE PROBLEM SUMMARY OF BETTER DESIGNS (NDP DESIGNS PER PAGE).
- NMBEST THE NUMBER OF BETTER DESIGNS TO BE PRINTED IN THE SUMMARY.
- NMBT THE NUMBER OF 4 CHARACTER WORDS OF LITERAL '****' TO BE USED AS LINES IN THE SUMMARY TABLES.
- NMDGN A COUNTER, USED IN 'MAIN' AND 'OUTPUT' THAT KEEPS COUNT OF THE DESIGN NUMBER FOR THE MATERIALS UNDER CONSIDERATION.
- NMP THE NUMBER OF MATERIAL PROPERTIES, INCLUDING SUBGRADE.
NMP = NM+1
- NN AN ARRAY, USED FOR LAYER INDEXING IN 'MAIN'.

NOK A FLAG RETURNED FROM 'OVRLAY'.
NOK=0 A FEASIBLE OVERLAY POLICY WAS NOT POSSIBLE WITHIN THE CONSTRAINTS.
NOK=1 MINIMUM TIME TO FIRST OVERLAY CONSTRAINT COULD NOT BE MET BY AN INITIAL DESIGN.
NOK=2 THE BEST OVERLAY POLICY WAS DETERMINED.

NPOS THE NUMBER OF DESIGN TYPES WITH NO FEASIBLE COMPLETE DESIGNS.

NPOSS AN ARRAY OF NMDGN(THE DESIGN NUMBER) OF DESIGN TYPES WITH NO FEASIBLE COMPLETE DESIGNS.

NPROB AN ALPHANUMERIC LITERAL ASSOCIATED WITH THE PROBLEM, USED FOR PAGE HEADINGS.

NSC THE NUMBER OF SEAL COATS DURING A GIVEN PERIOD, CALCULATED IN SUBROUTINE 'SEAL'.

NUMBER A COUNTER OF THE NUMBER OF FEASIBLE INITIAL DESIGNS AS DETERMINED BY 'SOLVE2'.

OCOST AN ARRAY OF COSTS PER SQUARE YARD(ONE FOR EACH IPOSS) CALCULATED FOR EACH DESIGN WITH A POSSIBLE COMBINATION OF MATERIALS.

OMININ AN INPUT VALUE, THE MINIMUM THICKNESS OF AN OVERLAY IN INCHES, CONVERTED TO YARDS FOR OVMIN.

OVCOST THE OVERLAY IN-PLACE COST (DOLLARS PER CUBIC YARD, EARLIER VERSIONS OF FPS IN DOLLARS PER SQUARE YARD ONE INCH THICK).

OVINC THE INCREMENT IN OVERLAY THICKNESS, NOMINALLY 1/2 INCH (EXPRESSED IN YARDS IN FPS-9, EARLIER VERSIONS AS A CONSTANT).

OVMAX THE ACCUMULATED MAXIMUM THICKNESS OF ALL OVERLAYS (YARDS, EARLIER VERSIONS IN INCHES).

OMAXIN AN INPUT VALUE, THE ACCUMULATED MAXIMUM THICKNESS OF ALL OVERLAYS, IN INCHES, CONVERTED TO YARDS FOR OVMAX.

OVMIN THE MINIMUM THICKNESS OF AN INDIVIDUAL OVERLAY (YARDS, EARLIER VERSIONS IN INCHES).

OVSALV THE PROPORTION OF THE OVERLAY COST WHICH HAS A SALVAGE VALUE (LESS THAN OR EQUAL ONE).

OVSTR THE OVERLAY STRENGTH COEFFICIENT OF THE MATERIAL.
SOME VERSIONS OF FPS ASSUME THE OVERLAY AS ADDED THICKNESS OF THE FIRST LAYER WITH THE SAME STRENGTH COEFFICIENT.

P INITIAL SERVICEABILITY INDEX, AT A GIVEN TIME EITHER PSI OR P1.

PCTRAT THE TIME VALUE OF MONEY EXPRESSED AS A PERCENTAGE FOR INPUT.

PCTRAT IS DIVIDED BY 100 TO OBTAIN RATE USED IN THE PROGRAM.

PN2 THE PROPORTION OF VEHICLES THAT WILL BE STOPPED IN THE NON-OVERLAY DIRECTION BECAUSE OF PERSONNEL OR EQUIPMENT.

POLICY AN ARRAY WITH A COLUMN (SECOND SUBSCRIPT) FOR EACH OF THE BETTER DESIGNS TO BE PRINTED IN THE SUMMARY TABLE. ROWS (FIRST SUBSCRIPT) OF THE POLICY ARRAY ARE PRESENT WORTH VALUES PER SQUARE YARD AND DESIGN SUMMARIES OF THE BETTER DESIGNS.

POLICY(1,) DESIGN NUMBER (NMDGN).
POLICY(2,) INITIAL CONSTRUCTION COST.
POLICY(3,) OVERLAY CONSTRUCTION COST.
POLICY(4,) USER COST.
POLICY(5,) SEAL COAT COST.
POLICY(6,) ROUTINE MAINTENANCE COST.
POLICY(7,) SALVAGE VALUE COST.
POLICY(8,) TOTAL COST.
POLICY(9,) NUMBER OF LAYERS.
POLICY(I+9,), I FROM 1 TO POLICY(9,) LAYER THICKNESSES.
POLICY(20,) NUMBER OF PERFORMANCE PERIODS.
POLICY(I+20,), I FROM 1 TO POLICY(20,) TIME OF EACH PERIOD.
POLICY(I+30,), I FROM 1 TO NO. OF OVERLAY THICKNESSES TO BE PRINTED THE OVERLAY THICKNESS.
POLICY(40,) NUMBER OF SEAL COATS.
POLICY(I+40,), I FROM 1 TO THE NUMBER OF SEAL COATS TO BE PRINTED THE LIFE OF THE SEAL COAT.

PO2 THE PROPORTION OF VEHICLES THAT WILL BE STOPPED IN THE OVERLAY DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT.

POCCT THE PRESENT VALUE OF THE TOTAL OVERLAY CONSTRUCTION COST FOR THE OVERLAY POLICY BEING EVALUATED.

PPN2 THE PERCENT OF VEHICLES THAT WILL BE STOPPED IN THE NON-OVERLAY DIRECTION BECAUSE OF PERSONNEL OR EQUIPMENT (VERSION 9, SEE PN2).

PPO2 THE PERCENT OF VEHICLES THAT WILL BE STOPPED IN THE OVERLAY DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT (VERSION 9, SEE PO2).

PROP THE PROPORTION OF AVERAGE DAILY TRAFFIC WHICH WILL PASS THROUGH THE OVERLAY ZONE DURING EACH HOUR WHILE OVERLAYING TAKES PLACE (NORMALLY ABOUT 0.06 FOR RURAL AREAS, 0.055 FOR URBAN AREAS, AND ABOUT 0.042 IF TRAFFIC IS EVENLY DISTRIBUTED DURING THE 24 HOUR DAY).

PSI THE SERVICEABILITY INDEX OF THE INITIAL STRUCTURE.

PSVGE THE PROPORTION OF THE ORIGINAL COST WHICH CAN BE DEDUCTED FOR SALVAGE VALUE (MAGNITUDE LESS THAN ONE, BUT MAY BE

POSITIVE, NEGATIVE, OR ZERO, EARLIER VERSIONS OF FPS MAY BE A PERCENTAGE).

PWSCC PRESENT WORTH OF SCC, THE COST OF SEAL COATS.

PWTSY PRESENT WORTH OF USER COSTS PER SQUARE YARD, CALCULATED BY 'USER', AT TIME ITIME.

P1 THE BEGINNING SERVICEABILITY OF THE PAVEMENT AFTER AN OVERLAY. P1 IS SET THE SAME AS PSI IN FPS-9.

P2 THE MINIMUM ALLOWED VALUE OF THE SERVICEABILITY INDEX (POINT AT WHICH AN OVERLAY MUST BE APPLIED).

P2P P2 PRIME, A NON-TRAFFIC DETERIORATION PARAMETER, THE LOWER BOUND ON THE SERVICEABILITY INDEX WHICH WOULD BE ACHIEVED IN INFINITE TIME WITH NO TRAFFIC.

RATE THE INTEREST RATE OR TIME VALUE OF MONEY. IF INTEREST IS INPUT AS A PERCENT, SUCH AS 5.0 PERCENT, IT NEEDS TO BE CHANGED TO 0.05 FOR RATE AS USED IN INTEREST CALCULATIONS.

RMAINT THE PRESENT WORTH(PER SQUARE YARD) OF ROUTINE MAINTENANCE, CALCULATED BY 'PWRM'.

RC THE ONE-DIRECTION AVERAGE DAILY TRAFFIC AT THE END OF THE ANALYSIS PERIOD.

RO THE ONE-DIRECTION AVERAGE DAILY TRAFFIC AT THE BEGINNING OF THE ANALYSIS PERIOD.

R20 AN INPUT VALUE, THE ONE-DIRECTION AVERAGE DAILY TRAFFIC AT THE END OF A 20 YEAR PERIOD. RC IS THE SAME AS R20 IF THE ANALYSIS PERIOD IS 20 YEARS.

SC THE COST OF A SEAL COAT PER LANE MILE.

SCC THE COST OF A SEAL COAT PER SQUARE YARD.

SCI THE SURFACE CURVATURE INDEX, A CALCULATED VALUE (VARIABLE SS IN PORTIONS OF THE FPS PROGRAM).

SCOST COST PER SQUARE YARD, CALCULATED IN 'SOLVE2', OF AN INITIAL DESIGN.

SS THE SURFACE CURVATURE INDEX, SCI, CALCULATED BY 'CALC'.

T TIME TO LOSS OF SERVICEABILITY OF A DESIGN, CALCULATED BY 'TIME'.

TBSC THE MINIMUM TIME BETWEEN SEAL COATS.

TCKMAX THE MAXIMUM ALLOWABLE TOTAL THICKNESS OF INITIAL CONSTRUCTION

- TMAXIN AN INPUT VALUE, THE MAXIMUM THICKNESS OF ORIGINAL CONSTRUCTION IN INCHES, CONVERTED TO YARDS FOR TCKMAX.
- TMIN THE MINIMUM TIME IN YEARS BETWEEN A SEAL COAT AND AN OVERLAY. IT MAY BE AS SMALL AS ZERO.
- TPRIM TIME FROM INITIAL CONSTRUCTION TO THE PRESENT PERFORMANCE PERIOD OR OVERLAY (YEARS).
- TSC AN ARRAY OF THE TIME PERIODS BETWEEN SEAL COATS FOR A GIVEN DESIGN (YEARS).
- TT AN ARRAY OF T'S, FOR EACH PERFORMANCE PERIOD, THE TIME TO THE NEXT OVERLAY (YEARS).
- TTSC THE MINIMUM TIME TO THE FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONSTRUCTION (YEARS).
- UPEVL IT IS ASSUMED THAT EACH TIME THAT AN OVERLAY IS CONSTRUCTED THERE IS AN ADDITIONAL CHARGE, THE 'LEVEL-UP' COST EQUAL TO UPEVL THICKNESS OF OVERLAY, NOMINALLY ONE INCH (EXPRESSED IN YARDS). UPEVL IS NOT INCLUDED IN OVERLAY THICKNESS FOR MATERIAL STRENGTH CALCULATIONS, BUT IS INCLUDED IN PRODUCTION RATE AND COST CALCULATIONS.
- USERCT AN ARRAY OF PWTSY (USER COSTS) FOR EACH OVERLAY, OBTAINED IN 'OVLAY'.
- XIC COST OF AN INITIAL DESIGN, SUBROUTINE OUTPUT (DOLLARS).
- XINC AN ARRAY WITH THE INCREMENT IN LAYER THICKNESS FOR EACH LAYER OF AN INITIAL DESIGN, CALCULATED IN 'MAIN' AND /OR FROM THE DATA ARRAY.
- XLSD THE DISTANCE, MEASURED ALONG THE DETOUR, AROUND THE OVERLAY ZONE IN MILES.
- XLSN THE DISTANCE, MEASURED ALONG THE C.L., OVER WHICH TRAFFIC IS SLOWED IN THE NON-OVERLAY DIRECTION IN MILES.
- XLSD THE DISTANCE, MEASURED ALONG THE C.L., OVER WHICH TRAFFIC IS SLOWED IN THE OVERLAY DIRECTION IN MILES.
- XLW THE WIDTH OF EACH LANE(Feet).
- XN THE NUMBER (IN MILLIONS) OF EQUIVALENT 18-KIP AXLE EQUIVALENTS DURING TIME T, CALCULATED BY 'TIME'.
- XNC THE ONE-DIRECTION ACCUMULATED NUMBER OF EQUIVALENT 18-KIP AXLES DURING THE ANALYSIS PERIOD IN MILLIONS (EARLIER VERSIONS OF FPS HAD XNC IN UNITS WITH CONVERSION TO MILLIONS AS PART OF THE TRAFFIC EQUATION IN 'TIME').
- XNDKP ALPHANUMERIC CHARACTERS ASSOCIATED WITH MATERIALS OF A

DESIGN (FROM DATA(,2)) PRINTED FOR IDENTIFICATION IN THE SUMMARY TABLES.

- XNPRIM THE NUMBER OF 18-KIP EQUIVALENT AXLES DURING TPRIM, CALCULATED IN 'OVRLAY' AND 'OUTPUT', USED IN 'TIME' (MILLIONS, EARLIER VERSIONS UNITS).
- XN20 AN INPUT VALUE, THE NUMBER OF 18-KIP AXLE EQUIVALENTS ACCUMULATED IN 20 YEARS. CONVERTED BY THE TRAFFIC EQUATION TO OBTAIN XNC.
- XTBO THE MINIMUM ALLOWED TIME BETWEEN OVERLAYS PERMITTED (YEARS).
- XTTO THE MINIMUM ALLOWED TIME TO THE FIRST OVERLAY (YEARS).
- Z AN ARRAY OF INITIAL DESIGN INFORMATION BEFORE OVERLAY, ONE ROW (FIRST SUBSCRIPT) FOR EACH FEASIBLE INITIAL DESIGN CONSIDERED.
- Z(,1) SCI, SURFACE CURVATURE INDEX (SN, STRUCTURAL NUMBER IN EVEN NUMBERED VERSIONS OF FPS),
LIFE OF THE INITIAL DESIGN, SOME VERSIONS OF FPS.
- Z(,2) COST OF INITIAL DESIGN (DOLLARS PER SQUARE YARD).
- Z(,I+2) THE THICKNESS OF THE I'TH LAYER (YARDS).
(VALIDITY OF ROW SUBSCRIPT VALUES CHECKED IN 'SOLVE2').

THE FPS-9 PROGRAM HAS BEEN RUN ON AN IBM 360/65 COMPUTER, BUT AN EFFORT HAS BEEN MADE TO AVOID MACHINE DEPENDENT FORTRAN EXTENSIONS. EARLIER VERSIONS OF FPS HAVE BEEN RUN ON A CONTROL DATA CORPORATION MODEL 6600 COMPUTER WITH ONLY MODIFICATION OF THE 'END-OF-FILE' TEST STATEMENT.

THE CORE MEMORY REQUIREMENT IS 100K BYTES(USING FORTRAN-G). PROGRAM TESTING, WITH COMPARABLE RESULTS, HAS BEEN PERFORMED USING . .
IBM FORTRAN G
IBM FORTRAN H, WITH OPT =0 AND OPT=2
WATFIV (IN-CORE COMPILER DEVELOPED BY UNIVERSITY OF WATERLOO)

EXPERIMENTS WITH PROGRAM RUNNING TIME WERE MADE ON THE IBM 360/65 AT TEXAS A&M UNIVERSITY COMPUTING CENTER MAKING USE OF A SYSTEM SUBROUTINE 'ACTTIM' WHICH RETURNS TIME REMAINING IN A JOB STEP.

TIMING OF THE EARLIER VERSION OF FPS SHOWED THAT NEARLY ALL OF THE COMPUTER TIME IN RUNNING TEST PROBLEMS WAS SPENT IN 'OVRLAY'. MUCH OF THIS TIME WAS BY SUBROUTINE TIME WHEN CALLED FROM 'OVRLAY'. IN FPS-9 THE 'TIME' SUBROUTINE WAS REWRITTEN WHICH SPEEDED RUNNING CPU TIME IN TYPICAL PROBLEMS ABOUT 30 PERCENT.

THE PROBLEMS T-1, T-2, T-3, AND T-4 ON THE FOLLOWING TABLE ARE FROM THE SAMPLE DATA. THE COMPUTER TIMES GIVEN ARE FOR ELAPSED TIME AFTER THE PROGRAM IS IN EXECUTION AND DO NOT INCLUDE THE CPU TIME FOR COMPILING AND LOADING THE PROGRAM NOR DO THE TIMES INCLUDE CLEAN-UP AT THE END OF THE JOB

PROGRAM RUNNING TIME (CPU SECONDS) ON AN IBM 360/65
USING THE FORTRAN H COMPILER WITH OPTIMIZATION 'OPT=2'

PROB- LEM	DESIGN	CPU SEC.	INITIAL DESIGNS		OVERLAYS		OVERLAY POLICIES	
			ALL CONSIDERED		ALL	FEASIBLE	ALL	FEASIBLE
T-1	1 A	3.7	37	37	840	788	420	384
	2 AL	5.4	777	61	904	855	437	439
	3 ALG	22.0	9,960	221	2,570	2,453	1,388	1,286
	4 AG	36.6	555	292	8,285	7,765	4,186	3,860
	TOTAL*	69.0	11,329	611	12,599	11,861	6,431	5,969
T-2	1 A	0.1	3	3	0	0	0	0
	2 AB	4.3	81	81	1,010	906	531	427
	3 ABX	6.8	78	78	1,482	1,326	780	624
	4 AX	0.4	3	3	57	51	30	24
	TOTAL*	12.6	165	165	2,549	2,283	1,341	1,075
T-3	1 A	0.4	21	21	119	66	57	12
	2 AS	1.5	150	18	360	292	187	121
	3 ASG	1.5	383	15	333	266	172	109
	TOTAL*	4.0	554	36	812	624	416	242
T-4	1 A	0.1	1	1	0	0	0	0
	2 AS	0.1	1	1	0	0	0	0
	3 ASG	0.4	1	1	53	51	27	25
	4 ASG	0.9	1	1	149	137	73	65
	5 AS	0.3	1	1	41	39	21	19
	6 ASG	0.1	0	0	0	0	0	0
	7 ASG	0.1	0	0	0	0	0	0
	8 A	0.6	1	1	130	121	64	58
	9 AS	0.3	1	1	41	39	21	19
	10 ASG	0.1	0	0	0	0	0	0
	11 ASG	0.4	1	1	41	39	21	19
	12 ASG	0.3	1	1	41	39	21	19
	13 ASG	0.1	0	0	0	0	0	0
	14 ASG	0.1	0	0	0	0	0	0
	TOTAL*	4.4	9	9	496	465	248	224

NOTES

* THE TOTAL CPU TIME GIVEN FOR A PROBLEM IS SLIGHTLY MORE THAN THE TOTAL OF EACH DESIGN SINCE THE PROBLEM TOTAL INCLUDES THE COMPUTER TIME READING IN THE DATA AND PRINTING THE PROBLEM SUMMARY.

THE FOLLOWING VARIABLES WITH FORTRAN DIMENSION AND COMMON STATEMENTS SHOULD BE CHECKED WHEN PLANNING CHANGES TO THE FPS PROGRAM TO PREVENT POTENTIAL ILLEGAL SUBSCRIPT VALUES AND STORING NUMBERS OUTSIDE THEIR ASSIGNED ARRAYS.

IF DIMENSIONS OF THE ARRAYS ARE DEFINED AS . . .

LAYD = MAXIMUM NUMBER OF LAYERS IN A DESIGN, EXCLUDING SUBGRADE.
NKD = MAXIMUM COUNT OF DESIGN TYPES WITH AN OPTIMAL DESIGN.
NMD = NUMBER OF MATERIALS EXCLUDING SUBGRADE.
NPERFD = MAXIMUM NUMBER OF PERFORMANCE PERIODS.
NPD = NUMBER OF ITEMS ALLOWED FOR EACH BETTER DESIGN (50 IN FPS-9).
NPOSD = MAXIMUM NUMBER OF DESIGN TYPES WITH NO FEASIBLE COMPLETE DESIGNS.
NSUMD = MAXIMUM NUMBER OF SUMMARY DESIGNS (BETTER DESIGNS).
NUMBRD = MAXIMUM FEASIBLE INITIAL DESIGNS (MAXIMUM 'NUMBER').

THE FOLLOWING ARRAYS SHOULD BE DIMENSIONED AS . . .

A(LAYD+1)
B(LAYD+1)
BB(NMD+1)
COST(LAYD)
DMAX(LAYD)
DMIN(LAYD)
DOVER(LAYD)
INDEX(LAYD)
IPOSS(NKD)
NMBMAT(LAYD)
NN(LAYD)
NPOSS(NPOSD)
OCOST(NKD)
POLICY(NPD,NSUMD)
PSVGE(LAYD)
TT(NPERFD)
XINC(LAYD)
Z(NUMBRD,LAYD+2)
XNDKP(LAYD,NSUMD)

NOTES

IN FPS-9, LAYD = 6, NKD=100, NMD=10, NPERFD=20, NPD = 50, NPOSD=100, NSUMD=24, AND NUMBRD=100.
ALL PROGRAM GENERATED VARIABLES, SUCH AS NUMBER, ARE CHECKED SO THAT SUBSCRIPTS NOT UNDER DIRECT CONTROL OF THE USER WILL BE VALID. HOWEVER, THE INPUT DATA SHOULD BE CAREFULLY CHECKED TO PREVENT PROGRAM FAILURE OR ILLOGICAL RESULTS.

THE FOLLOWING FEATURES OR CHANGES OF FPS - 9, AS COMPARED WITH EARLIER VERSIONS, SHOULD BE NOTED . . .

1. THE GAMMA TERM HAS BEEN ADDED TO THE DEFLECTION EQUATION.
2. DATA MAY BE INPUT ON TWENTY YEAR TRAFFIC ESTIMATES AND THE TRAFFIC EQUATION WILL CALCULATE DATA FOR ANALYSIS PERIODS OF ANY LENGTH. PREVIOUS VERSIONS REQUIRED TRAFFIC ESTIMATES AND ANALYSIS PERIODS TO BE OF IDENTICAL LENGTH.
3. CERTAIN INPUT DATA PREVIOUSLY REQUIRED RELATING TO TRAFFIC SPEEDS IS NO LONGER REQUIRED.
4. THE SEQUENCE AND FORMAT OF THE DATA CARDS WERE CHANGED.
5. THE PROGRAM CALCULATES THE TIME REQUIRED FOR OVERLAY FROM INPUT PRODUCTION RATES INSTEAD OF REQUIRING AN INPUT OF THE TIME REQUIREMENT SEPARATELY.
6. THE SUMMARY OF THE MOST OPTIMAL DESIGNS WAS CHANGED.
 - A. THE USER MAY INPUT THE NUMBER OF PAGES OF OPTIMAL DESIGN SUMMARIES DESIRED, EIGHT SUMMARIES PER PAGE (PREVIOUSLY THREE PAGE, 24 DESIGNS, ASSUMED).
 - B. NON-APPLICABLE DATA IS BLANK INSTEAD OF ZERO ON OUTPUT.
7. A LAYER NUMBER FOR EACH MATERIAL ON THE CARD WITH THE INPUT DATA ELIMINATES SOME OF THE COMPLEXITY IN THIS PORTION OF THE INPUT DATA.
8. ALL LINEAR, SQUARE, AND CUBIC MEASUREMENTS RELATED TO PAVEMENT WERE CONVERTED TO YARDS BEFORE PLACING IN COMMON. INPUT AND OUTPUT VALUES WERE NOT CHANGED.
9. OVERLAY INCREMENTS OF 1/2 INCH (IN YARDS) USED INSTEAD OF 1/4 INCH AS PREVIOUS VERSIONS.
10. TABLES OF USER COSTS IN 'SUBROUTINE USER' WERE EXPANDED AND UPDATED AS SHOWN IN THE APPENDIX ON USER COSTS.
11. THE SERVICEABILITY INDEX MUST BE THE SAME AS THE SERVICEABILITY INDEX AFTER AN OVERLAY IN THIS VERSION.
12. SUBROUTINE TIME HAS BEEN CHANGED TO DECREASE RUNNING TIME OF THE PROGRAM BY IMPROVING THE ITERATION SCHEME AND REMOVING CERTAIN CALCULATIONS OUTSIDE OF THE INNER DO LOOPS.
13. SEVERAL CHANGES WERE MADE IN THE OUTPUT INCLUDING . . .
 - A. DISTICTIONS BETWEEN DESIGN TYPES, PROBLEMS, INITIAL DESIGNS FEASIBLE, AND A CHANGE OF TERMINOLOGY TO BETTER DESIGNS INSTEAD OF BEST DESIGNS.
 - B. A PROGRAM EXECUTION REPORT WAS ADDED TO ENABLE THE USER TO HAVE SOME FEELING OF THE DESIGNS CALCULATED AS A RESULT OF THE INPUT DATA.

14. ALL VARIABLES IN COMMON WERE PLACED IN AN ALPHABETICAL ORDER.
15. SEVERAL POTENTIAL 'BUGS' IN THE PROGRAM WERE REMOVED BY CHECKING OF GENERATED SUBSCRIPT VALUES WHICH COULD CAUSE PROGRAM FAILURE.
16. SOME OF THE CONSTRAINT MESSAGES WERE CORRECTED.
17. FEASIBLE INITIAL DESIGNS WHICH ARE OF LESSER STRENGTH AT A HIGHER INITIAL COST ARE NOT CONSIDERED WITHIN A DESIGN TYPE.

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APPENDIX I

Documentation of Mathematical and Cost Formulas

The basic equations used in FPS-9 are given in this appendix with their location (MAIN or SUBROUTINE) given in the computer program. When applicable, both the FORTRAN variable name and the mathematical equation variable are given. FORTRAN variable names and subprogram names are given in capital letters to distinguish them from the mathematical variables.

This appendix is divided into the following sections:

Section 1 - Variables for Basic Equations

- A. Design Variables
- B. Deflection Variables
- C. Traffic Variables
- D. Performance Variables

Section 2 - Basic Equations

- A. Deflection Equation
- B. Traffic Equation
- C. Performance Equation

Section 3 - Evaluation of Swelling Clay Parameters

Section 4 - Costs used in the Computer Program

- A. Total
- B. Cost of Initial Construction
- C. Annual Routine Maintenance Costs
- D. Overlay Construction Cost
- E. Traffic Cost of Overlay
- F. Seal Coat Costs
- G. Salvage Value

Appendix I - Section 1
Variables for Basic Equations

A. Design Variables

A(J) a_i = the strength coefficient of the i^{th} layer of a pavement,
 $i = 1, 2, \dots, n + 1.$

DOVER(J) D_i = the thickness of the i^{th} layer in inches.
 (in yards) $D_{n+1} = \infty.$

B. Deflection Variables

W_j = the deflection sensed by the j^{th} sensor of the Dynaflect.

r_j = distance, in inches, from the point of application of either Dynaflect load, to the j^{th} sensor.

$$r_1^2 = 100. \quad r_2^2 = 244.$$

C. Traffic Variables

T or TPRIM t = time (years) since initial construction.

XN or XNPRIM N = total number of equivalent applications of an 18-kip axle that will have been applied in one direction during the time, t . N is expressed in millions.

CL C = length in years of the analysis period.

XNC $N_c = N$ when $t = C$.

XN $N_k = N$ when $t = t_k$ (defined below).

RO $r_o = \text{ADT (one direction) when } t = 0.$

RC $r_c = \text{ADT (one direction) when } t = C.$

D. Performance Variables

P P = the serviceability index at time, t .

PSI initial or P_1 if overlay P_1 = the expected maximum value of P , occurring only immediately after initial or overlay construction.

P2 P_2 = the specified value of P at which an overlay will be applied.

P2P P_2' , a swelling clay parameter = the assumed value of P at $t = \infty$, in the absence of traffic. In general,
 $0 \leq P_2' \leq P_1.$

BI

b_k = a swelling clay parameter applying to the k th performance period. A value between zero and 0.3 must be specified for b_1 , depending on the expected activity of foundation clays.

$$b_{k+1} = b_k e^{-b_k (t_k - t_{k-1})}$$

GAMMA

γ = a swelling clay parameter (constant) related to a component of the foundation movement that persists indefinitely. Specifically, $dP/dt = -\gamma$ serviceability units per year, in the absence of traffic at any time after b_k ($k > 1$) is small enough to be neglected.

T or TPRIM

t_k = the value of t at the end of the k th performance period, or the beginning of the next period.

$$t_0 = 0.$$

α , a daily temperature constant = $1/2$ (maximum daily temperature + minimum daily temperature) - 32°F .

ALPHA

$\bar{\alpha}$ = the effective value of α for a typical year in a given locality, defined by the formula for the harmonic mean--

$$\bar{\alpha} = \frac{n}{\sum_{i=1}^n \left(\frac{1}{\alpha_i} \right)}$$

where n is the number of days in a year, and α_i is the value of α for the i th day of the year. To obtain an approximate value of $\bar{\alpha}$ for this report, the formula was used with $n = 12$, and α_i = the mean value of α for the i th month averaged over a ten year period.

Appendix I - Section 2

Basic Equations

A. The Deflection Equation (MAIN and SUBROUTINE CALC)

The empirical equation used in this method for estimating the surface curvature index S from the design variables a_i and D_i was developed from deflection data gathered on the A&M Pavement Test Facility located at Texas A&M University's Research Annex near Bryan. A description of the facility is contained in Research Report 32-9 (reference 4). The equation is given below:

$$S = W_1 - W_2$$

$$\text{where } W_j = \sum_{k=1}^{n+1} \Delta_{jk}$$

$$\Delta_{jk} = \frac{C_0}{a_k^{c_1}} \left[\frac{1}{r_j^2 + C_2 \left(\sum_{i=0}^{k-1} a_i D_i \right)^2} - \frac{1}{r_j^2 + C_2 \left(\sum_{i=0}^k a_i D_i \right)^2} \right],$$

$$C_0 = 0.891,$$

$$C_1 = 4.503,$$

$$C_2 = 6.25,$$

$$a_0 = D_0 = 0,$$

and the other variables are as previously defined.

B. The Traffic Equation (SUBROUTINE TIME)

The Traffic Equation was furnished by Mr. James Brown of the Texas Highway Department and is given below in the form used in this method.

$$N_k = \frac{N_c}{C(r_o + r_c)} \left[2r_o t_k + \left(\frac{r_c - r_o}{C} \right) t_k^2 \right]$$

where the symbols are as previously defined.

C. The Performance Equation (SUBROUTINE TIME)

The empirical relationship between the performance variables used in this method was developed from AASHO Road Test data and then modified to include the swelling clay variables b_k (BI), P_2' (P2P), and γ (GAMMA) listed under performance variables and discussed more in detail next.

$$P = 5 - \left[\sqrt{5 - P_1} + \frac{53.6 (N_k - N_{k-1}) S^2}{\bar{\alpha}} + (\sqrt{5 - P_2'} - \sqrt{5 - P_1}) \right. \\ \left. (1 - e^{-b_k(t_k - t_{k-1})}) \right]^2 - \gamma (t_k - t_{k-1})$$

SUBROUTINE TIME solves for t by iteration until $|P - P_2| \leq \text{error}$, where error is an arbitrary small number.

Appendix I - Section 3
Evaluation of Swelling Clay Parameters

Until future research provides a link between laboratory swell tests and the performance curves of pavements, the designer will be compelled to rely upon experience and judgement in assigning values to the swelling clay parameters, P_2' , b_1 , and γ . Meanwhile the following guide lines are offered as an aid in evaluating these parameters.

P_2' is the value that P would reach in infinite time with no traffic, but since little or no data yet exists on which to base a judgement of what value P_2' should have, it is recommended that P_2' be assigned the value of zero for the present. Then, with P_2' fixed at zero, the following table may help in selecting a value for b_1 to represent a given area.

<u>Past Experience In Area</u>	<u>Value of b_1</u>
The accumulated effect of subgrade movements barely noticeable 12 to 15 years after construction	.02
The accumulated effect of subgrade movements noticeable 3 to 6 years after construction	.08
Severe heaving of subgrade noticeable within 1 year of construction	.32

The value $b_1 = 0$ is excluded since it is inconceivable that no subgrade movements whatever will occur during the life of a pavement.

GAMMA (γ) is the loss in P_2 expected per year and lasts throughout the design life at that rate. GAMMA would be 0.20 if a loss of 1.00 in

P was expected in five years, or, GAMMA would be 0.02 if only a 0.10 loss in P would be expected over a five year period at a constant rate as loss from swelling clay.

Appendix I - Section 4
Costs Used in the Computer Program

A. Total Cost

There are a number of cost considerations associated with the investment in a pavement. Other than initial construction, this investment is accumulated throughout the life of the structure in the form of different types of maintenance charges. At the end of the analysis period, the pavement will usually have some salvage value (although this may be a negative value). A complete list of these cost considerations with the location of the calculations may be outlined as follows:

- I. Initial construction cost (SUBROUTINE CALC)
- II. Future costs
 - A. Overlay costs
 - 1. Overlay construction costs (SUBROUTINE OVLAY)
 - 2. User costs due to traffic delays (SUBROUTINE USER)
 - B. Annual routine maintenance costs (SUBROUTINE PWRM)
 - C. Seal coat costs (SUBROUTINE SEAL)
- III. Salvage value (SUBROUTINE OVLAY)

The purpose of this chapter is to describe how each of these costs is computed.

Since the majority of these costs will be accrued in the future, their present worth values must be obtained for determining the present value of the total cost of the pavement.

The present value of the total cost may be computed as

$$TC = XIC + PRM + POCCT + PWSCC + SALVGE$$

where TC = the present worth value of the total cost.

XIC = the cost of initial construction.

PRM = the sum of the present worth values of annual routine maintenance cost.

POCCT = the sum of the present worth values of overlay construction and user costs.

PWSCC = the sum of the present worth values of seal coat costs.

SALVGE = the present worth of salvage value at the end of the analysis period.

A description of how each of these quantities is calculated will be given in following sections. The cost of each of the above quantities will be in terms of cost per square yard of pavement.

B. Cost of Initial Construction (SUBROUTINE SOLVE2)

The cost per compacted cubic yard in place for each material must be input into the computer program. The cost of initial construction for a design can then be computed as

$$XIC = \sum_{j=1}^n D_j C_j$$

where LAYER n = number of layers above the subgrade.

DOVER(K) D_j = depth of the j^{th} layer (yards)

COST(K) C_j = in-place cost/cubic yard of the material used in the j^{th} layer.

This initial construction cost is compared with the maximum cost constraint (CMAX) and if greater it is a "not-feasible" initial design, otherwise SOLVE2 stores it in the Z (j, 2) for the j^{th} initial design, and later fetched for XIC in SUBROUTINE OUTPUT.

C. Annual Routine Maintenance Costs (SUBROUTINE PWRM)

The cost of annual routine maintenance during each year after initial or overlay construction is assumed to increase at a uniform rate of the form

$$\text{ANNUAL COST} = C_1 + (m-1) C_2$$

where CM1 C_1 = routine maintenance cost/square yard during the first year after initial or overlay construction.

m = number of years after initial or overlay construction.

CM2 C_2 = incremental increase in routine maintenance cost/square yard per year.

The model that has been developed assumes that all costs occurring within a year are paid at the beginning of that year. After an overlay the cost of routine maintenance during the following year is again C_1 . The present value of all routine maintenance charges during the analysis period can be found from

$$RM = \sum_{m=1}^{M_1} \frac{C_1 + (m-1) C_2}{(1+i)^{m-1}} + \sum_{m=1}^{M_2} \frac{C_1 + (m-1) C_2}{(1+i)^{L_2+m-1}} + \dots + \sum_{m=1}^{M_K} \frac{C_1 + (m-1) C_2}{(1+i)^{L_K+m-1}}$$

where RM = present value of the total cost per square yard of all routine maintenance during the analysis period,

RATE i = interest rate.

N M_K = number of years in the k^{th} performance period = $t_k - t_{k-1}$, (= IT - ITIME) where t_k and t_{k-1} (T and TPRIM) are rounded to the nearest integer before M_K (N) is calculated.

K = number of performance periods within the analysis period.

$$L_K = \sum_{j=1}^{k-1} M_j$$

The last performance period is truncated to terminate at the end of the analysis period so that maintenance costs beyond the analysis period are not considered.

D. Overlay Construction Cost (SUBROUTINE OVLAY)

Calculation of the overlay construction cost amounts to no more than computing the present value of all future overlays. In general, it is assumed that overlays will be constructed from asphaltic concrete. It is also assumed that an overlay must be at least OVINC

thick, and that all overlays greater than OVINC must be in even increments of OVINC. OVINC is 1/2 inch (expressed in yards) in FPS-9.

The final assumption is that each time an overlay is constructed, there is an additional charge equal to the cost of UPLEVL thickness of overlay. This additional charge is included as a level-up cost. UPLEVL is one inch (expressed in yards) in FPS-9.

The present value of the total cost attributed to overlay construction is

$$OC = \sum_{k=1}^{K-1} \frac{C_1 O_k + C_1}{(1+i)^{t_k}}$$

where K-1 = number of overlays constructed in analysis period (there are K performance periods).

OVCOST C_1 = cost/cubic yard of asphaltic concrete.

DEXT(I) O_k = overlay thickness, not including the level-up increment, applied at the end of the k^{th} performance period (yards).

ITIME t_k = time (rounded to the nearest year) at the end of the k^{th} performance period, as previously defined.

RATE i = interest rate

E. Traffic Cost of Overlay (SUBROUTINE USER)

Subroutine USER calculates users' (or motorists') increase in costs due to overlaying operations.

Calculated from the inputs of production rate of asphalt in tons per hour (ACPR), and the density of the overlay in tons per cubic yards (ACCD), the time (in hours) for overlay operations per square yard of pavement (HPSY) is: (in FORTRAN)

$$\text{HPSY} = \text{ACCD} * (\text{DELD} + \text{UPLEVL}) / \text{ACPR}$$

where DELD = overlay thickness (yards),

UPLEVL = "level-up" increment (yards),

ACPR, ACCD and HPSY defined above.

Total user cost per hour (TUCH) is: (in FORTRAN)

$$\begin{aligned} \text{TUCH} = & \text{TIPH} * (\text{PO1} * (\text{CO1} + \text{CO2} + \text{CO3}) + (1.0 - \text{PO1}) * (\text{CO3} + \text{CO4}) + \text{PO2} * \text{CO5}) \\ & + \text{TIPH} * (\text{PN1} * (\text{CN1} + \text{CN2} + \text{CN3}) + (1.0 - \text{PN1}) * (\text{CN3} + \text{CN4}) + \text{PN2} * \text{CN5}) \end{aligned}$$

where O for overlay direction and N for non-overlay direction,

TIPH = vehicles per hour from each direction,

PO1 & PN1 = proportions of traffic, stopped because of congestion,

PO2 & PN2 = proportion of traffic stopped due to overlay personnel and equipment,

CO1 & CN1 = excess costs of stopping from highway speeds,

CO2 & CN2 = excess costs of vehicle idling time while stopped,

CO3 & CN3 = excess costs for reduced speed,

CO4 & CN4 = excess costs of changing speed,

CO5 & CN5 = excess costs due to delays from overlay personnel and equipment (stopping plus idling).

The total user cost per hour (TUCH) is calculated using one of five methods (MODEL), tables 1 to 5, appendix "User Cost Tables", and the present worth of total user costs of an overlay per square yard (PWTSY) is: (in FORTRAN)

$$\text{PWTSY} = (\text{HPSY} * \text{TUCH}) / ((1. + \text{RATE}) ** \text{ITIME})$$

where ITIME = rounded integer time of overlay (years)

RATE = interest rate

PWTSY, HPSY, and TUCH as previously defined.

The tables for calculating the excess costs by each of the five methods of handling traffic near the overlay zone (MODEL = 1, MODEL = 2, . . . , MODEL = 5) are given in the appendix "User Cost Tables" and are incorporated in the DATA statements in SUBROUTINE USER.

F. Seal Coat Costs (SUBROUTINE SEAL)

The model for the application of seal coats assumes that the design engineer will specify the cost per lane mile of applying a seal coat and a schedule of (1) the time in years before the first seal coat, τ_1 , and (2) the time in years between subsequent seal coats, τ_2 . These two times may be identical without loss of generality. This schedule is to initiate after initial construction and after each overlay.

It is assumed that a seal coat does not affect the serviceability index of the pavement. It is also assumed that a seal coat will not be applied within TMIN years prior to an overlay. TMIN is zero in FPS-9 (seal coats may occur up to the time of overlay).

The computer program first converts the seal coat cost to cost per square yard of pavement. The determination of the present value of all seal coats is actually rather simple to describe but rather complicated to formulate mathematically. The basic idea is that of taking the following sum:

$$SC = \sum_{j=1}^{NUM} \frac{SCC}{(1+i)^{Y_j}}$$

where SC = present value per square yard of all future seal coats,

SCC = cost/square yard of a seal coat,

RATE i = interest rate,

NUM = total number of seal coats,

TSC(NSC) y_j = year in which the j^{th} seal coat is applied.

To be more specific:

$$SC = \sum_{k=1}^K \sum_{j=1}^{J_k} \frac{SCC}{(1+i)^x}$$

where SC = present value per square yard of all future seal coats,

SCC SCC = cost per square yard of a single seal coat,

RATE i = interest rate,

I K = number of performance periods (which is equal to one plus the number of overlays within the analysis period)

POWER $x = [t_{k-1} + \tau_1 + (j-1)\tau_2]$, where t_{k-1} is the number of years, after initial construction, that elapse before the beginning of the k^{th} performance period, with $t_0 = 0$, and τ_1 and τ_2 are as previously defined, and

NSC J_k = the number of seal coats in the k^{th} performance period,

and where:

$$J_k = \begin{cases} \frac{t_k - t_{k-1} - \tau_1 - TMIN}{\tau_2} + 1, & \text{if } t_k - t_{k-1} \geq \tau_1 + TMIN \\ 0, & \text{otherwise.} \end{cases}$$

The reason TMIN is subtracted from the numerator of the first part of the above equation is because of the assumption that no seal coat is applied within TMIN years prior to an overlay. The quantity J_k (NSC) is rounded down, i.e., truncated, to integer form.

G. Salvage Value (SUBROUTINE OVLAY)

The salvage value of each material is input as a percentage and the proportion (percentage/100.) of the material costs of each pavement layer (excluding level-up) are summed at the end of the analysis period, then converted to the present worth value.

APPENDIX II

User Cost Tables

This group of tables from Research Report 32-11 (reference 3) as revised by later reports documents the user cost tables in SUBROUTINE USER incorporated as DATA statements. These costs include those associated with delay (time), vehicle operation, and accidents. Only user delays and vehicle operating costs are considered at this time since little information is available on the effect of overlaying on accident rates.

This appendix is divided into three parts, the first of which describes the assumed speed profiles of vehicles in the vicinity of the overlay operation. The second part gives the time and operating costs associated with the different movements described by the speed profiles.

In the third part of this appendix, the five methods of handling traffic are described and equations are given for calculating the proportion of vehicles stopped and average time stopped for conditions where traffic congestion arises because of the overlay operation.

The formulas using these tables were given in the Appendix I "Documentation of Mathematical and Cost Formulas".

APPENDIX II - PART 1
Speed Profiles

It is assumed that all vehicles approach the overlay area at the same speed, called the "approach speed". It is further assumed that there is a "restricted area", the length of which is LS_0 or LSN , through which vehicles travel at a reduced speed. For some methods of handling traffic this reduced speed may be the same for vehicles traveling in both directions but for other methods it may be different for each direction; it is assumed to always be the same for all vehicles going in the same direction. Generally, the vehicles traveling in the "overlay direction" will have their speed reduced as much or more than will those traveling in the "non-overlay direction", LS_0 and LSN respectively.

The length LS_0 of the restricted area generally will be longer than the length L_0 of the actual overlay operation. The amount by which LS_0 is longer than L_0 will be determined by the road geometrics and the method of handling traffic. This is discussed more fully below in the section on methods of handling traffic.

As was mentioned above it is assumed that vehicles approach the restricted area at an "approach speed" denoted by SA . If there were no overlay taking place then the vehicles would travel through the area which is restricted during overlay at the "approach speed". During overlay, however, most vehicles travel through the restricted area at a reduced speed called the "through speed, overlay direction" denoted by SO or the "through speed, non-overlay direction" denoted by SN . It is assumed that vehicles maintain these "through speeds" all the way through the restricted area.

A proportion (called PO_1 in the overlay direction and PN_1 in the non-overlay direction) of all vehicles will be stopped as they approach the restricted area. It is assumed that these vehicles stop and then accelerate back to the through speed which is reached at the moment they enter the restricted area of length LS_0 or LS_N ; the vehicles then travel at the reduced speed (SO or SN) through the restricted area for a distance, and as soon as they leave the restricted area they return to a speed which is the same as their approach speed.

Figure AII-1 shows the speed profile for such a vehicle which is stopped. The letters along the horizontal axis denote points where speeds are changed. The vehicle approaches the restricted area at a speed of SA , begins decelerating at point A and is stopped by the time it reaches point B, remains stopped for a time (DO_1 in the overlay direction and DN_1 in the non-overlay direction) at point B, then accelerates back to the through speed SO or SN which is reached at point C which is the beginning of the restricted area of length LS_0 or LS_N , then travels from point C to point D at the through speed, and at point D begins accelerating back to the approach speed which is reached at point E.

Vehicles which do not stop are slowed down when they pass through the restricted area and it is assumed that their deceleration is such that they reach the through speed (SO or SN) at the moment they enter the restricted area. The proportion of vehicles which do not stop equals one minus PO_1 for the overlay direction and one minus PN_1 for the non-overlay direction.

Figure AII-2 shows the speed profile for a vehicle which is not stopped but is slowed by the overlay operation. The letters along the horizontal axis denote points where speeds are changed. The vehicle

approaches the restricted area at a speed of SA, begins decelerating at point A, decelerates to the through speed SO or SN which is reached at point B which is the beginning of the restricted area of length LSØ, continues at the through speed from point B to point C which is at the end of the restricted area, then at point C begins accelerating back to the approach speed which is reached at point D.

Because of overlay operations, vehicles will travel through the overlay area with speed profiles as shown in Figures AII-1 and AII-2. In the absence of overlay operations they would have traveled at the approach speed through the overlay area. The excess traffic costs due to overlay include the excess time and operating costs due to reducing from the approach speed to a stop (from A to B in Figure AII-1) and returning back to that speed (from B to C and from D to E in Figure AII-1), the excess time and operating (idling) costs due to being stopped (at point B in Figure AII-1), the excess time and operating costs due to reducing from the approach speed to the through speed (from A to B in Figure AII-2) and returning to the approach speed (from C to D in Figure AII-2), and the excess time and operating costs due to traveling distance LSØ or LSN (from C to D in Figure AII-1 and from B to C in Figure AII-2) at a reduced speed (SO or SN) instead of traveling at the approach speed (SA).

APPENDIX II - PART 2
Time and Operating Costs

The excess user costs because of an overlay include the excess cost of stopping and slowing down, the cost of delay while stopped, and the excess cost of traveling at a reduced speed through the restricted area. The information needed for calculating these costs are given in Tables AII-1 through AII-4. The program user must stipulate whether the overlay operation is in an urban or rural area and this determines which tables or which columns in the table are used. The difference between the urban and rural costs is the vehicle distributions used to derive the costs. The operating costs for different types of vehicles were taken from a publication by Winfrey (5), and this same source was used for the excess time of making speed changes. The values of time used in calculations were based on information in studies by the Stanford Research Institute (6), Lisco (7), and Adkins (8). The proportions of vehicles of different types for urban and rural areas in Texas is taken from proportions for 1966 given in a study by the Planning Survey Division of the Texas Highway Department (9). The reason that the costs are higher for rural areas than for urban areas is that there is a higher proportion of trucks in rural areas and their costs are higher than those for passenger cars.

Tables AII-1 and AII-2 give the excess time and operating costs for stopping (in the first columns) and for slowing down (in the other columns). Table AII-3 gives the time and operating costs for operating at a uniform (constant) speed. Table AII-4 gives the time and operating costs of delay (or idling).

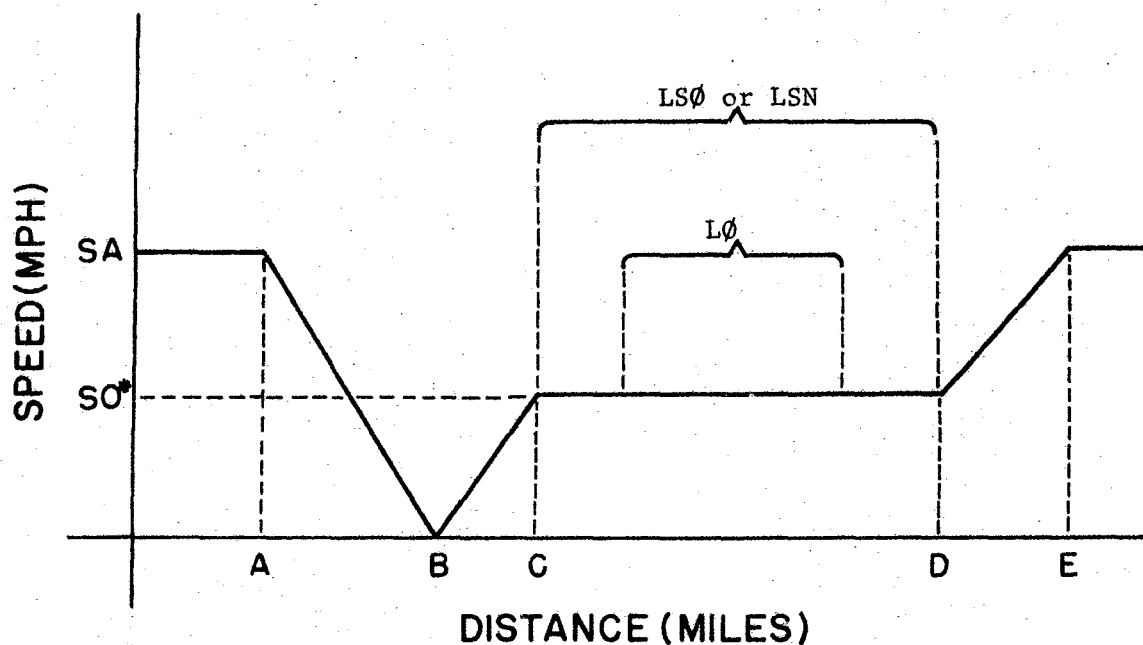


Figure AII-1: Speed profile for vehicles which are stopped during overlay.

* This speed is SO in the overlay direction but would be SN in the non-overlay direction. L_0 is length of overlay work. LS_0 or LSN is the length of restricted area in the overlay direction or non-overlay direction as applicable.

TABLE AII - 1: DOLLARS OF EXCESS OPERATING AND TIME
COST OF SPEED CHANGE CYCLES - EXCESS COST ABOVE
CONTINUING AT INITIAL SPEED, FOR RURAL ROADS IN TEXAS

Initial Speed MPH	Dollars Per 1000 Cycles, By Speed Reduced To And Returned From (MPH)					
	<u>0</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>
10	10.676					
20	22.932	11.860				
30	39.753	27.079	14.306			
40	63.454	49.907	35.812	19.902		
50	98.194	93.454	67.935	50.326	28.491	
60	151.888	134.793	116.527	95.788	71.070	40.931

TABLE AII - 2: DOLLARS OF EXCESS OPERATING AND TIME
 COST OF SPEED CHANGE CYCLES - EXCESS COST ABOVE
 CONTINUING AT INITIAL SPEED, FOR URBAN ROADS IN TEXAS

Initial Speed MPH	Dollars Per 1000 Cycles					
	Speed Reduced To And Returned From (MPH)					
	<u>0</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>
10	7.395					
20	14.829	7.059				
30	24.570	16.200	8.191			
40	37.838	28.896	20.130	10.845		
50	56.703	47.046	37.309	27.024	14.939	
60	85.514	74.330	61.884	50.705	36.994	20.704

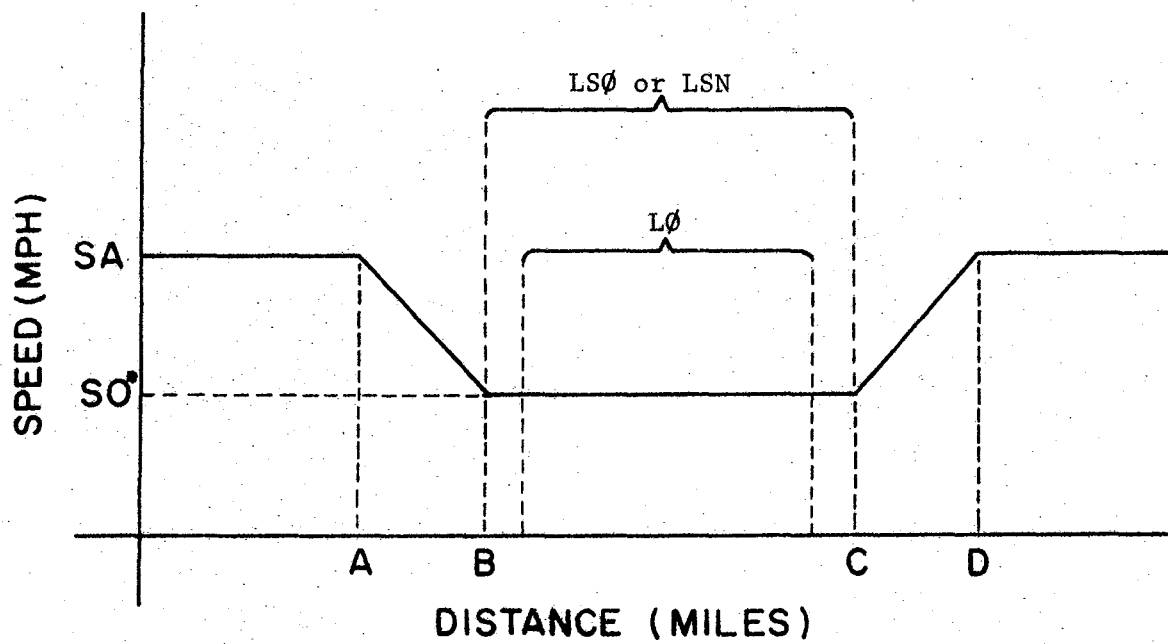


Figure AII-2: Speed profile for vehicles which are not stopped but are slowed during overlay.

* This speed is SO in the overlay direction but would be SN in the non-overlay direction. $LØ$ is length of overlay. $LSØ$ or LSN is the length of restricted area overlay or non-overlay direction respectively.

TABLE AII - 3: DOLLARS OF OPERATING AND TIME COST
PER 1000 VEHICLE MILES AT UNIFORM SPEEDS IN TEXAS

Uniform Speed, <u>MPH</u>	<u>Dollars Per 1000 Miles</u>	
	<u>Rural Roads</u>	<u>Urban Roads</u>
10	495.77	456.66
20	270.31	248.30
30	196.62	179.64
40	162.58	147.22
50	145.54	130.08
60	138.80	121.88

TABLE AII - 4: DOLLARS OF OPERATING AND TIME COST OF DELAY
(OR IDLING) PER 1000 VEHICLE HOURS, FOR TEXAS

Type Of Delay <u>Cost</u>	<u>Dollars Per 1000 Hours</u>	
	<u>Rural</u> <u>Roads</u>	<u>Urban</u> <u>Roads</u>
Operating	\$ 166.60	\$ 154.84
Time	4,243.10	3,956.68
Total	4,409.70	4,111.52

APPENDIX II - PART 3
Methods of Handling Traffic

There are several methods of handling traffic during an overlay operation. The method used depends mainly on highway geometrics, especially the number of lanes, the type of median (if any), and the presence or absence of pavement shoulders, frontage roads, or other alternate routes. In the two following subsections are described the five methods of handling traffic which are most commonly used and the way of calculating average delay and proportion of vehicles stopped for each method.

The five methods. The first two methods of handling traffic are for two-lane roads (with or without shoulders) and the other three methods are for roads with four or more lanes. Figures AII-3 through AII-7 depict in a general way the five situations. In each figure $L\emptyset$, $LS\emptyset$, and LSN are shown. $L\emptyset$ is the amount of road which is overlayed at any one time -- not the total overlay job length. $LS\emptyset$ is the distance over which traffic is slowed down by the overlay operation at any one time in the overlay direction, LSN is the non-overlay direction. In the situations depicted in Figures AII-3, 4, and 5, $LS\emptyset$ and LSN are only slightly longer than $L\emptyset$ by say one-tenth of a mile, but in the situations depicted in Figures AII-6 and 7, $LS\emptyset$ may be considerably longer than $L\emptyset$. $LS\emptyset$ and LSN are input variables provided by the program user. $L\emptyset$ is not used in the calculation of user costs and is included only for illustration. (Note: The variable $L0$ used as a subscript in SUBROUTINE USER is not $L\emptyset$ as illustrated in these figures.) In the figures, the "overlay direction" is always to the left.

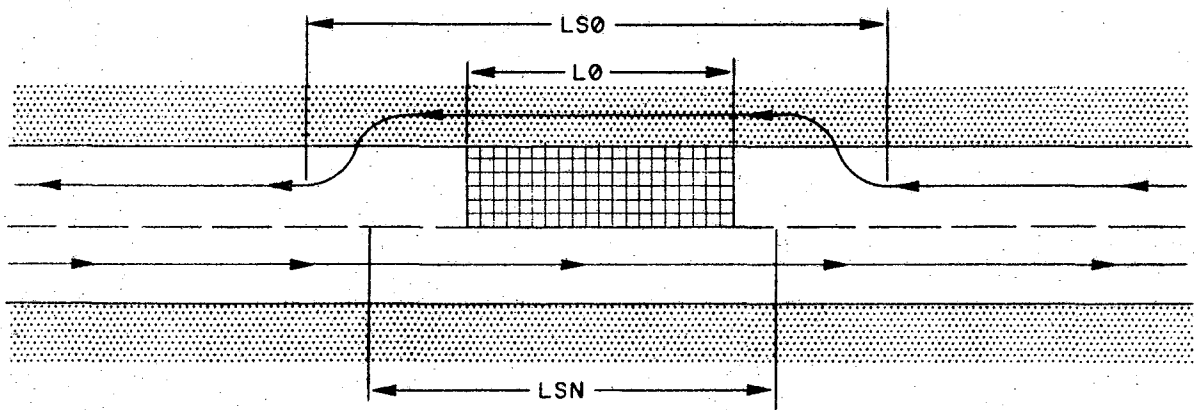


Figure AII-3. MODEL=1: traffic routed to shoulder.

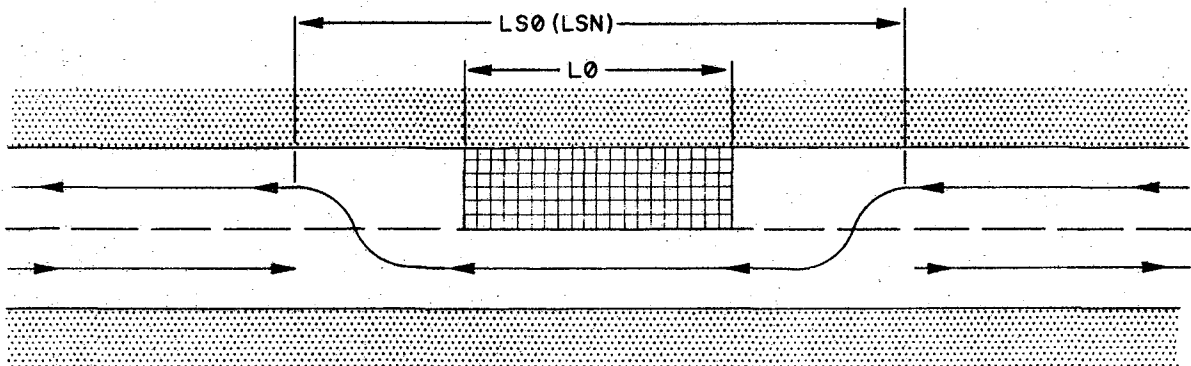


Figure AII-4. MODEL=2: alternating traffic in one lane.

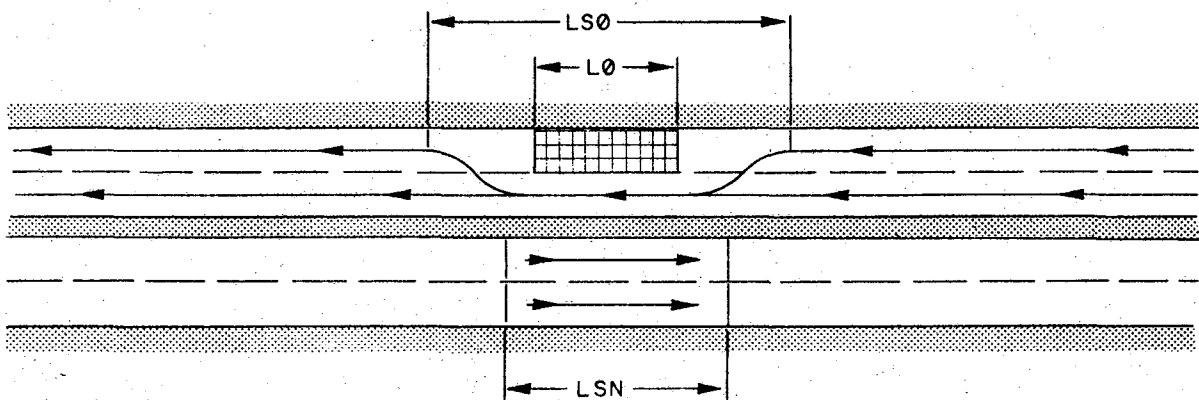


Figure AII-5. MODEL=3: two lanes merge, non-overlay direction not affected.

MODEL = 1 (Figure AII-3). For two-lane roads with shoulders, one lane of traffic can be diverted onto a shoulder. Traffic going "west" in the "overlay direction" can be diverted onto the shoulder as shown in Figure AII-3 and such traffic will generally be slowed down. Traffic in the non-overlay direction proceeds as usual but also must slow down though probably not by as much as the traffic going in the overlay direction. Another version of this method is to divert the traffic in the non-overlay direction onto their shoulder and divert the traffic going in the overlay direction into the eastward lane. In addition to the delay due to traveling at a reduced speed, traffic may be additionally delayed by having to stop due to movement of overlay personnel and equipment in the overlay area and by the inability to overtake other traffic in the overlay area.

MODEL = 2 (Figure AII-4). For two-lane roads without shoulders, it is sometimes necessary to post flagmen at each end of the overlay operation and to stop traffic in one direction while traffic from the other direction proceeds through the overlay area. The flagmen determine from which direction traffic is let through the overlay area at any one time. The vehicle arriving first usually has priority. If an additional vehicle arrives while other vehicles going in the same direction are proceeding through the overlay area then this additional vehicle usually may also proceed through the area, except that it will be stopped when the vehicles in the queue from the other direction are of a number or have been waiting a time which justifies priority for them. Traffic from each direction travels through the overlay area at a reduced speed. Some vehicles from each direction are stopped to give way to vehicles

from the opposite direction, or because of the movement of overlay personnel and equipment in the overlay area, or because vehicles do not have the ability to overtake other vehicles in the overlay area. Generally speaking, the proportion of traffic stopped to give way to vehicles from the opposite direction will be higher the longer is $LS\emptyset$ and the larger is the traffic volume.

MODEL = 3 (Figure AII-5). For roads with two or more lanes in each direction and with a non-transversable median, it is assumed that traffic in only one direction will be affected by the overlay operation. It is also assumed that at least one lane in the overlay direction remains open for traffic. For low traffic volumes the effects on traffic in the overlay direction will be that of reduced speed through the area, stops due to movement of overlay personnel and equipment, and inability to overtake other vehicles as easily. For higher volumes for which the flow of traffic is above the capacity of the restricted roadway, a queue will result upstream of the overlay operation and will lead to vehicles being stopped due to congestion.

MODEL = 4 (Figure AII-6). For roads with two or more lanes in each direction and with no medians or with medians which can be crossed at any point or which have median openings, it may sometimes be desirable to block all lanes in the overlay direction and divert the overlay-direction traffic to non-overlay-direction lanes. MODEL = 1 depicts the situation and those with either no median, or situations for which it is intended that traffic will cross the median immediately in front and behind the overlay job, is that $LS\emptyset$ and LSN in these latter two cases would bear approximately the same relation to $L\emptyset$ as is the relation where MODEL = 1, 2, or 3 instead of being the distance between

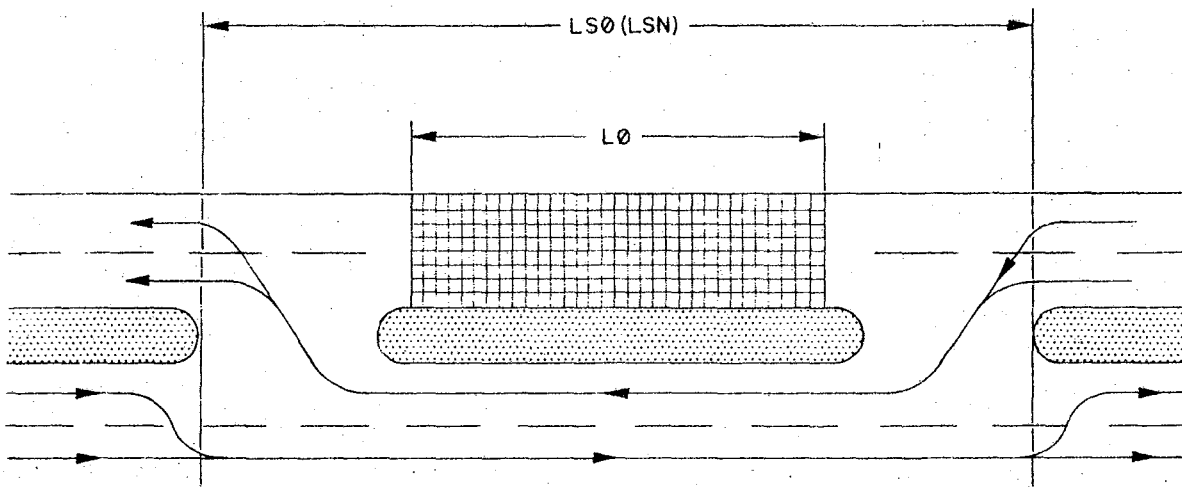


Figure AII-6 MODEL=4: overlay direction traffic routed to non-overlay lanes.

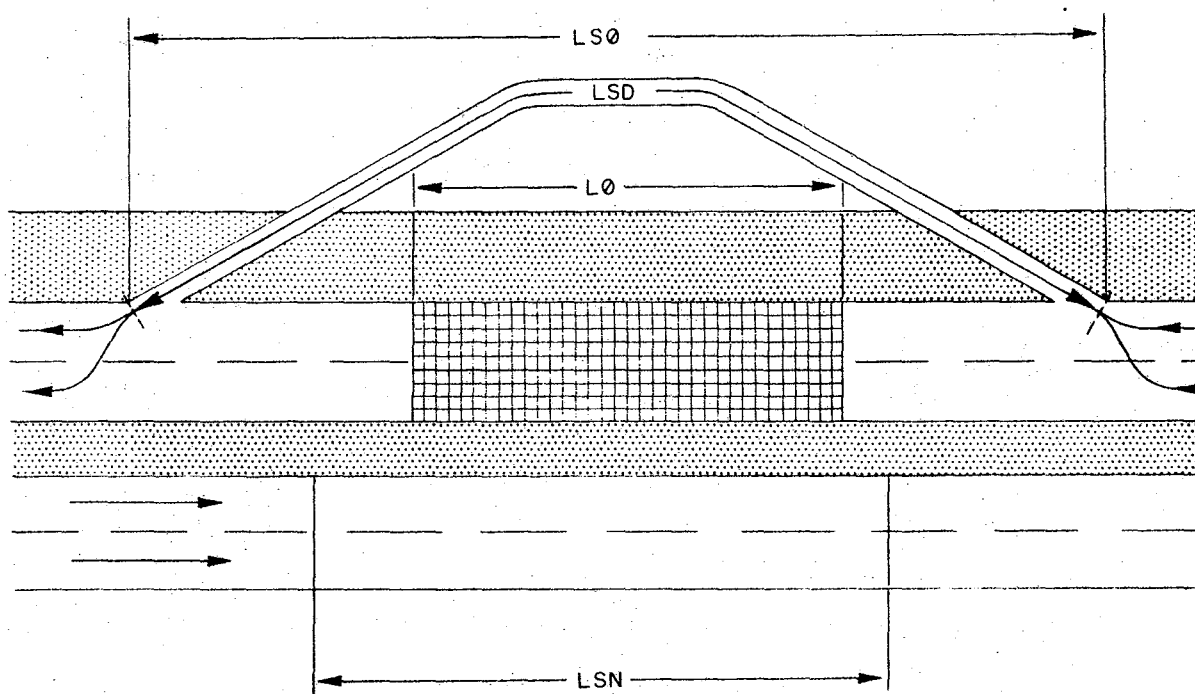


Figure AII-7. MODEL=5: overlay direction traffic routed to frontage road or other parallel route.

median openings at each end of the overlay job as when MODEL = 4. For these situations both lanes of traffic will be affected, and the method of calculating average delay and proportion of vehicles stopped is the same as that used for MODEL = 3, but in MODEL = 4 traffic going in both directions is affected.

MODEL = 5 (Figure AII-7). In some situations traffic in the overlay direction is diverted to an alternate route such as a frontage road or some other parallel road or street. The addition variable of LSD is the distance traveled by detour in the overlay direction.

Average delay and Proportion of Vehicles Stopped. The delay to traffic due to overlay is of four basic types which are related to vehicles:

- (1) traveling at a reduced "uniform" speed in the restricted area,
- (2) not having the ability to overtake and pass other vehicles traveling in the same direction,
- (3) having to stop because of the movement of overlay personnel and equipment in the overlay area, and
- (4) having to stop because of congestion when the traffic demand exceeds the capacity of the restricted area.

The delay per vehicle due to traveling at a reduced speed equals the travel time at the reduced speed through the restricted area minus the travel time vehicles would have had through the restricted area had it not been restricted.

The delay due to vehicles not having the ability to overtake and pass other vehicles traveling in the same direction because of the overlay operation may result both in the restricted area and outside the restricted area. This delay when it occurs in the restricted area

is included in the delay discussed in the preceding paragraph if accurate estimates of speeds through the restricted area are used. The delay due to the inability to pass outside the restricted area because of the overlay is a more complicated calculation and is probably largest in the cases where the capacity of the restricted area is smaller than the demand (or input) for use of the area. In such cases wherein demand exceeds capacity there will be congestion and queueing of vehicles. These queues must disperse after leaving the restricted area and before such dispersion occurs there probably will be some inability to pass outside the restricted area. Such effects probably will be small in all cases except MODEL = 2 with considerable queueing. If the length of the restricted area is fairly long and/or the traffic volumes are fairly large, then when MODEL = 2, there will arise fairly long queues of vehicles. Such queues arise in one direction while vehicles are traveling through the restricted area from the other direction; then, when this queue is allowed to proceed through the restricted area it will emerge as a moving queue, sometimes of considerable length, and extra delay will result outside the restricted area until the queue disperses. The rate of dispersion of this moving queue will depend mainly upon the amount of traffic from the opposite direction, the road geometrics, and the type of vehicles in the queue. This moving queue will also impede passing by traffic from the opposite direction; however, there will be a considerable length of road in front of this queue in which there will be no (or very few) vehicles which will somewhat offset the effects of the moving queue on traffic in the opposite direction.

Since the type of delay discussed in this paragraph probably is small in most cases and since it is difficult to calculate, it is ignored (i.e., assumed to be zero).

The third type of delay, that resulting from vehicles having to stop because of the movement of overlay personnel and equipment in the overlay area, is calculated by multiplying the number of vehicles stopped by the excess delay of stopping. The program user must estimate (1) PO_2 and PN_2 , the proportion of vehicles stopped due to the movement of overlay personnel and equipment and (2) DO_2 and DN_2 , the average time that each vehicle stopped (because of such movement) remains stopped. It is expected that the overlay operation will be conducted in a way such that the number of vehicles stopped due to the movement of overlay personnel and equipment will be small. Therefore, in the absence of information on the number of such stops, the program user probably should estimate that number to be near or equal to zero.

The last type of delay (denoted by DO_1 in the overlay direction and by DN_1 in the non-overlay direction) results when a proportion of vehicles (denoted by PO_1 in the overlay direction and PN_1 in the non-overlay direction) have to stop because of congestion which results when traffic demand or input per hour (Q) exceeds the hourly capacity or output ($\emptyset$) of the restricted area.

When $MODEL = 1$ (shoulder routed traffic model) is used, congestion stopping delay should be almost nonexistent and is assumed to be zero; i.e., $DO_1 = DN_1 = 0$ and $PO_1 = PN_1 = 0$ for $MODEL = 1$.

When MODEL = 2 (alternating traffic model) is used, it is assumed that the hourly traffic is evenly divided between directions. It is also assumed that vehicle arrivals from each direction are Poisson. The proportion of vehicles stopped due to congestion from each direction (PO_1 or PN_1) is estimated by the following equation:

$$PO_1 = (= PN_1) = \frac{(1 - e^{-aQ})^2}{2}$$

where a = the time that it takes a vehicle to travel through the restricted area, in hours, and

Q = the number of vehicles arriving at the overlay area per hour in the overlay direction.

An equation for estimating the average delay per stopped vehicle (DO_1 or DN_1) for MODEL = 2 is developed from equations formulated by Tanner (10) and given by:

$$DO_1 (= DN_1) = \frac{(1 + e^{2aQ}) (e^{aQ} - aQ - 1)}{2Q(e^{2aQ} - e^{aQ} + 1) PO_1}$$

where a , Q , and PO_1 are as previously defined.

If MODEL = 3 or 5, both PN_1 and DN_1 will equal zero. If MODEL = 3, 4, or 5 is used to handle traffic DO_1 for all three methods and DN_1 for MODEL = 4 are calculated using the following equation developed and verified by the California Division of Highways (11):

$$DO_1 = \frac{H(Q - \emptyset)(R - \emptyset)}{2Q PO_1 (R - Q)} \quad \text{if } Q > \emptyset$$

$$DO_1 = \emptyset \quad \text{if } Q \leq \emptyset$$

where H = the number of hours per day that overlay construction takes place,

R = the recovery rate in vehicles per hour,

$\emptyset$ = the restricted output rate in vehicles per hour, and

Q and PO_1 are as previously defined.

TABLE AII - 5: CAPACITY TABLE (MODEL = 3, 4, or 5)

Variable Name (FORTRAN)	% Trucks	Rural or Urban	Overlay or Recovery Zone	Lane Capacities in Vehicles per Hour Lanes (one direction)						
				<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
RUTFOV	10+	RU	Ø	1350	2700	4350	6000	7650	9300	na
RUTFRV	10+	RU	R	na	3000	4500	6200	7900	9600	11300
URTF OV	0 - 10	UR	Ø	1400	2800	4500	6200	7900	9620	na
URTFRV	0 - 10	UR	R	na	3000	4700	6400	8100	9800	11500

Note: In SUBROUTINE USER additional lanes are ignored if beyond the table limits of 6 lanes for the overlay zone and 7 lanes for the recovery zone.

It is assumed that the input rate Q is the same for both directions of travel and equals 6 percent of average daily traffic in rural areas and 5 percent of average daily traffic in urban areas. The output rate $\emptyset$ and recovery rate R are taken from the California study (11) and are given in Table AII-5. The California study also gives the number of vehicles which will be stopped at the time when recovery begins, i.e., when all lanes are reopened for travel, and this number equals $H(Q-\emptyset)$. The average number of vehicles which will be stopped at any one time during overlay will be $H(Q-\emptyset)/2$. By assuming that each vehicle which is stopped stays stopped for some average amount of time D , which is assumed to equal 1/12 hour, not including the time stopped after recovery begins, and assuming that no vehicles are stopped after recovery begins, the total number of vehicles stopped can be estimated as $H^2(Q-\emptyset)/2D$ if $Q > \emptyset$ and is zero if $Q \leq \emptyset$. Thus, for MODEL = 3, 4, or 5, the proportion of vehicles stopped PO_1 (and also PN_1 for MODEL = 4) is estimated by dividing the total number of vehicles stopped by the total input of vehicles during overlay ($H \times Q$):

$$PO_1 = \frac{H(Q - \emptyset)}{2DQ} \quad \text{if } Q > \emptyset$$

$$PO_1 = 0 \quad \text{if } Q \leq \emptyset,$$

with the constraint that: if this value exceeds 1.0, it is assigned a value of 1.0.

More research, including field observations, needs to be done on the precise number of stops under stop-and-go operation which results from congestion. Use of the above formulas gives reasonable accurate estimates of hours of delay but may underestimate the vehicle operating costs associated with stop-and-go operation.

TEXLIS

THE PROGRAM 'TEXLIS' IS INCLUDED IN THIS REPORT TO AID IN A SYSTEM UPDATING THE FPS SERIES OF PROGRAMS. WITH THIS PROGRAM THE BODY OF THE 123-9 REPORT MAY BE EASILY CHANGED, LINE BY LINE OR AN ENTIRE SECTION, AND AN UPDATED REPORT GENERATED IMMEDIATELY BY SUBMITTING 'TEXLIS' AND THE UPDATED DECK OF COMPUTER CARDS.

THIS PROGRAM IS USED TO LIST ALPHABETIC TEXT TO FORM AN EDITED LISTING OF PROGRAM DOCUMENTATION. THIS LISTING WAS PRINTED BY THE PROGRAM. THE PROGRAM PROVIDES FOR CHANGING THE PAGE SIZE, AND ALLOWS FOR THREE BASIC OUTPUT FORMATS.

ACKNOWLEDGEMENT.

THE PROGRAM TEXLIS IS BASED ON AN EARLIER PROGRAM TXTLST BY LARRY BRISTOL, TEXAS A&M UNIVERSITY, COLLEGE STATION, TEXAS.

SHOULD ANY PROBLEMS ARISE WHEN USING THIS PROGRAM, PLEASE DIRECT THE INQUIRY TO . . .

DALE L. SCHAFER
TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS
77801

PHONE 713 845-1717

PROGRAM ACTION.

THE PROGRAM READS INPUT CARDS SEQUENTIALLY AND PRODUCES SEQUENTIAL LISTINGS AS DIRECTED BY THE INPUT CARDS. ANY CARD WITH A DOLLAR SIGN (\$) IN COLUMN 1 IS TREATED AS A CONTROL CARD. ALL OTHER CARDS ARE TEXT CARDS. THE PROGRAM PRINTS EACH TEXT CARD ON A LINE SINGLE SPACING. IT AUTOMATICALLY DETECTS THE END OF A PAGE AS SET BY A PAGE LINE LIMIT, AND PRODUCES FOOTINGS AND HEADINGS AT THESE POINTS.

'TEXLIS' - TEXT LISTER PROGRAM DOCUMENTATION

CONTROL CARDS.

THERE ARE SEVEN CONTROL CARD TYPES. A CONTROL CARD IS INDICATED BY A DOLLAR SIGN (\$) IN COLUMN 1. THE CONTROL TYPE IS PUNCHED IN COLUMNS 2-9. IN COLUMN 10, ADDITIONAL DATA IS READ FROM THE CONTROL CARD TO FURTHER PROVIDE CONTROL INFORMATION.

- 1) \$START - THIS CARD ENDS ONE DATA GROUP, AND INDICATES THE START OF A NEW GROUP. SIX ADDITIONAL FIELDS ARE READ FROM THE CARD IN THE FORMAT (9X, 4I2,2L1)

FIELD 1 - PAGE NUMBER OF THE FIRST PAGE OF THE LISTING. IF ZERO, THE PAGE COUNTER WILL NOT BE CHANGED.

FIELD 2 - LINE NUMBER FOR THE FIRST TEXT LINE OF EVERY PAGE.

FIELD 3 - LINE NUMBER FOR THE LAST TEXT LINE ON EVERY PAGE.

FIELD 4 - LINE NUMBER TO PUT FOOTING.

FIELD 5 - PUNCH T TO TAKE FULL SIZE OPTION.

FIELD 6 - PUNCH T TO TAKE CARD 2 OPTION.

NOTE THE DEFAULT VALUES SELECTED IF ALL OF THE FIELDS ARE BLANKS ARE (0,3,56,58,F,F)

- 2) \$HEADING - THIS CARD SPECIFIES TEXT TO BE PRINTED AS A PAGE HEADING ON ALL SUBSEQUENT PAGES. THE HEADING TEXT IS TO BE PUNCHED IN COLUMNS 10-72. THESE 63 CHARACTERS ARE CENTERED ON LINE 1 OF EACH PAGE.

- 3) \$FOOTING - THIS CARD SPECIFIES TEXT TO BE PRINTED AS A PAGE FOOTING ON ALL SUBSEQUENT PAGES. THE FOOTING TEXT IS PUNCHED IN COLUMNS 10-72. THESE 63 CHARACTERS ARE CENTERED ON THE SPECIFIED FOOTING LINE OF EACH PAGE.

- 4) \$PAGE - THIS CARD CAUSES A NEW PAGE TO BE STARTED BY GENERATING A FOOTING FOR THE CURRENT PAGE, PRODUCING THE HEADING ON THE NEXT PAGE, AND POSITIONING TO THE FIRST TEXT LINE SPECIFIED.
- 5) \$LINE - THIS CARD SPECIFIES AN ABSOLUTE LINE ON A PAGE TO BE SKIPPED TO. THE SKIP IS MADE IN A FORWARD DIRECTION ONLY. IF THE SPECIFIED LINE HAS BEEN PASSED ON THE CURRENT PAGE, THE PROGRAM SKIPS TO THE LINE ON THE FOLLOWING PAGE, GENERATING FOOTING AND HEADING. IF THE LINE SPECIFIED IS OUTSIDE THE TEXT RANGE (FIRST LINE TO LAST LINE) THE EFFECT IS THE SAME AS THE \$PAGE CARD. THE LINE NUMBER IS SPECIFIED IN COLUMNS 10-11.
- 6) \$SKIP - THIS CARD CAUSES A SPECIFIED NUMBER OF LINES TO BE SKIPPED. FIELD 1 (COLUMNS 10-11) SPECIFIES THESE NUMBER OF LINES. FIELD 2 (COLUMNS 12-13) SPECIFIES THE NUMBER OF LINES THAT MUST REMAIN ON THE CURRENT PAGE AFTER THE SKIP. IF THE SKIP WOULD RESULT IN FEWER THAN THE SPECIFIED LINES TO REMAIN, THE ACTION TAKEN IS THE SAME AS A \$PAGE CARD.
- 7) \$END - THIS CARD IS THE LAST CARD OF THE DECK.

PAGE SIZE OPTIONS.

THE TWO OPTIONS AS SPECIFIED ON THE \$START CARD HAVE THE FOLLOWING EFFECTS (NOTE THAT THEY WORK IN COMBINATION.)

- 1) NO FULL SIZE AND NO CARD 2 - EACH INPUT CARD IS A SEPARATE LINE IN THE LISTING. THE PAGE FORMAT FOR 8 1/2 X 11 FORMS IS ASSUMED.
- 2) NO FULL SIZE WITH CARD 2 - THIS COMBINATION IS ILLEGAL.
- 3) FULL SIZE WITH NO CARD 2 - EACH INPUT CARD IS A SEPARATE LINE. THE PAGE FORMAT IS ASSUMED TO FIT 132 CHARACTER (14 X 11) FORMS.
- 4) FULL SIZE AND CARD 2 - TWO TEXT CARDS FORM A SINGLE PRINT LINE. THE FIRST 72 OF CARD 1 AND 60 FROM COLUMNS 7-66 OF CARD 2 FORM A 132 CHARACTER LINE. NOTE THAT CONTROL CARDS STILL USE ONLY ONE CARD.

TEXT CARD FORMAT.

THERE ARE TWO FORMATS FOR TEXT CARDS, DEPENDING ON THE USE OF CARD 2 OPTION. IF THE OPTION IS NOT USED, TEXT IS READ FROM COLUMNS 1-72 OF EACH CARD. COLUMNS 73-80 ARE IGNORED. IF THE OPTION IS USED, THE FIRST 72 CHARACTERS OF THE LINE COME FROM COLUMNS 1-72 OF CARD 1, AND THE REMAINING 60 COME FROM COLUMNS 7-66 OF CARD 2. THE REMAINING COLUMNS ARE IGNORED. NOTE, HOWEVER, THAT COLUMNS 1-6 OF CARD 2 MUST BE BLANK.

MULTI-PRINTING ON ONE LINE.

THE FOLLOWING PARAGRAPH ON OVERPRINTING APPLIES IF A '+' IN COLUMN ONE AS CARRIAGE CONTROL WILL CAUSE THE PRINTER TO PRINT WITHOUT SKIPPING TO A NEW LINE.

MULTIPLE TEXT CARDS CAN BE OVER-PRINTED ON A SINGLE LINE BY PLACING A PLUS SIGN (+) IN COLUMN 72 FOR NO CARD 2, OR IN COLUMN 66 OF CARD 2 FOR USE WITH THE CARD 2 OPTION.

```

C-----
C
C          PROGRAM TEXLIS, A TEXT LISTING PROGRAM
C
C          ACKNOWLEDGEMENT   BASED ON 'TXTLST' BY LARRY BRISTOL
C                               TEXAS A&M UNIVERSITY
C-----
C          INTEGER  LINE1(72), LINE2(64), HEADNG(64), FOOTNG(64), PAGE,
*          * SLINE, FLIN
C          INTEGER HT, CHK1, CHK2, PLUS, BLANK, DOLLAR, COMND(7)
C          LOGICAL  FULLSZ, CARD2, FIRST
C          COMMON   HEADNG, FOOTNG, LINE1, LINE2, LINE, PAGE, SLINE, MLINE,
1          FLIN, FULLSZ, CARD2, FIRST
C          DATA BLANK /1H /, DOLLAR /1H$/ , PLUS /1H+/, HT/1HT/
C          DATA COMND/1HS, 1HH, 1HF, 1HP, 1HL, 1HS, 1HE/
C
C          FULLSZ= .FALSE.
C          CARD2= .FALSE.
C          FIRST= .TRUE.
C          DO 20 I = 1,64
C            HEADNG(I) = BLANK
C            FOOTNG(I) = BLANK
C            LINE2(I) = BLANK
20          CONTINUE
C          LINE = 100
C          PAGE = 0
C          SLINE = 3
C          MLINE = 58
C          FLIN = 56
C
C          C*****          FOR OTHER THAN IBM MACHINES,          *****
C          C***** EXCHANGE THE 'C' ON THE FOLLOWING TWO STATEMENTS. *****
C          1 READ(5,501      ) LINE1
C          1 READ(5,501,END=170) LINE1
C          501 FORMAT (72A1)
C            IF (LINE1(1) .EQ. DOLLAR) GO TO 100
C            FIRST = .FALSE.
C            IF (.NOT. CARD2) GO TO 10
C            READ(5,502)      CHK1, CHK2, (LINE2(I), I=1,60)
C          502 FORMAT (A3, A3, 60A1)
C            IF( CHK1.NE.BLANK .OR. CHK2.NE.BLANK )GO TO 1000
C
C          10 CALL WRITE
C             GO TO 1
C
C          100 DO 101 I = 1,7
C             IF( LINE1(2).EQ.COMND(I) )
C               1 GO TO(110, 120, 130, 140, 150, 110, 170), I
C          101 CONTINUE
C             GO TO 1002
C          C--$START IF NOT $SKIP (THIRD CHARACTER NOT A 'T')
C          110 IF( LINE1(3) .NE. HT ) GO TO 160

```

'TEXLIS' - TEXT LISTER PROGRAM DOCUMENTATION

```

NPAGE=INTG(LINE1, 72, 10, 2)
PAGE = 0
SLINE=INTG(LINE1,72,12,2)
MLINE=INTG(LINE1,72,14,2)
FLINE=INTG(LINE1,72,16,2)
IF( LINE1(18) .EQ. HT )FULLSZ = .TRUE.
IF( LINE1(19) .EQ. HT )CARD2 = .TRUE.
IF (NPAGE .NE. 0) PAGE = NPAGE - 1
IF (CARD2 .AND. .NOT. FULLSZ) GO TO 1001
IF (SLINE .LT. 3 .OR. SLINE .GT. 24) SLINE = 3
IF (MLINE .LT. SLINE .OR. MLINE .GT. 56) MLINE = 56
IF (FLINE .LT. MLINE+1 .OR. FLINE .GT. 58) FLINE = MLINE + 2
LINE = 100
GO TO 1
C--$HEADING
120 DO 121 I = 2,64
121 HEADNG(I) = LINE1(8+I)
GO TO 1
C--$FOOTING
130 DO 131 I = 2,64
131 FOOTNG(I) = LINE1(8+I)
GO TO 1
C--$PAGE
140 IF (PAGE .EQ. 0) GO TO 1
CALL FOOT
CALL HEAD
GO TO 1
C--$LINE
150 L =INTG(LINE1,72,10,2)
161 IF (L .LT. SLINE .OR. L .GT. MLINE) L = SLINE
IF (LINE .LE. L) GO TO 152
IF (PAGE .EQ. 0) GO TO 151
CALL FOOT
151 CALL HEAD
152 CALL POS (L)
GO TO 1
C--$SKIP
160 L =INTG(LINE1,72,10,2)
M =INTG(LINE1,72,12,2)
IF (L .LE. 0) L = 1
L = LINE + L
IF (L+M .GT. MLINE) GO TO 140
GO TO 161
C--$END OR EOF
170 CALL FOOT
WRITE(6,666)
666 FORMAT (23H1PROGRAM = TEXLIS END )
STOP
1000 WRITE(6,6000) CHK1, CHK2, (LINE2(I), I=1,60)
6000 FORMAT (
1 18H1ILLEGAL CARD 2 - ,A4, A4, 60A1)
STOP
1001 WRITE(6,6001)

```

'TEXLIS' - TEXT LISTER PROGRAM DOCUMENTATION

```

6001 FORMAT(55H1CARD-2  OPTION MUST ALSO HAVE  FULL-SIZE  OPTION  )
      STOP
1002 WRITE(6,6002) LINE1
6002 FORMAT(20H1UNDEFINED COMMAND-- , /1H , 80A1)
      STOP
      END
      FUNCTION INTG( IALPHA, NDIM, IBEG, NCHAR)
C--INTG AN INTEGER FROM ALPHA CONVERSION FUNCTION.  ASSUMES ALL NON-
C--NUMERICS TO BE ZEROS.
      DIMENSION NUMBRS( 9), IALPHA(NDIM)
      DATA NUMBRS /1H1, 1H2, 1H3, 1H4, 1H5, 1H6, 1H7, 1H8, 1H9 /
      INTG=0
      ITEN=1
      IEND=IBEG+NCHAR-1
      DO 10 I = IBEG, IEND
        INDEX = IEND + IBEG - I
        DO 8 J = 1, 9
          IF(IALPHA(INDEX) .NE. NUMBRS(J) ) GO TO 8
          INTG = INTG + J * ITEN
          GO TO 10
        8 CONTINUE
      10 ITEN = ITEN * 10
      RETURN
      END
      SUBROUTINE POS (L)
      INTEGER LINE1(72), LINE2(64), HEADNG(64), FOOTNG(64), PAGE,
* SLINE, FLINE
      LOGICAL FULLSZ, CARD2, FIRST
      COMMON HEADNG, FOOTNG, LINE1, LINE2, LINE, PAGE, SLINE, MLINE,
1 FLINE, FULLSZ, CARD2, FIRST
1 IF (L .LE. LINE) RETURN
      LINE = LINE + 1
      WRITE(6,600)
600 FORMAT (1H )
      GO TO 1
      END
      SUBROUTINE FOOT
      INTEGER LINE1(72), LINE2(64), HEADNG(64), FOOTNG(64), PAGE,
* SLINE, FLINE
      LOGICAL FULLSZ, CARD2, FIRST
      COMMON HEADNG, FOOTNG, LINE1, LINE2, LINE, PAGE, SLINE, MLINE,
1 FLINE, FULLSZ, CARD2, FIRST
      CALL POS (FLINE)
      IF (FULLSZ) WRITE(6,601) FOOTNG
601 FORMAT (35X,64A1)
      IF (.NOT. FULLSZ) WRITE(6,602) FOOTNG
602 FORMAT (9X,64A1)
      RETURN
      END
      SUBROUTINE HEAD
      INTEGER LINE1(72), LINE2(64), HEADNG(64), FOOTNG(64), PAGE,
* SLINE, FLINE
      LOGICAL FULLSZ, CARD2, FIRST
      COMMON HEADNG, FOOTNG, LINE1, LINE2, LINE, PAGE, SLINE, MLINE

```

'TEXLIS' - TEXT LISTER PROGRAM DOCUMENTATION

```
1  FLINE, FULLSZ, CARD2, FIRST
   PAGE = PAGE + 1
   IF (FULLSZ) WRITE(6,601) HEADNG, PAGE
601 FORMAT (1H1,28X,64A1,10X,5HPAGE ,I3)
   IF (.NOT. FULLSZ) WRITE(6,602) HEADNG, PAGE
602 FORMAT (1H1,3X,64A1,2X,5HPAGE ,I3)
   LINE = 2
   CALL POS (SLINE)
   RETURN
   END
   SUBROUTINE WRITE
   INTEGER LINE1(72), LINE2(64), HEADNG(64), FOOTNG(64), PAGE,
*   SLINE, FLINE
   INTEGER PLUS
   LOGICAL FULLSZ, CARD2, FIRST
   COMMON HEADNG, FOOTNG, LINE1, LINE2, LINE, PAGE, SLINE, MLINE,
1  FLINE, FULLSZ, CARD2, FIRST
   DATA PLUS /1H+/
   IF (LINE .LE. MLINE) GO TO 1
   IF (PAGE .NE. 0) CALL FOOT
   CALL HEAD
1  IF (FULLSZ) GO TO 100
   IF (LINE1(72) .EQ. PLUS) GO TO 10
   WRITE(6,601) LINE1
601 FORMAT (9X,72A1)
   LINE = LINE + 1
   RETURN
10  WRITE(6,602) (LINE1(I), I = 1,71)
602 FORMAT (1H+,8X,72A1)
   RETURN
100 IF (CARD2) GO TO 150
   IF (LINE1(72) .EQ. PLUS) GO TO 110
   WRITE(6,603) LINE1
603 FORMAT (27X,80A1)
   LINE = LINE + 1
   RETURN
110 WRITE(6,604) (LINE1(I), I = 1,71)
604 FORMAT (1H+,26X,79A1)
   RETURN
150 IF (LINE2(60) .EQ. PLUS) GO TO 160
   WRITE(6,605) LINE1, LINE2
605 FORMAT (1X,132A1)
   LINE = LINE + 1
   RETURN
160 WRITE(6,606) LINE1, (LINE2(I), I = 1,59)
606 FORMAT (1H+,131A1)
   RETURN
   END
```

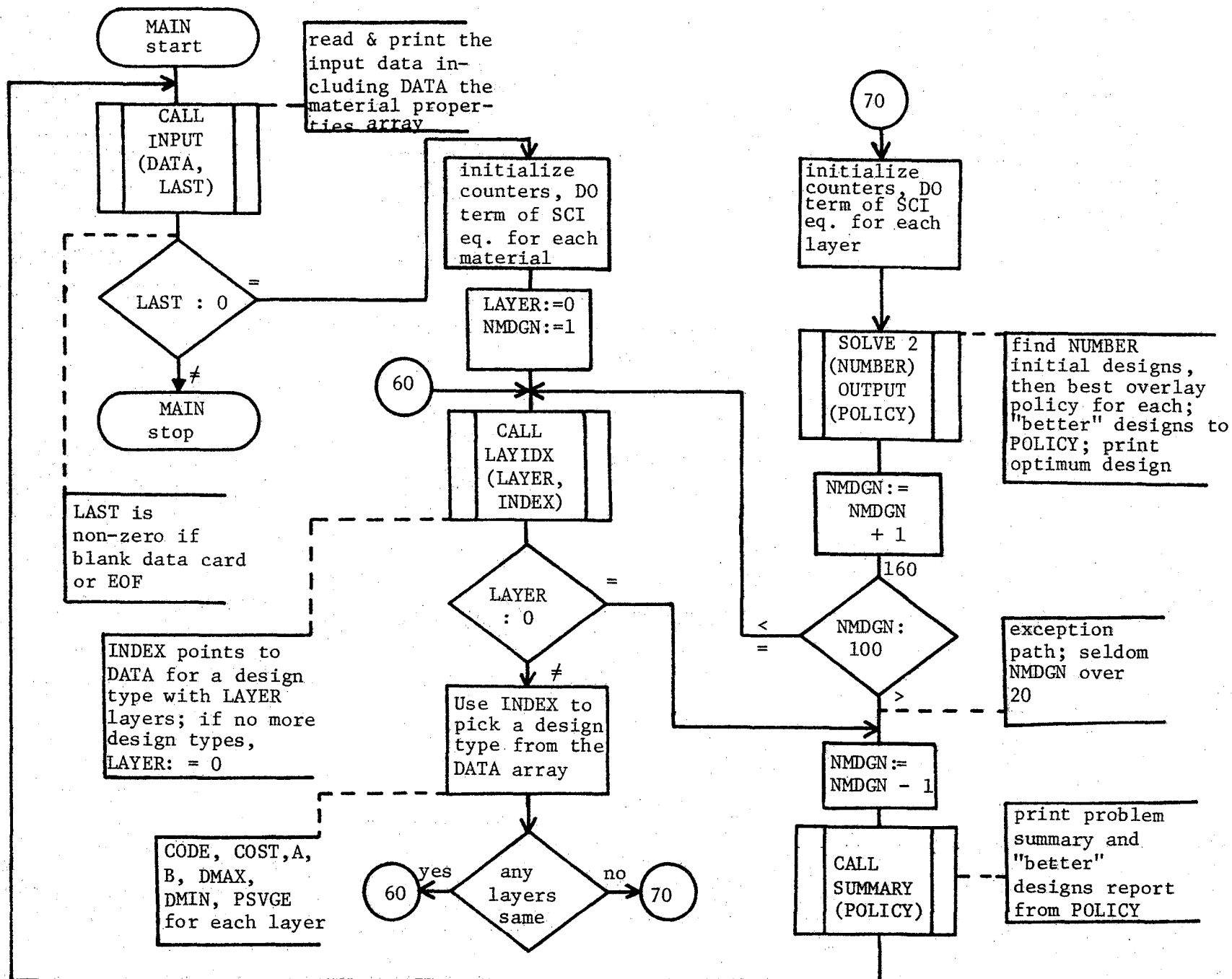
APPENDIX IV

FLOWCHARTS

This appendix is composed of a Summary Flowchart drawn to ANSI X3.5 Standard (reference 12) and a computer produced flowcharted program listing.

The Summary Flowchart serves as a macro flowchart with the flowchart listing, by program FORTCHT, to serve as a micro flowchart and program listing combination (reference 13).

The micro flowchart of the MAIN program is first with all SUBROUTINE flowcharts following in alphabetical order.



FPS-9 SUMMARY FLOWCHART

Figure A IV-1

PAGE 2

C NMDGN IS A COUNTER THAT KEEPS TRACK OF THE DESIGN TYPE FOR THE
C MATERIALS UNDER CONSIDERATION.

OK

```
IF(LAYER.EQ.0)GO TO 170
```

```

.....
IX = INDEX(J)
B(J) = BB(IX)
XINC(J) = DATA(IX,1)
CODE(J) = DATA(IX,2)
COST(J) = DATA(IX,9)
A(J) = DATA(IX,10)
DMIN(J) = DATA(IX,11)
DMAX(J) = DATA(IX,12)
PSVGE(J) = DATA(IX,13)

```

* I F I J . E O . I I * G O * T O * 9 O

C--THE SAME MATERIAL MAY NOT BE USED IN SUCCESSIVE LAYERS OF A DESIGN.

```
IF(CODE(J).EQ.CODE(J-1))GO TO 60
```

C INCREMENTS OF ALL BUT FIRST LAYER ARE CALCULATED IN PROPORTION
C TO THE COST OF THE FIRST LAYER

```
IF(COST(J).NE.0.)XINC(J)=IF(X(0.5+COST(I)/COST(J))*XINC(I).
```

C 1/4 INCH INCREMENTS ASSUMED IF CALCULATED INCREMENT IS LESS.

OK.

```
*XINC(J)*=AMAX1(1./144.,*XINC(J)*I
```

C COST, XINC, DMIN, DMAX, AND PSVGE ARE INVALID FOR THE SUBGRADE.
C--ZERO COUNTERS FOR THIS DESIGN TYPE

00 110 IK 1 NKTD

$$110 \text{ Kt} (1 \text{ K}) = 0$$

C--INCLUDE THE PROPERTIES OF THE SUBGRADE.

```

100 A(LAYER + 1) = DATA (NM+1,10)
      B ( LAYER+1) = BB(NM+1)

```

C JVCOST-THE OVERLAY IN-PLACE COST PER COMPACTED CUBIC YARD.
C--INCLUDE THE OVERLAY PROPERTIES, ASSUMED TO BE SAME AS 1ST LAYER.
C OVSALV-THE OVERLAY SALVAGE VALUE OF THE MATERIAL.

```

OVCOST  = COST(1)
OVSALV  = PSVGE(1)

```

C CINT IS THE INITIAL TERM IN THE DEFLECTION EQUATION, USED IN 'CALC'.

CINT = B(1) * 144. / 24400.

```

C
C
C CALL SOLVE2(ISKIP,ICOST,NUMBER,SCOST)
C CALL OUTPUT(ICOST,INDGN,KNTOL,KOUNT,POLICY,NMBEST,ISKIP,ICOST,
C      1 NUMBER,SCOST,XNDKP,ILAYER,CODE)
C
C

```

```
.....IF( KOUNT .EQ. 0 ) GO TO 140
```

C--THE FOLLOWING DESIGN TYPES HAVE AN OPTIMAL SOLUTION.

```

NK = NK + 1
IPUSS(NK) = NMOGN
OCOST(NK) = BCOST

```

.....
GO TO 150
.....

OK

C--CHECK IF ALL COMBINATIONS EXHAUSTED, IF NOT OBTAIN A NEW COMBINATION.

OK

C--OPTIONAL, A MESSAGE HERE THAT NOT ALL DESIGN TYPES OBTAINED.

OK.

i

C--PRINT THE PROBLEM SUMMARY

GO TO 10

OK.

```
t STOP
```

.....
END

HEADNG

SYMBOL KEY

EEEE = ENTRY
TTTT = TERMINAL
CCCC = CALL
RRRR = READ
WWWW = WRITE

```

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
SUBROUTINE HEADNG(NPROB, AN2, IPAGE)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
C SURROUTINE HEADNG IS A PROGRAM TO PRINT A PAGE HEADING WITH AN
C INCREMENTED PAGE NUMBER.
C NPROB IS AN ALPHNUMERIC 2 BYTE PROBLEM NUMBER.
C AN2 IS A 16 WORD (4 BYTES PER WORD) HEADING OR PROBLEM TITLE.
C IPAGE IS THE PREVIOUS PAGE NUMBER. IPAGE WILL BE INCREMENTED BEFORE
C PRINTING.
C
      DIMENSION AN2(16)
      I
      IPAGE = IPAGE + 1
      WRITE(6,875)NPROB, (AN2(I), I=1,16), IPAGE
      RETURN
      T
      d75 FORMAT(6H1PROB , A4, 1H*, 16A4, 3H* P, I3, 4X, 10H1-----TRIM /)
      END

```

CALC

SYMBOL KEY

EEEE = ENTRY
TTTT = TERMINAL
CCCC = CALL
RRRR = READ
WWWW = WRITE

```

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
SUBROUTINE CALC(CS)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      COMMON A(7), AAS, ACCD, ACPR, ALPHA, AN2(16), ASN, ASD, B(7),
      1 DB(11), B ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
      2 DN2, DQ2, DMAX(6), DMN(6), DOVER(6), GAMMA, HPD, INDEX(10),
      3 IPAGE, ITYPE, KT(6), LAYER, MATYPE, MODEL, NLD, NLRN, NLRO, NM
      COMMON NMB, NPROB, OVCOST, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
      1 P02, PN2, PROB, PSL, PSVGE(6), P1, P2, P2P, RATE, RL, RO,
      2 SC, SCC, TBSC, TCRMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
      3 XLSD, XLSN, XLSD, XNC, XTBO, XTTO, Z(750,8)
      C GIVES SC1 FOR ANY SET OF DEPTHS. CINT IS THE FIRST TERM OF THE
      C DEFLECTION EQUATION.
      I
      TERM = 0
      SS = CINT
      DO 60 J=1,LAYER
      C DOVER, THE THICKNESS OF THE JTH LAYER, IS CONVERTED TO INCHES.
      TERM = TERM + AT(J)*DOVER(J) * 36.0
      PART = 6.25*TERM**2
      60 SS = SS + (B(1J+1) - B(1J))*144./((100.*PART)**(24.*PART))
      RETURN
      T
      END

```

SYMBOL KEY

EEEEEE	=	ENTRY
TTTTTT	=	TERMINAL
CCCCC	=	CALL
RRRRR	=	READ
WWWWW	=	WRITE

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PAGE 3

```

.....
.      C1 =CM1*9.0/(5280. * XLW )
.      C2 =CM2*9.0/(5280. * XLW )
.      SCC = SC *9.0/(5280. * XLW)

```

00 20 J-1, NMPD

[illegible]

```

      IF (ILAYER(J) .EQ. 0) GO TO 21

```

C THE COLUMN DESCRIPTIONS ARE AS FOLLOWS--
 3 THREE BLANK SPACES

THREE BLANK SPACES.
FIRST FIELD--1 COLUMN--LAYER ID (THE LAYER NUMBER IN WHICH
THE MATERIAL MAY BE USED.)
**** NOTE **** FIRST FIELD MUST BE 1-9 OR ZERO FOR SUB

**** NOTE ***** FIRST FIELD MUST BE BLANK OR ZERO FOR SUBGRADE*****
THREE BLANK SPACES

SECOND FIELD-1 COLUMN-CODE LETTER OF THE MATERIAL.

C THIRD FIELD-18 COLUMNS-THE NAME OF THE TYPE OF MATERIAL

C FOURTH FIELD-6 COLUMNS-THE IN-PLACE COST PER COMPACTED CUBIC YARD.
C FIFTH FIELD--8 COLUMNS-THE STRENGTH COEFFICIENT OF THE MATERIAL.

SIXTH FIELD--8 COLUMNS--THE MINIMUM LAYER THICKNESS ALLOWED.
SEVENTH FIELD--8 COLUMNS--THE MAXIMUM LAYER THICKNESS ALLOWED.

C EIGHTH FIELD-8 COLUMNS-SALVAGE VALUE PERCENTAGE OF THE MATERIAL.
C THICKNESSES ARE CONVERTED FROM INCHES TO YARDS AND PERCENT TO

L THICKNESSES ARE CONVERTED FROM INCHES TO YARDS AND PERCENT TO
C PROPORTION.

.....

```
DATA(J,11) = DAT11 / 36.0
DATA(J,12) = DAT12 / 36.0
```

```
DATA(J,12) = DAT12 * 30.0
DATA(J,13) = DAT13 * 0.01
```

C DATA(J,1) IS THE INCREMENT IN LAYER THICKNESS, MAY BE RECALCULATED

C ONE FOURTH INCH INCREMENTS IN ALL LAYERS ASSUMED RATHER THAN READING

C THE INCREMENTS FROM INPUT CARDS.

```
.....DATA(1,1) = 0.25 / 36.0
```

20 CONTINUE

.....J=NMPD

21 NM = J-1

```

C *****
C END OF USER INPUTS, SET OTHER PROGRAM VARIABLES
C ***** FPS-9 DOES NOT ALLOW A INITIAL SERVICEABILITY
C ***** AFTER OVERLAY DIFFERENT THAN INITIAL STRUCTURE.

```

$$\vdots \dots [F(P_1, NE, PSI)] P_1 = PSI$$

C OVINC-THE INCREMENT IN OVERLAY THICKNESS.

C 1/2 INCH CONVERTED TO FRACTIONAL YARD

.....OVINC = 0.5/36.0

C UPLEVL-THE AMOUNT OF LEVEL-UP THICKNESS REQUIRED IN OVERLAYS

.....

.....

C--OVSTR IS THE STR

.....

C TMIN THE MINIM

.....TMIN = 0.0

C--CALCULATE NLO, NUMBER OF LANES IN ONE DIRECTION, IF LANES NOT INPUT.
C--THIS WILL ALLOW USE OF DATA FROM PREVIOUS VERSIONS.

THIS WILL ALLOW USE OF DATA

INPUT

PAGE 4

```

.....
NLO=1
.....
IF (MODEL .LT. 3) GO TO 29
.....
NLO = MAX0(2, NLO+1)
.....
OK
.....
29 CONTINUE
.....
C *****
C LIST THE INPUT DATA
C *****
W *****
W WRITE(6,901)
W *****
.....
DO 30 IJK=1,NM
.....
C WRITE OUT THE DATA ARRAY ITEMS IN INCHES AND PERCENTAGE.
.....
D11 = DATA(IJK,11)* 36.0
D12 = DATA(IJK,12)* 36.0
D13 = DATA(IJK,13)*100.0
.....
W *****
W 30 WRITE(6,902) (LAYER(IJK),DATA(IJK,LK),LK=2,10), D11, D12, D13 W
W *****
C--WRITE THE PROPERTIES OF THE SUBGRADE.
W *****
W WRITE(6,903) (DATA(NM+1,LK),LK=3, 8), DATA(NM+1,10) W
W *****
C LANES FOR OUTPUT AS TOTAL LANES, BOTH DIRECTIONS
.....
NL = NLO*2
.....
W *****
W WRITE(6,919) NDP, NMB, NM, CL, XLW, NL
W *****
W WRITE(6,924) ALPHA, P1, P1, P2, P2P, BONE, GAMMA
W *****
C PROPORTION CHANGED TO PERCENT FOR PRINTING OUT
C THIS VERSION PRINTS TRAFFIC VARIABLES IN 20 YEAR VALUES AS INPUT
.....
PROPCT = PROP * 100.0
.....
W *****
W WRITE(6,927) R0, R20, XN20, PROPCT
W *****
W *****
IF (ITYPE .EQ. 2) GO TO 37
.....
W *****
W WRITE(6,938) ITYPE
W *****
.....
GO TO 39
.....
OK
.....
W *****
W 37 WRITE(6,939) ITYPE
W *****
.....
OK
.....
39 CONTINUE
.....
W *****
W WRITE (6,930) XTTO,XTBO,TTSC,TBSC
W *****
W WRITE(6,931) CMAX,TPAXIN,OMININ,OMAXIN
W *****
C *****
C CALL HEADNG(NPROB, ANZ, IPAGE)
C *****
C *****
W *****
W WRITE(6,920) ACPR,ACCD,XLSO,XLSN
W *****
W WRITE(6,933) XLSO,HPO
W *****
W WRITE(6,932) NLRO,NLRN
W *****
W WRITE(6,943) PPO2,PPN2,DO2,ON2
W *****
W WRITE(6,944) AAS,ASO,ASN,MODEL
W *****
W *****

```

INPUT

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C PERCENTAGE RATE PRINTED OUT FOR INTEREST, LANE MILES FOR COST.

```

.....
CM1 = C1 * 5280.0 * XLW / 9.0
CM2 = C2 * 5280.0 * XLW / 9.0
PCTRAT = RATE * 100.0
.....

```

```

.....
WRITE(6,948) CM1,CM2,SC,PCTRAT
.....

```

GO TO 550

OK

540 LAST

OK

```

TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
T 550 RETURN
TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT

```

C

```

780 FORMAT(4X,6X,16A4)
790 FORMAT(2I10,2F10.2,1I10)
793 FORMAT(5F10.2,2F10.4)
795 FORMAT(3F10.0,0F10.2,1I10)
798 FORMAT(4F10.1,4F10.2)
800 FORMAT(6F10.2,2I10)
803 FORMAT(1H0,5X,13H***WARNING***10X,47HAS INPUT,THE PRODUCT OF HPD
LAND PROP IS GREATER/10X,39THAN 100.0 PERCENT -- PROGRAM CONTINUES
2)
805 FORMAT(2F10.2,2F10.4,3F10.2,1I10)
807 FORMAT(4F10.2)
818 FORMAT(3X,11,3X,A1,3X,6A3,F6.2,5F8.2)
900 FORMAT(11H0,INPUT DATA)
901 FORMAT(12X,50HTHE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE
1 /10X,9H MATERIALS,12X,4HCOST,4X,4HSTR,4X,4HMIN,4X,4HMAX,2X,
2 8HSALVAGE,71X,5H LAYER,5H CODE,7X,4HNAME,8X,6HPER CY,2X,
3 6HCOEFF,2X,5HDEPTH,3X,5HDEPTH,6X,4HPCI,1)
902 FORMAT(3X,11,4X,A1,2X,6A3,F6.2,5F8.2)
903 FORMAT(11X, 6A3, 6H -----, F8.2, 3(8H -----) 1)
919 FORMAT(1X, 4X, 39HNUMBER OF SUMMARY OUTPUT PAGES DESIRED(, 12,
1 15/4X,50HTOTAL NUMBER OF INPUT MATERIALS,EXCLUDING SUBGRADE,20X,
2 15/4X,37HLENGTH OF THE ANALYSIS PERIOD (YEARS),33X,F5.1/4X,
3 25HWIDTH OF EACH LANE (FEET),45X,F5.1/, 4X,
4 39HNUMBER OF LANES (BOTH DIRECTIONS), 37X, 15)
920 FORMAT(20X, 22HINPUT DATA (CONTINUED)
1 1H0, 3X,46H ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR),24X,
2 F5.1/4X,48H ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.),22X,
3 F5.2/ 4X,64H C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.
3D. (MILES), 8X,F5.2/ 4X,64H C.L. DISTANCE OVER WHICH TRAFFIC IS SLO
4WED IN THE N.O.D. (MILES), 6X,F5.2)
924 FORMAT(1/4X,29HDISTRICT TEMPERATURE CONSTANT,41X,F5.1/ 4X,
1 45HSERVICEABILITY INDEX OF THE INITIAL STRUCTURE,5X,F5.1/4X,
2 40HSERVICEABILITY INDEX P1 AFTER AN OVERLAY,30X,F5.1/ 4X,
3 31HMINIMUM SERVICEABILITY INDEX P2,39X,F5.1/ 4X,36H SWELLING CLAY
4 PARAMETERS -- P2 PRIME,33X,F6.2/ 32X,2H81,38X,F7.4,
5 F32X, 5HGAMMA,35X,F7.2)
927 FORMAT(1/4X,64H ONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (
1VEHICLES/DAY), 3X,F8.0/ 4X,56H ONE-DIRECTION ADT AT END OF TWENTY Y
2EARS (VEHICLES/DAY), 11X,F8.0/4X,17H ONE-DIRECTION 20, 46H-YR AC
3CUMULATED NO. OF EQUIVALENT 18-KIP AXLES, 2X,F10.0/4X,62H PROPORTIO
4N OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT),8X,F5.1)
930 FORMAT(1/ 4X,37H MINIMUM TIME TO FIRST OVERLAY (YEARS),34X,F4.1/ 4X,
1 37H MINIMUM TIME BETWEEN OVERLAYS (YEARS),33X,F5.1/ 4X,62H TIME TO
2 FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS),8X,
3 F5.1/ 4X,31H TIME BETWEEN SEAL COATS (YEARS),39X,F5.1)
931 FORMAT(4X,59H MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DO
1LLARS),11X,F5.2/ 4X,58H MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTR
2UCTION (INCHES),12X,F5.1/4X,34H MINIMUM OVERLAY THICKNESS (INCHES),
336X,F5.1/4X,50H ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES),
420X,F5.1)
932 FORMAT(1/4X,47H NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.,23X,
1 15/4X,49H NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.,
2 21X,1)
933 FORMAT(4X,47H DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES),
1 23X,F5.2/4X,37H OVERLAY CONSTRUCTION TIME (HOURS/DAY),33X,F5.1)
938 FORMAT(4X,29H THE ROAD IS IN: RURAL AREA, 16)
939 FORMAT(4X,29H THE ROAD IS IN AN URBAN AREA, 16)
943 FORMAT(1/4X,66H PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN
1 O.D. (PERCENT), 4X,F5.2/ 4X,68H PROPORTION OF VEHICLES STOPPED BY
2 ROAD EQUIPMENT IN N.O.D. (PERCENT), 2X,F5.2/ 4X,54H AVERAGE TIME STO
3PPED BY ROAD EQUIPMENT IN O.D. (HOURS),15X,F6.3/ 4X,56H AVERAGE TIM
4E STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS),13X,F6.3)
944 FORMAT(4X,48H AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH),22X,
1 F5.1/4X,48H AVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH),
2 22X,F5.1/4X,50H AVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH
3),20X,F5.1/4X,34H TRAFFIC MODEL USED IN THE ANALYSIS,38X,13)
948 FORMAT(1/4X,58H FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LAN
1E MILE),10X,F7.2/ 4X,64H INCREMENTAL INCREASE IN MAINT. COST PER YE
2AR (DOLLARS/LANE MILE), 4X,F7.2/ 4X,39H COST OF A SEAL COAT (DOLLAR
3S/LANE MILE),29X,F7.2/ 4X,46H INTEREST RATE OR TIME VALUE OF MONEY
4 (PERCENT),24X,F5.1)

```

END

SYMBOL KEY

```

EEFFEF  =  ENTRY
TTTTT   =  TERMINAL
CCCCC    =  CALL
RRRRR    =  READ
WWWWW    =  WRITE

```

```

C--'LAYIDX' IS A LAYER INDEXING SUBROUTINE.  EACH CALL TO 'LAYIDX'
C--RETURNS A UNIQUE LAYER INDEXING ARRAY UNTIL ALL COMBINATIONS
C--ARE EXHAUSTED AND 'LAYER' IS RETURNED AS ZERO.  THE FIRST CALL TO
C--LAYIDX MUST HAVE 'LAYER' EQUAL ZERO FOR INITIALIZATION.

C--GIVEN * THE NUMBER OF MATERIALS, MUST BE GREATER THAN ZERO, NOT
C--GREATER THAN NMD.
NM * THE NUMBER OF MATERIALS, MUST BE GREATER THAN ZERO, NOT
C--GREATER THAN NMD.

C--LAYER AN ARRAY WITH THE LAYERS WHICH EACH MATERIAL MAY
C--OCCUR.  ILAYER MUST BE SORTED IN ASCENDING ORDER WITH
C--AT LEAST ONE LAYER PER MATERIAL.
ILAYER * THE LAYER INDEXING ARRAY.
NMD THE DIMENSION OF THE LAYER ARRAY.
LAYER MUST BE EQUAL ZERO THE FIRST CALL FOR A GIVEN SET OF
C--MATERIALS. OTHERWISE MUST BE RETURNED WITH THE VALUE
C--THE LAST CALL TO LAYIDX.

```

```

C--RETURNED
LAYER      THE NUMBER OF LAYERS FOR THIS DESIGN TYPE, OR LAYER SET
           EQUAL ZERO IF NO MORE DESIGN TYPES FOR THIS SET OF
           MATERIALS.
INDEX      AN ARRAY, ONE PER LAYER, POINTING TO THE I-LAYER ARRAY
           AND THE 'DATA' ARRAY, FOR THE SELECTION OF MATERIALS
           FOR THIS DESIGN TYPE.

```

```

DIMENSION ILAYER(NMD), INDEX(LAYD)

```

```

C--THE FOLLOWING DIMENSIONS MUST BE NOT LESS THAN THE MAXIMUM NUMBER
C--OF LAYERS (THE MAXIMUM VALUE IN THE ILAYER ARRAY)

```

```

DIMENSION NN(10), NMBMAT(10)

```

```

C
IF(LAYER .NE. 0) GO TO 50
DO 30 I = 1, LAYD
NNL(I) = 0
30 NMBMAT(I) = 0
DO 40 J = 1, NM
LAY I(LAYER(J))
C-----OPTIONAL, CHECK CF SORTING AND MAXIMUM VALUES OF ILAYER
40 NMBMAT(LAY) = NMBMAT(LAY) + 1
MAXLAY = LAY
OK-----
50 IF(LAYER .GE. MAXLAY) GO TO 55
LAYER = LAYER + 1
GO TO 60
OK-----
55 IF( NNL(LAYER) .LT. NMBMAT(LAYER)) GO TO 60
IF( LAYER .EQ. 1) GO TO 170
NNL(LAYER) = 0
LAYER = LAYER - 1
GO TO 55

```

OK.

LAYIDX

PAGE 2

```

: 60 NN(LAYER) = NN(LAYER) + 1
:
: DO 90 J = 1, MAALAY
:
: IF(NN(J) .EQ. 0) GO TO 100
:
: INDEX(J) = NN(J)
:
: IF(J .EQ. 1) GO TO 90
:
: DO 70 I = 2, J
:
: 70 INDEX(J) = INDEX(J) + NMBHAT(I-1)
:
: 90 CONTINUE
:
: 100 RETURN
:
: 170 LAYER = 0
:
: RETURN
:
: END

```

SYMBOL KEY

FFFF	= ENTRY
TTTT	= TERMINAL
CCCC	= CALL
RRRR	= READ
WWWW	= WRITE

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7 . 6 4 . 3 . 2 . 1

OUTPUT

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```

.....
DO 260 J = NEW, II
.....
JJ = JCONST - J
.....
DO 230 K=1,NPD
.....
230 POLICY(K,JJ+1) = POLICY(K,JJ)
.....
DO 235 I = 1, LAYD
.....
235 XNDKPI(I,JJ+1) = XNDKPI(I,JJ)
.....
260 CONTINUE
C--NOW INSERT THE CURRENT DESIGN IN COLUMN NEW OF THE ARRAY POLICY.
.....
265 POLICY(1,NEW) = NADGN
POLICY(2,NEW) = XIC
POLICY(3,NEW) = RPOCCT
POLICY(4,NEW) = BPTUC
POLICY(5,NEW) = BPHSCC
POLICY(6,NEW) = BPRM
POLICY(7,NEW) = BSAL
POLICY(8,NEW) = AMINCT
.....
C--POLICY(9, ) CONTAINS THE NUMBER OF LAYERS OF THE DESIGN
.....
POLICY(9,NEW) = MINO(10,LAYER)
.....
DO 270 I=1,LAYER
.....
XNDKPI(I,NEW) = CODE(I)
.....
270 POLICY(I+9,NEW) = Z(JL,I+2)
.....
C--POLICY(20, ) CONTAINS THE NUMBER OF PERFORMANCE PERIOD FOR THE DESIGN
.....
KK = MINO(10,IBT)
POLICY(20,NEW) = KK
.....
DO 275 I=1,KK
.....
275 POLICY(I+20,NEW)=BTT(I)
.....
IF (IBT.EQ. 1) GO TO 285
.....
IBTM = IBT-1
.....
DO 280 I=1,IBTM
.....
280 POLICY(I+30,NEW) = BDEXT(I+1)
.....
285 KK = MINO(9,NBSC)
POLICY(40,NEW) = KK
.....
IF (NBSC.EQ. 0) GO TO 300
.....
DO 290 I=1,KK
.....
290 POLICY(I+40,NEW) = BTSC(I)
.....

```

OK

OK

OK

OUTPUT

PAGE 4

```

100 CONTINUE
      IF (AMINCT .GE. BCCOST) GO TO 69
      C--HCCOST IS THE TOTAL COST OF THE BEST DESIGN SO FAR FOR THE SET OF
      C--MATERIALS UNDER CONSIDERATION. IF AMINCT IS LESS THAN BCCOST THIS BEST
      C--IS REPLACED BY THE CURRENT DESIGN UNDER CONSIDERATION.
      JBEST = J
      BCCOST = AMINCT
      BICC = XIC
      BBISS = RISS
      BBPOCC = BPOCCT
      BBPTUC = BPTUC
      BBPSCC = BPWSCC
      BBPRH = BPRH
      BBSAL = BSAL
      NBBS = NBSC
      C--SET THE OVERLAY TIME CONSTRAINT FLAG, FOR THE CURRENT BEST DESIGN.
      ISWIN = ISWIN
      ISMOVB = ISMOV
      C--RESET CONSTRAINT FLAG IN CASE A BETTER DESIGN NOT FLAGGED.
      ISWIN=0
      ISMOV=0
      C--NBSC WILL BE THE OPTIMAL NUMBER OF SEAL COATS DURING THE ANALYSIS PER
      IF (NBSC .EQ. 0) GO TO 62
      DO 61 KN=1,NBSC
      61 BTSC(KN) = BTSC(KN)
      C--IBBT WILL BE THE OPTIMAL NUMBER OF PERFORMANCE PERIODS.
      OK
      62 IBBT = IBBT
      DO 63 KN=1,IBBT
      IF (KN .GT. 1) BBDEXT(KN) = BBDEXT(KN)
      63 BBT(KN) = BBT(KN)
      OK
      69 CONTINUE
      C
      IF (IMESS .EQ. 1) GO TO 85
      IF (IMESS .EQ. 0) GO TO 92
      C--PRINT THE OPTIMAL DESIGN FOR THE SET OF MATERIALS
      C--UNDER CONSIDERATION.
      W
      WRITE(6,967) NROGN
      W
      DO 71 K=1,LAYER
      71 INDEX(K)
      C--THE LAYER THICKNESS IS CONVERTED TO INCHES FOR PRINTING.
      BALLK = 36.0 * Z(JBEST,K*2)
      W
      71 WRITE(6,968) (DATA(I,J),J=3,8),BALLK
      W

```

OUTPUT

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```

*****
W WRITE(6,970) BBISS
W WRITE(6,969) BBT(I)
*****
      IF( IBBT.EQ. 1 ) GO TO 140
*****
W WRITE(6,972)
*****
      DO 72 I=2,IBBT
*****
      IM = I - 1
*****
      C--LEVEL UP IS ADDED FOR PRINTING OUT BUT IS NOT ADDED TO OVERLAY
      C--THICKNESS ACCUMULATED FOR OVERALL DEPTH OF OVERLAY.
*****
      UPLVIN = UPLEVL * 36.0
      TOVER = (BBDEXT(I) + UPLEVL) * 36.0
*****
      72 WRITE(6,975) TOVER, UPLVIN, BBT(IM)
*****
      OK
      I
*****
      140 IF( NBSSC.EQ. 0 ) GO TO 73
*****
W WRITE(6,981) BBT(IBBT), (I,BBTSC(I),I=1,NBSSC)
*****
      GO TO 74
*****
      OK
      I
*****
      73 WRITE(6,982) BBT(IBBT)
*****
      OK
      I
*****
      74 WRITE(6,983) BICC,BBPRN,BBPOCC,BBPTUC,BBPSCC,BBSAL,BCOST
*****
      C--THE REMAINDER OF THIS SUBROUTINE IS USED TO DETECT AND LIST
      C--ALL RESTRICTIONS THAT ARE BINDING AT THE OPTIMAL SOLUTION.
      CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      C TRADE IN PROB AND IPRBL
      CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
*****
W WRITE(6,1000) (CODE(I), I=1, LAYER)
W WRITE(6,1001)
*****
      STK = 0
      J = 0
*****
      DO 308 K=1,LAYER
*****
      STK = STK + Z(JBEST,K+2)
*****
      C--A MINIMUM CONSTRAINT IF (WITHIN ROUNDING ERROR) EQUAL LAYER MINIMUM.
*****
      IF( ABS( Z(JBEST,K+2) - DMIN(K) ) .GT. 0.001) GO TO 305
*****
      J = J + 1
*****
W WRITE(6,1002) J,K
*****
      C--IF ADDITION OF ANOTHER INCREMENT WOULD EXCEED MAX., CONSTRAINED.
*****
      OK
      I
*****
      305 IF( Z(JBEST,K+2) + XINC(K) .LT. DMAX(K) ) GO TO 308
*****
      J = J + 1
*****
W WRITE(6,1005) J,K
*****

```

4 . 3 . 2 . 1

5 . 4 . 3 . 2 . 1

OUTPUT

PAGE 6

308 CONTINUE

IF(15TRXINC(1)-0.001).LT.TCKMAX) GO TO 311

J = J + 1

WRITE(6,1008) J

311 IF(ABS(16CC-SCOST).GT.0.001) GO TO 314

J = J + 1

WRITE(6,1011) J

C--THE CONDITIONS FOR LISTING OF THE FOLLOWING TWO CONSTRAINTS MAY NEED
C--FURTHER CHECKING, HOWEVER THIS METHOD IS BETTER THAN THE PREVIOUS.

314 IF(15MINB.EQ.0) GO TO 317

J = J + 1

WRITE(6,1014) J

C--CHECK FOR OVERLAY TIME CONSTRAINT IF AN OVERLAY DESIGN.

317 IF(16BT.EQ.1) GO TO 323

IF(15MOV8.EQ.0) GO TO 323

J = J + 1

WRITE(6,1017) J

323 IF(16BT.EQ.1) GO TO 330

SOVER = 0.0

DO 326 I=3,16BT

326 SOVER = SOVER + 880EXT(I)

IF(ABS(SOVER - OVMAX).GT.0.001) GO TO 330

J = J + 1

WRITE(6,1020) J

330 IF(J.EQ.0) WRITE(6,1023)

GO TO 99

PAGE 7

OK

OK.

OK.

— 張 —

820 FORMAT(14HOF THE DESIGN TYPES CONSIDERED, THE FUNDS AVAILABLE
10T BE/58H SPENT PER SQ YD. ARE NOT ENOUGH TO COVER THE DESIGN WIT
2M/39H ALL MATERIALS AT THEIR MINIMUM DEPTHS.)
902 FORMAT(3X,11.4X,1,2X,6A3,F6.2,5F8.2)
904 FORMAT(11X, 6A3, 6H, 5F8.2, 4F8H)
906 FORMAT(1X, 8HIVE LAYS, 10X, 5H WITH, 12, 9H LAYS,
959 FORMAT(12H DESIGN TYPE, 13, 5H WITH, 12, 9H LAYS,

1 10MATERIALS , 6A11 / 10X,9MATERIALS, 12X, 4HCOST, /
960 FORMATT 4HSTR, 4X, 4HMIN-, 4X 4HMAX, 21GHSALVAGE INCR- /
1 1X, 5HSLAYER, 5H CODE, 7X, 4HNAME, 8X, 4HPCR CX, 2X, /
2 3HOCFF-, 2X, 5HDEPTH, 3X, 5HDEPTH, 4X, 12HPCT. MENT)
967 FORMATT 12HODESIGN TYPE, 12H1MAL DESIGN FOR THE MATERIALS UNDER CO
2NSIDERATION-- / 8X, 4H5HFOR INITIAL CONSTRUCTION, THE DEPTHS SHOULD BE

3 1
968 FORMAT(15X,6A3,F8.2,7H INCHES)
969 FORMAT(18X,35H THE LIFE OF THE INITIAL STRUCTURE =,F6.2,6H YEARS)
970 FORMAT(18X,35H THE SET OF THE INITIAL STRUCTURE =,F7.3)
972 FORMAT(18X,23H THE OVERLAY SCHEDULE IS)
975 FORMAT(15X,F5.2,21H INCHES) (INCLUDING ,F4.1, 21H INCH LEVEL-UP)

* AFTER F6.2 (7H YEARS.)
981 FORMAT(15X, (2H TOTAL LIFE = 5X, F6.2, 6H YEARS// 8X, 29H SEAL COATS S
1MOULD OCCUR AFTER (14X, 2H = 11, 1H), F7.2, 6H YEARS)
982 FORMAT(15X, (2H TOTAL LIFE = 5X, F6.2, 6H YEARS// 8X, 29H SEAL COATS S

983 FORMATI, 78X, 56HTH TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATION
15 ARE/ 15X, 25INITIAL CONSTRUCTION COST 9X, F6, 3/15X, 30HTH TOTAL ROU
3000 MAINTENANCE COST 4X, F6, 3/15X, 30HTH CONSTRUCTION
3000 9X, 25HTH USER COST, DUR 25X, 20HTH CONCR
40CTION, 3X, F7, 3/15X, 20HTH TOTAL SEAL COAT COST, 14X, F6, 3/15X, 13SHALVAG
5E VALUE, 20X, F7, 3/48X, 7HTH - 79X, 18HTH TOTAL OVERALL COST, 21X, F7, 3/15X, 13SHALVAG

```

993 FORMAT(1X10H, 'INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = ', I4)
996 FORMAT(1X4, '8TH THE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO
OBTAIN A STRUCTURE/ 4X.65THAT WILL MEET THE MINIMUM TIME TO THE FI
28S OVERLAY RESTRICTION.
998 FORMAT(1X4, '52TH THE MINIMUM TIME BETWEEN OVERLAYS IS TOO LONG AND/
10R 4X.52TH THE MAXIMUM ALLOWABLE TOTAL OVERLAY THICKNESS IS TOO
THICK. 1X4, 'OVERLAY POLICY CANNOT BE MET. 1X4, 'OVERLAY POLICY

```

199 FORMAT(1/4X, 52HEAD OF THE MATERIALS AT THEIR MINIMUM DEPTH RESUL
ITS/ 4X, 49H A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM/ 4X,

```

2 24HALLLOW TOTAL THICKNESS.)
1000 FORMAT(42HOFPS PROGRAM ACTIVITY REPORT, DESIGN TYPE, 6A1)
1001 FORMAT(11H0, 39HAT THE OPTIMAL SOLUTION, THE FOLLOWING, 34HBOUND
200X RESERVATIONS ARE ACTIVE.)

```

```

0002 FORMAT( 20X,12,28H. THE MINIMUM DEPTH OF LAYER,(13)
0005 FORMAT( 20X,12,29H. THE MAXIMUM DEPTH OF LAYER,(13)
0008 FORMAT( 20X,12,47H. THE MAXIMUM THICKNESS OF INITIAL CONSTRUCTION)

```

0111 FORMAT= 20X,12,54H. THE MAXIMUM FUNDS AVAILABLE FOR INITIAL CONSTR
1UCTION)
0114 FORMAT= 20X,12,39H. THE MINIMUM TIME TO THE FIRST OVERLAY)
0117 FORMAT= 20X,12,54H. THE MINIMUM TIME BETWEEN OVERLAYS)

```

010 FORMAT(20X,12,35D, THE MAXIMUM ALLOWED BETWEEN OPERATIONS
020 FORMAT( 20X, 20H, THE MAXIMUM ALLOWED CUMULATIVE OVERLAY THICKNE
155)
1023 FORMAT( /20X,4HNONE)

```

999 FORKATHIHO		50HCOUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE	
1	/ IHO, IIO, 45H	INITIAL DESIGNS	
1 *	/ IH, IIO, 45H	INITIAL DESIGNS CONSIDERED	
2	/ IH, IIO, 45H	WHICH WERE FEASIBLE TO FIRST OVERLAY	
3	/ IHO, IIO, 45H	OVERLAYS	
4	/ IH, IIO, 45H	WHICH WERE FEASIBLE	
5	/ IHI, IIO, 45H	OVERLAY POLICIES	
6	/ IH, IIO, 45H	WHICH WERE FEASIBLE	
7	/ IHO, IIO, 45H	FEASIBLE COMPLETE DESIGNS	

END

SYMBOL KEY

EEEE	=	ENTRY
TTTT	=	TERMINAL
CCCC	=	CALL
RRRR	=	READ
WWWW	=	WRITE

101

OVRLAY

PAGE 2

```

.....
IF (T.GE. CL) GO TO 23
.....
C THE REMAINDER OF THE OVERLAY OPTIMIZATION RESEMBLES A "TREE". IT
C IS NECESSARY TO SELECT THE OVERLAY POLICY WITH THE LEAST COST.
.....
DSAV = DVER(I)
TPRIM = T
XNPRIM = XN
BI = BIP
I = 2
.....
OK-----
8 DELO = OVMIN
.....
C THE DEPTH OF LAYER 1 IS = ORIGINAL D(1) + SUM OF PREVIOUS OVERLAYS +
C CURRENT OVERLAY DEPTH.
OK-----
10 DVER(I) = DSAV + ABDD + DELO
KT(3) = KT(3) + 1
.....
IF (ABDD + DELO .GT. OVMAX) GO TO 34
.....
C DETERMINE THE NEW SCI AFTER THE OVERLAY OF DELO THICKNESS.
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CALL CALCISS1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C DETERMINE HOW LONG THIS OVERLAYED PAVEMENT WILL LAST.
.....
P = P1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CALL TIME(I,SS,XN,TPRIM,XNPRIM,ISW,BI,BIP,P)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
IF (ISW.EQ. 0) GO TO 15
.....
C--INCREASE OVERLAY THICKNESS TO PREVENT FAILURE, SET FAILURE SWITCH
ISW = 1 + ISW
DELO = DELO + OVINC
.....
GO TO 10
.....
C--FEASIBLE OVERLAY, SAVE THICKNESS FOR LATER
OK-----
15 DEXT(I) = DELO
KT(4) = KT(4) + 1
ADT = RO + ((RC-RO)/CL)*TPRIM
.....
C DETERMINE THE PRESENT WORTH OF USER COST DURING THE I TH PERFORMANCE
C PERIOD (DURING THE (I-1) OVERLAY)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CALL USER (ADT,I,TPRIM,PMTSY,ITIME,DELO)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
USERCT(I) = PMTSY
.....
C DETERMINE THE PRESENT WORTH OF OVERLAY CONSTRUCTION COST INCLUDING
C THE COST OF LEVEL-UP DURING THE I TH PERFORMANCE PERIOD.
OCC(I) = (DEXT(I)*OVCOST*CTLVOP) / ((1+RATE)**ITIME)
.....
C DETERMINE THE PRESENT WORTH OF ROUTINE MAINTENANCE DURING THE
C I TH PERF. PERIOD.
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CALL PMRMMAINT(RATE,I,TPRIM,C1,C2,CL)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
RM(I) = RMAINT
DADD(I) = DELO
TI(I) = I
TN(I) = XN
XB(I) = BIP
.....
C INCREMENT THE OVERLAY THICKNESS, THEN TEST FOR COMPLETION.
ABDD = ABDD + DELO
.....

```

PAGE 3

.....IF(T,GE,CL) GO TO 23

```
.....IF(I .GE. NPERFD) GO TO 34
```

```
.....IF( ABDD .GT. OVMAX) GO TO 34
```

```

I = I + 1
TPRIM = T
XNPRIM = XN
BI = BIP

```

..... GO TO 1

C DETERMINE THE PRESENT WORTH OF ALL SEAL COATS THAT WILL BE REQUIRED DURING THIS ALTERNATIVE OVERLAY POLICY.

[illegible]

C DETERMINE THE PRESENT WORTH OF THE SALVAGE VALUE OF THE PAVEMENT. THIS
C WILL BE THE COST OF REBUILDING THE PAVEMENT AT THE END OF THE
C ANALYSIS PERIOD.
C--FEASIBLE OVERLAY POLICY

```
..... KTI(6) = KTI(6) + 1  
SALVGE = (SALV-ABDD*OVCOST*OVSALV) / (RATE+1.0)**CL  
PRMC = 0.  
PTUC = 0.0
```

00 27 J=1;1

```

.....POCCT = POCCT + OCCT(J)
.....PRM = PRM + RM(J)

```

```

.....27 PTUC = PTUC + USERBT(J)

```

C EVALUATE THE COST OF THE ALTERNATIVE OVERLAY PROCEDURE AND COMPARE
C TO THE CHEAPEST COST SO FAR.
C TC-THE SUM OF ALL PRESENT WORTHS OF OVERLAY COSTS.

..... TC = POCCT+PTUC+PRM+PWSCC+SAI VGE

..... IFC AMINCT IFC TC I GO TO 34

.....
 NOK = 2
 AMINCT = TC
 BPOCCT = POCCT
 BPTUC = PTUC
 BPRM = PRM
 BPWSCC = PWSCC
 NBSC = NSC
 BSAL = SALVGE

```
IF( NSC :EQ: 0 ) GO TO 29
```

```
DO 28 J=1,NB SC
```

...28 BTSC(J) = TSC(J)

C I=IBT = NUMBER OF PERFORMANCE PERIODS.

29 OCT 1961

00 30 JK±1.1

PAGE 4

T 60 RETURN

SYMBOL KEY

EEEEEE	=	ENTRY
TTTTTT	=	TERMINAL
CCCCCC	=	CALL
RRRRRR	=	READ
WWWWWW	=	WRITE

105

SEAL

SYMBOL KEY
 EEEEE = ENTRY
 TTTT = TERMINAL
 CCCCC = CALL
 RRRR = READ
 WWWW = WRITE

```

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
SUBROUTINE SEAL(TTSC,TBSC,TT,CL,CL,CL,RATE,PWSCC,NSC,TSC,TMIN)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
  
```

C--THIS SUBROUTINE DETERMINES THE PRESENT WORTH PER SQUARE YARD OF ALL
 C SEAL COATS WHICH WILL BE APPLIED DURING THE ANALYSIS PERIOD I.
 C--VSC WILL BE THE NUMBER OF SEAL COATS PERFORMED.

DIMENSION TT(20),NUM(20),TSC(20)

NSC = 0

DO 2 K=1,I

2 NUM(K) = 0

J = 1

YEARS = TT(J)

IF (YEARS .GT. CL) YEARS = CL

C--NO SEAL COAT WILL BE APPLIED IF OVERLAY IS WITHIN TMIN YEARS

OK

3 IF (YEARS-TTSC) .LE. TMIN) GO TO 10

REMAIN = YEARS - TTSC

C--NUM SEAL COATS WILL BE APPLIED DURING THE ITH OVERLAY PERIOD.

NUM(J) = 1.0 * (REMAIN/TBSC)

C--THE 1 IN THE NEXT RELATIONSHIP IS FOR THE SEAL COAT
 C APPLIED AFTER TTSC YEARS.

XNUM = NUM(J) - 1

C--AGAIN NO SEAL COAT WITHIN 'TMIN' YEAR(S) PRIOR TO OVERLAY

IF (REMAIN-XNUM*TBSC) .LT. TMIN) NUM(J)=NUM(J)+1

OK

10 IF (TT(J) + TTSC) .GE. CL) GO TO 15

J = J + 1

YEARS = TT(J) - TT(J-1)

IF (TT(J) .GT. CL) YEARS = CL-TT(J-1)

GO TO 3

C--DETERMINE THE PRESENT WORTH OF ALL SEAL COATS FOR THE ANAL. PERIOD.

OK

15 PWSCC = 0.0

PT = 0.0

DO 25 K=1,J

IF (NUM(K) .EQ. 0) GO TO 25

POWER = TTSC + PT

KK = NUM(K)

DO 20 L=1,KK

NSC = NSC + 1

C--TSC(NSC) CONTAINS THE TIME AT WHICH THE NSC TH SEAL COAT IS APPLIED.
 C--KK IS THE NUMBER OF SEAL COATS IN THE K TH PERF. PERIOD.

TSC(NSC) = POWER

SEAL

PAGE 2

C--PRESENT WORTH IS CALCULATED TO THE NEAREST INTEGER YEAR.

.....
 PWSCC = PWSCC + SCC/(1.0+RATE)**(IFIX(POWER*0.5))
 POWER = POWER + TBSC

20 CONTINUE

OK

25 PT = T/(K)

.....
 RETURN

END

SOLVE2

SYMBOL KEY
 EEEEE = ENTRY
 TTTT = TERMINAL
 CCCC = CALL
 RRRR = READ
 WWWW = WRITE

```

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
SUBROUTINE SOLVE2(IKSKIP, ICOST, NUMBER, SCOST)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE

```

```

COMMON A(7), AAS, ACCD, ACPR, ALPHA, AN2(16), ASN, ASO, B(7),
1  BB(11), B ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
2  ON2, DO2, DMAX(6), DMIN(6), DOVER(6), GAMMA, HPD, INDEX(10),
3  IPAGE, ITYPE, KT(9), LAYER, MATYPE, MODEL, NLD, NLRN, NLRD, NM
COMMON NMR, NPROB, OVCOST, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
1  PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
2  SC, SCC, TBC, TCKMAX, TWIN, IT(20), ITSC, UPLEVL, XINC(6),
3  XLSD, XLSN, XLSD, XMC, XTBO, XTTO, Z(750,8)
DIMENSION IIX(6), XIINC(6)

```

C--NUMBER IS THE FIRST DIMENSION OF Z TO PREVENT SUBSCRIPT OUT OF RANGE.
 C--FUZZ IS USED TO PREVENT ARBITRARY ROUNDING BY FORTRAN FROM CAUSING
 C--TROUBLES.

DATA NUMBRD/750/, FUZZ/ 1.000/

DO 2 J=1,LAYER

XIINC(J) = XINC(J)

2 IIX(J) = 0

IK = 0
 CT = 0
 SCOST = 0
 ISKIP = 0
 ICOST = 0
 NUMBER = 0
 LZ = LAYER + 2

DO 5 J=1,LAYER

CT = CT + COST(J) * DMIN(J)

5 DOVER(J) = DMIN(J)

IF (IK .LE. TCKMAX * FUZZ) GO TO 8

ISKIP = 1

GO TO 30

OK

8 IF (CT .LE. CMAX * FUZZ) GO TO 10

ICOST = 1

GO TO 30

OK

10 I = 1

IN = 0

OK

```

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
15 CALL CALC(155)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

```

IN = IN + 1

NUMNOW = NUMBER

IF (NUMBER .LT. 1) GO TO 159

C--THE FOLLOWING ELIMINATES HIGH COST, LOW QUALITY DESIGNS FROM THE
 C--ARRAY OF FEASIBLE DESIGNS. A DESIGN OF HIGHER COST MUST NOT HAVE
 C--A SHORTER INITIAL PERFORMANCE PERIOD (ISS NOT GREATER) TO BE CON-
 C--SIDERED. THE FOLLOWING DO LOOP CHECKS THE Z ARRAY WHILE KEEPING
 C--Z SORTED IN DESIGNS OF ASCENDING STRENGTH TO BE CONSIDERED.
 C--REMOVE ALL STATEMENTS BETWEEN HERE AND STATEMENT 158 IF ALL INITIAL
 C--DESIGNS TO BE CONSIDERED AND REPLACE 158 WITH IN=NUMNOW + 1.

DO 158 IX=1, NUMBER

SOLVE2

PAGE 2

```

.....
IF( IN .GT. NUMNOW) GO TO 159
C--IF THIS DESIGN IS NOT WEAKER, GO TO A CHECK OF FORMER DESIGN.
.....
IF( SS .LT. Z( IN,1) * FUZZ) GO TO 156
C--ELSE DISCARD THIS DESIGN IF IT IS NOT CHEAPER, SINCE IT IS WEAKER.
.....
IF( CT * FUZZ .GE. Z( IN,2) ) GO TO 170
C--ELSE GO TO INCLUDE IN Z ARRAY OF DESIGNS TO BE CONSIDERED.
.....
GO TO 159
.....
C--IF THE FORMER DESIGN IS CHEAPER, KEEP IT.

```

```

.....
OK-----
156 IF( Z( IN,2) * FUZZ .LT. CT ) GO TO 158
C--ALSO KEEP IF COST AND STRENGTH NEARLY EQUAL,
.....
IF( Z( IN,2) .LE. CT * FUZZ .AND. Z( IN,1) .LE. SS * FUZZ) GO TO 158
C--ELSE DISCARD THE FORMER DESIGN.

```

```

.....
KT(8) = KT(8) - 1
NUMNOW = NUMNOW - 1

```

```

.....
IF( IN .GT. NUMNOW) GO TO 159

```

```

.....
DO 157 J = IN, NUMNOW

```

```

.....
DO 157 L = 1, L2

```

```

.....
Z( J,L) = Z( J+1,L)

```

```

.....
157 CONTINUE

```

```

.....
IN = IN - 1

```

```

.....
158 IN = IN + 1

```

```

.....
159 NUMNOW = NUMNOW + 1

```

```

.....
IF( NUMNOW .GT. NUMBDD) GO TO 35

```

```

C--INSERT THE DESIGN AT 'IN'.

```

```

.....
IF( IN .GT. NUMNOW) GO TO 16

```

```

.....
NUM = NUMNOW - 1
JCONST = NUM + IN

```

```

.....
DO 160 J = IN, NUM

```

```

.....
JJ = JCONST - J

```

```

.....
DO 160 L = 1, L2

```

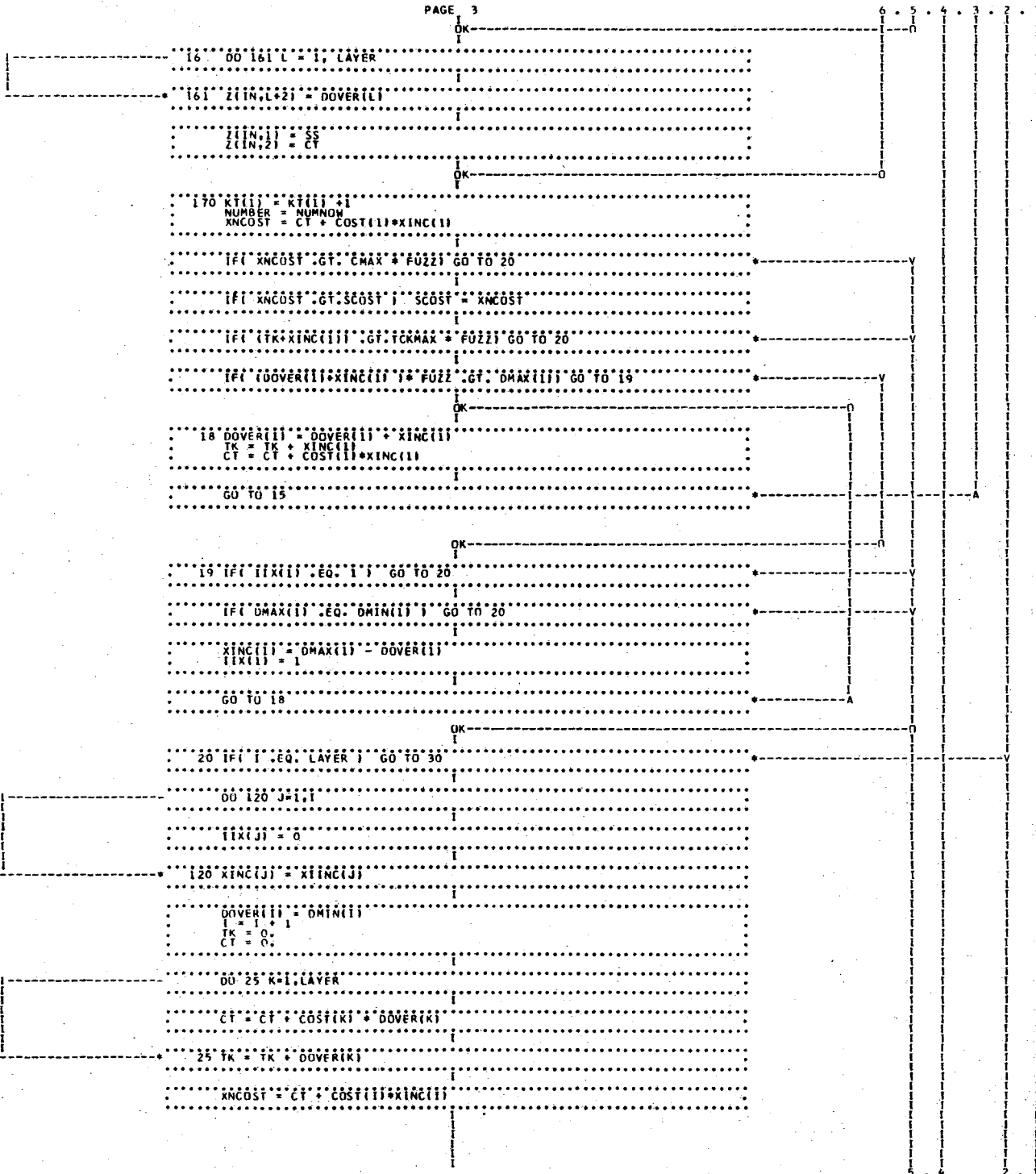
```

.....
160 Z( JJ+1,L) = Z( JJ,L)

```

SOLVE2

PAGE 3



PAGE 4

```

PAGE 4
.....
1 IF1 XNCOST.GT.CMAX.F0221 GO TO 20
.....
2 IF1 XNCOST.GT.SECOST.SECOST = XNCOST
.....
3 IF1 (1X1XNC111).GT.TCMMAX.F0221 GO TO 20
.....
4 IF1 (DOVER111.XINC111).F0221.GT.CMAX111 GO TO 22
.....
5 OK
.....
6 21 DOVER111 = DOVER111 + XINC111
   TK = TK + XINC111
   CT = CT + COST111.XINC111
.....
7 GO TO 10
.....
8 OK
.....
9 22 IF1 (1X111).EQ.1 GO TO 20
.....
10 IF1 DMAX111.EQ.DMIN111 GO TO 20
.....
11 XINC111 = DMAX111 - DOVER111
   1X111 = 1
.....
12 GO TO 21
.....
13 OK
.....
14 30 DO 31 L = 1 LAYER
.....
15 31 XINC111 = XINC111
.....
16 GO TO 36
.....
17 OK
.....
18 W 35 WRITE(6,900) NUMBRD
.....
19 NUMBER = NUMBRD
.....
20 OK
.....
21 36 KT(R) = NUMBER
.....
22 RETURN
.....
23 900 FORMAT(1H1,19THERE ARE MORE THAN,15,52H FEASIBLE INITIAL DESIGNS
   1FOR THIS SET OF MATERIALS. )
.....
24 END
.....

```

SUMARY

SYMBOL KEY
 EEEEE = ENTRY
 TTTT = TERMINAL
 CCCC = CALL
 RRRR = READ
 WWWW = WRITE

```

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
SUBROUTINE SUMMARY(INDP, NMB, NPROB, AN2, IPAGE, UPLEVL,
* KNTOL, XNDKP, POLICY, NPOS, NPOSS, NK, IPOSS, OCOST)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
  
```

```

C--FOR THE PROBLEM SUMMARY
C--THIS SUBROUTINE WILL SORT AND PRINT IN ORDER A SUMMARY OF THE OPTIMUM
C--FOR EACH DESIGN TYPE, THEN PRINT A SUMMARY OF BETTER DESIGNS.
C--THE DIMENSIONS OF THE FOLLOWING WILL NEED TO BE CHANGED IF ARRAYS
C IN THE CALLING PROGRAM ARE CHANGED.
  
```

```

      DIMENSION IDUMMY(24), AN2(16), NMBMAT(6), POLICY(50,24)
      DIMENSION OCOST(100), IPOSS(100), NPOSS(100)
      DIMENSION XNDKP(6,24)
      DIMENSION F850(22), F854(22), F858(22), F864(22)
      DATA F850(1)/4H1X,/, F850(2)/4H2H,/, F850(3)/4H,11,/,
1 F850(4)/4H1H,/, F850(5)/4H1X,/, F850(22)/3H1X,/,
1 DATA F854(1)/4H1X,/, F854(2)/4H2H,/, F854(3)/4H,11,/,
1 F854(4)/4H1H,/, F854(5)/4H1X,/, F854(22)/3H1X,/,
1 DATA F858(1)/4H1X,/, F858(2)/4H2H,/, F858(3)/4H,11,/,
1 F858(4)/4H1H,/, F858(5)/4H1X,/, F858(22)/3H1X,/,
1 DATA F864(1)/4H1X,/, F864(2)/4H2H,/, F864(3)/4H,11,/,
1 F864(4)/4H1H,/, F864(5)/4H1X,/, F864(22)/3H1X,/,
2 F864(23)/2H,/,
1 DATA ABLK/2H,/, F4/4HF6.1/, COM/4H,1X,/, F6/4HF6.2/,
1 COM1/4H,1X,/,
1 DATA BLANK/1H,/, STAR/4H****/
  
```

```

C *****
  
```

```

      IF( NK - 1 ) 530,210,180
  
```

```

      180 NKM = NK - 1
  
```

```

      DO 200 II=1,NKM
  
```

```

        IIP = II - 1
  
```

```

        DO 190 JJ=IIP,NK
  
```

```

          IF( OCOST(IIP) .LT. OCOST(JJ) ) GO TO 190
  
```

```

          STORE = OCOST(IIP)
          OCOST(IIP) = OCOST(JJ)
          OCOST(JJ) = STORE
          IS = IPOSS(IIP)
          IPOSS(IIP) = IPOSS(JJ)
          IPOSS(JJ) = IS
  
```

```

          OK
  
```

```

      190 CONTINUE
  
```

```

      200 CONTINUE
  
```

```

      CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      CALL HEADNG(INPROB, AN2, IPAGE)
      CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
  
```

```

      OK
  
```

```

      WWWW
      W 210 WRITE(6,825)
      W WRITE(6,826) (IPOSS(KK),OCOST(KK),KK=1,NK)
      WWWW
  
```

```

      IF( NPOS .EQ. 0 ) GO TO 220
  
```

```

      WWWW
      W WRITE(6,827) (NPOSS(I),I=1,NPOS)
      WWWW
  
```

```

      GO TO 210
  
```

```

      OK
  
```

```

      WWWW
      W 220 WRITE(6,829)
      WWWW
  
```

```

C--THE REMAINDER OF THIS SUBROUTINE WRITES OUT THE SUMMARY TABLE.
  
```

```

      OK
  
```

SUMARY

PAGE 2

```

230 NMBEST = MIN0(NMB*NDP, KNTOL)
DO 520 L = 1, NMBEST, NDP
LL = MIN0(L*NDP-1, NMBEST)
C-NMBT THE NUMBER OF 4 CHARACTER WORDS OF LITERAL '****' TO BE USED AS
C LINES IN THE SUMMARY TABLES.
NMBT = (LL-LL*7+31)/4
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C CALL HEADNG(INPROB, AN2, IPAGE)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
NMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
M WRITE(6,830) (I,I=0,LL)
M NMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
DO 240 I = 1, LL
240 IDUMMY(I) = POLICY(I)
DO 270 I = 1, 5
NKOUNT = 0
DO 260 K = 1, LL
IF( IDUMMY(K) .GE. 1 ) GO TO 250
POLICY(I+9,K) = 0.0
XNDKP(I,K) = BLANK
GO TO 260
OK
250 NKOUNT = NKOUNT + 1
OK
260 CONTINUE
IF( NKOUNT .EQ. 0 ) GO TO 280
NLINE = 1
270 CONTINUE
OK
NMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
M 280 WRITE(6,831) STAR, I = 1, NMBT
M NMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
IF( NLINE .GE. 4 ) GO TO 310
NLP = NLINE + 2
DO 300 I = NLP, 5
DO 290 K = 1, LL
290 XNDKP(I,K) = BLANK
300 CONTINUE

```

SUMARY

PAGE 3

OK

```

#####
W 310 WRITE(6,832) ((XNDKP(I,1),I=1,51),I=L,LL)
W WRITE(6,834) (POLICY(2,1),I=L,LL)
W WRITE(6,836) (POLICY(3,1),I=L,LL)
W WRITE(6,838) (POLICY(4,1),I=L,LL)
W WRITE(6,840) (POLICY(5,1),I=L,LL)
W WRITE(6,842) (POLICY(6,1),I=L,LL)
W WRITE(6,844) (POLICY(7,1),I=L,LL)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,846) (POLICY(8,1),I=L,LL)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,848) (DUMMY(1),I=L,LL)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,849)
#####

```

DO 340 I=1,NLINE

DO 320 K=6,20,2

F850(K) = F6

320 F850(K+1) = COM1

DO 330 K=L,LL

M = K-L+1

C--CONVERT LAYER DEPTHS TO INCHES FOR PRINTING.

POLICY(I+9,K) = POLICY(I+9,K) * 36.0

IF (POLICY(I+9,K).NE.0.) GO TO 330

F850(2*M+1) = ABLK

F850(2*M+5) = COM

OK

330 CONTINUE

```

#####
W WRITE(6,F850), (POLICY(I+9,J),J=L,LL)
#####

```

340 CONTINUE

DO 350 I = L,LL

350 DUMMY(I) = POLICY(20,I)

```

#####
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,852) (DUMMY(I),I=L,LL)
W WRITE(6,831) (STAR,I=1,NMBT)
W WRITE(6,853)
#####

```

DO 390 I=1,10

DO 360 K=6,20,2

F854(K) = F4

360 F854(K+1) = COM

NKOUNT = 0

DO 380 K = L,LL

SUMARY

PAGE 4

```

.....
M = K - L + 1
.....
IF( IDUMMY(K) .GE. I ) GO TO 370
.....
POLICY(I+20,K) = 0.0
F854(2*M+4) = ABLK
.....
GO TO 380

```

```

.....
370 NKOUNT = NKOUNT + 1
.....

```

```

.....
380 CONTINUE
.....

```

```

.....
IF( NKOUNT .EQ. 0 ) GO TO 400
.....
WRITE(6,F854) I, (POLICY(I+20,J), J=L,LL)
.....

```

```

.....
390 CONTINUE
.....

```

```

.....
400 WRITE(6,831) (STAR, I = 1, NMBT)
.....

```

```

.....
DO 440 I=1,9
.....

```

```

.....
DO 410 K=6,20,2
.....

```

```

.....
F858(K) = F4
.....

```

```

.....
410 F858(K+1) = COM
.....

```

```

.....
NKOUNT = 0
.....

```

```

.....
DO 430 K = L,LL
.....

```

```

.....
M = K-L+1
.....

```

```

.....
IF( IDUMMY(K) .GE. I+1 ) GO TO 420
.....

```

```

.....
POLICY(I+30,K) = 0.0
F858(2*M+4) = ABLK
.....

```

```

.....
GO TO 430
.....

```

```

.....
420 NKOUNT = NKOUNT + 1
.....

```

```

.....
C--ADD THE LEVEL-UP INCREMENT, CONVERT TO INCHES
.....

```

```

.....
POLICY(I+30,K) = (POLICY(I+30,K) + UPLEVL) * 36.0
.....

```

```

.....
430 CONTINUE
.....

```

```

.....
IF( NKOUNT .EQ. 0 ) GO TO 450
.....

```

SUMARY

PAGE 5

```

*****
WRITE (6,F858) I, (POLICY(I+30,J), J=L,LL)
*****

```

440 CONTINUE

OK

450 DO 460 I = L,LL

460 IDUMMY(I) = POLICY(I+40,I)

```

*****
WRITE (6,831) (STAR, I = 1, NMBT)
WRITE (6,860) (IDUMMY(I), I = L,LL)
WRITE (6,831) (STAR, I = 1, NMBT)
WRITE (6,862)
*****

```

DO 500 I = 1,8

DO 470 K = 7,19,2

F864(K) = F4

470 F864(K+1) = COM

F864(21) = F4

NKOUNT = 0

DO 490 K = L,LL

M = K-L+1

IF (IDUMMY(K) .GE. I) GO TO 480

POLICY(I+40,K) = 0.0

F864(2+M+5) = ABLK

GO TO 490

OK

480 NKOUNT = NKOUNT + 1

OK

490 CONTINUE

IF (NKOUNT .EQ. 0) GO TO 510

```

*****
WRITE (6,F864) I, (POLICY(I+40,J), J=L,LL)
*****

```

500 CONTINUE

OK

510 CONTINUE

```

*****
WRITE (6,831) KNTOL
*****

```

520 CONTINUE

```

*****
WRITE (6,866)
*****

```

GO TO 540

SUMMARY

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```

.....
530 CONTINUE
.....
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C  CALL HEADNG(INPROB, AN2, IPAGE)
C  CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
WWWXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
W  WRITE(6,870)
WWWXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
.....
TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
T 540 RETURN
TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT

C
C--FORMAT STATEMENTS
825 FORMAT(49H)PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE
1 76X,47H      IN ORDER OF INCREASING TOTAL COST//11X,
2 13HDESIGN TYPE 4X,10HTOTAL COST)
826 FORMAT(16X,12,11X,F7.3)
827 FORMAT(//5X, 58HTHE MATERIALS ASSOCIATED WITH EACH OF THE FOLLOWIN
1G DESIGN//5X, 49H TYPES DO NOT HAVE AT LEAST ONE FEASIBLE DESIGN./
2 /12X,15) )
829 FORMAT(//5X, 60HALL MATERIAL COMBINATIONS HAVE AT LEAST ONE FEASIB
1LE DESIGN.)
830 FORMAT(19X, 46H)PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS/26X,
1 33HIN ORDER OF INCREASING TOTAL COST// 20X,817)
831 FORMAT(2X,32A4,A2)
832 FORMAT( 2X,20HMATERIAL ARRANGEMENT, 4X,8(5A1,2X) )
834 FORMAT( 2X,17HINIT. CONST. COST,4X,8F7.3)
836 FORMAT( 2X,19H)OVERLAY CONST. COST,2X,8F7.3)
838 FORMAT( 2X, 9HUSER COST,12X,8F7.3)
840 FORMAT( 2X,14H)SEAL COAT COST,7X,8F7.3)
842 FORMAT( 2X,19HROUTINE MAINT. COST,2X,8F7.3)
844 FORMAT( 2X,13H)SALVAGE VALUE,8X,8F7.3)
846 FORMAT( 2X,10HTOTAL COST,11X,8F7.3)
848 FORMAT( 2X,16H)NUMBER OF LAYERS,2X,817)
849 FORMAT( 2X,20H)LAYER DEPTH (INCHES) )
852 FORMAT( 2X,18H)NO. OF PERF. PERIODS,817)
853 FORMAT( 2X,18H)PERF. TIME (YEARS) )
856 FORMAT( 2X,20H)OVERLAY POLICY(INCH)/2X, 20H(INCLUDING LEVEL-UP) )
860 FORMAT( 2X,20H)NUMBER OF SEAL COATS,2X,13,7(4X,13) )
862 FORMAT( 2X,18H)SEAL COAT SCHEDULE/5X, 17H(YEARS) )
866 FORMAT(//10X,51H)THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WA
1S, 110////)
870 FORMAT(//10X,60H)THERE WERE NO FEASIBLE DESIGNS FOR THE CONDITION
1S SPECIFIED.////)

.....
END
.....

```

TIME

SYMBOL KEY

EEEEE = ENTRY
 TTTT = TERMINAL
 CCCC = CALL
 RRRR = READ
 WWWW = WRITE

```

    EEEEEEEEEE
    SUBROUTINE TIME( I, T, SS, XN, TPRIM, XNPRIM, ISW, BI, BIP, P )
    EEEEEEEEEE
  
```

```

    COMMON A(7), AAS, ACCO, ACPR, ALPHA, ANZ(16), ASN, ASD, B(7),
    1 BB(11), B ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
    2 DNZ, DOZ, DMAX(6), DMIN(6), DOVER(6), GAMMA, HPD, INDEX(10),
    3 IPAGE, ITYPE, KT(9), LAYER, MATYPE, MODEL, NLO, NLRN, NLRO, NM
    COMMON NMB, NPROB, OVCOST, OYINC, OVMAX, OYMIN, OVSALV, OVSTR,
    1 P02, PN2, PROP, PSI, PSYGE(6), P1, P2, P2P, RATE, RC, RO,
    2 SC, SCC, TBSC, TCKMAX, THIN, TT(20), ITSC, UPLEVL, XINC(6),
    3 XLSO, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
  
```

C THIS SUBROUTINE SOLVES FOR THE LIFE OF A PERFORMANCE PERIOD BY
 C ITERATION. AN ESTIMATE IS MADE OF T, THE TIME(YEARS) AT THE END OF
 C THE PERFORMANCE PERIOD, AND THE TRAFFIC EQUATION IS USED TO CALCULATE
 C THE 18 KIP AXLE-EQUIVALENTS DURING THE PERIOD AND THE PERFORMANCE
 C EQUATION SOLVES FOR P, THE SERVICEABILITY, AND THIS VALUE IS CHECKED
 C FOR ERROR BY COMPARISON WITH P2, THE GIVEN LIMIT OF SERVICEABILITY.
 C IF NOT WITHIN THE REQUIRED ACCURACY A NEW ESTIMATE OF T IS MADE.
 C--THE SWITCH ISW IS INCLUDED SO THAT THE ITERATION PROCEDURE FOR
 C DETERMINING TIME MAY BE TRUNCATED WHEN THE LIFE OF AN OVERLAY
 C IS LESS THAN THE APPLICABLE OF TIME TO THE FIRST OVERLAY OR TIME
 C BETWEEN OVERLAYS ALLOWED.
 C--THESE DESIGNS ARE NOT ALLOWED AND WILL NOT BE CONSIDERED.

```

    C I PERFORMANCE PERIOD, WHEN EQUAL ONE, TIME TO FIRST OVERLAY CHECKED
    C T TIME(IN YEARS) SINCE INITIAL CONSTRUCTION, RETURNED AS TIME TO
    C SS SURFACE CURVATURE INDEX.
    C XN NUMBER(IN MILLIONS) OF EQUIV. AXLES IN ONE DIRECTION DURING TIME
    C XNC ONE DIRECTION 18-KIP EQUIV. AXLES DURING ANALYSIS PERIOD(IN
    C MILLIONS)
    C TPRIM TIME TO THE PRESENT PERIOD.
    C XNPRIM AXLE EQUIVALENT DURING TPRIM.
    C CL LENGTH (IN YEARS) OF THE ANALYSIS PERIOD.
    C ISW A SWITCH RETURNED NON-ZERO IF TIME CONSTRAINTS TO OVERLAY NOT MET
    DATA ACCUR/0.01/, TLIM/99.9/, MITER/20/
  
```

```

    C ACCUR IS THE ALLOWABLE P ERROR IN TIME CALCULATION
    C TLIM IS AN ARBITRARY MAXIMUM T
    C MITER (MAXIMUM ITERATIONS) SHOULD BE APPROXIMATELY . . .
    C MITER = IFIX(ALOG2(TLIM)) + IFIX(ALOG2(TLIM/ACCUR))
    C WHERE ALOG2 IS LOGRITHM, BASE TWO.
  
```

```

    .....
    C--THE MIN. TIME BETWEEN OVERLAYS IS XTBO EXCEPT IN THE 1ST PERIOD, XTTO.
    .....
    DELT = XTBO
    IF( I.EQ. 1 ) DELT = XTTO
    .....
  
```

```

    C--TERMS OR PARTIAL TERMS OF THE TRAFFIC EQUATION
    .....
    TRDEL = (RC-RO) / CL
    TRFTRM = XNC / (CL*(RO+RC))
    RO2 = RO + RO
    .....
  
```

```

    C--TERMS OR PARTIAL TERMS FROM THE PERFORMANCE EQUATION
    .....
    SORTSP = SORT(5.-P1)
    SWLTRM = SORT(5.-P2) - SORTSP
    PRFTRM = 53.6 * (SS**2) / ALPHA
    .....
  
```

```

    C--ESTIMATE OF T MADE USING MINIMUM CONSTRAINT TIMES.
    .....
    EST T = T1 + DELT
    .....
  
```

```

    C--SOLVE FOR T, UNLESS A CONSTRAINT FAILURE.
    .....
    DO 40 ITER=1,MITER
    .....
  
```

```

    C--TRAFFIC EQUATION
    .....
    XN = TRFTRM * (RO2 + TRDEL*EST T)*EST T
    .....
  
```

```

    C--PERFORMANCE EQUATION (NEXT THREE STATEMENTS)
    .....
    TRLOSS = PRFTRM * (XN-XNPRIM)
    SWLOSS = SWLTRM * (1.0-EXP(-BI*(EST T - T1)))
    EST P = 5.0 - (SORTP+TRLOSS*SWLOSS)**2 - GAMMA *(EST T - T1)
    P ERROR = ABS(EST P - P2)
    .....
  
```

```

    C ITERATION COMPLETE IF P ERROR WITHIN ACCURACY REQUIREMENT.
    .....
    IF(P ERROR .LT. ACCUR) GO TO 60
    .....
  
```

```

    DELT = DELT * 0.5
    .....
  
```

TIME

PAGE 2

C OVERESTIMATE OF TIME IF P AT ESTIMATED T IS LESS THAN P2.

IF (EST P .LT. P2) GO TO 20

IF (ISW .NE. 0) DELT = EST T * ITER
EST T = EST T + DELT

GO TO 40

C IF OVEREST. OF T FIRST ITERATION, A TIME CONSTRAINT FAILURE

20 IF (ITER .EQ. 1) GO TO 60
IF (ITER .EQ. 1) GO TO 60

EST T = EST T - DELT
ISW = 0

40 CONTINUE

C CONVERGENCE GUARANTEED IN LESS THAN 20 ITERATION WITH 100 YR
T VALUE, EXPECT 3 TO 10 ITERATIONS.

EST T = TLIM

C--ITERATION COMPLETE, ISW=1 IF OVEREST. WITH MINIMUM TIME CONSTRAINT.

60 T = EST T
IF (T .GT. TLIM) T = TLIM
IF (ABS(P ERROR) .LE. ACCUR) ISW=0

C--CALCULATE TERM USED FOR NEXT PERFORMANCE PERIOD.

RIP = B1*EXP(-B1*(EST T-T1))

RETURN

END

USER

SYMBOL KEY

```

EEEEEE = ENTRY
TTTTT = TERMINAL
CCCCC = CALL
RRRRR = READ
WWWWW = WRITE

```

[illegible]

```

COMMON A171, AAS, ACCC, ACPR, ALPHA, AN21161, ASN, ASD, B171,
1 8B1111, BONE, CINT, CL, CMAX, CL, C2, COST(61), DATA111131,
2 DN2, DQ2, DNAX(61), DM1N(61), DOVER(61), GAMMA, HPD, INDEX11131,
3 PAGE, ITYPE, HPD, LAYER, MAX, MAX, MODEL, NLO, NLKN, NLO, NM
COMMON NMA, HPB, GCDS, GWIND, GWAVE, OVR, OVR,
1 PQZ, PMZ, PROP, PSI, PSYGE(61), P1, P2, P2P, RATE, RC, RO,
2 SC, SCE, TBSC, TCKMAX, TRIN, TT(20), TISC, UPLEVEL, XINC(61),
3 XLSO, XLSN, XLSO, XNC, XTBO, XTDT, Z1750(8)
DIMENSION C, CCSU(1), CU(1,2), CU(1,2)
DIMENSION BUTFQ(16), BUTRIV(16), BUTEQV(16), BUTFRV(16)

```

C REPORT 123-11, APPENDIX II-PART 2.

```

C--THE FORTRAN ARRAY IS AS FOLLOWS
C--CCSR(1,1), CCSR(2,1), . . . , CCSR(6,1), CCSR(1,2), CCSR(2,2), . . . ,
C--CCSR(6,6), CCSR(1,7), CCSR(2,7), . . . , CCSR(6,7).
C COST OF SLOWING DOWN IN A RURAL AREA

```

* DATA CCSR / 10.676, 22.932, 39.753, 63.454, 98.194, 151.888,
* 0.0, 11.860, 27.079, 33.490, 73.835, 134.793,
* 0.0, 0.0, 14.306, 38.812, 67.933, 116.527,
* 0.0, 0.0, 0.0, 19.902, 51.326, 188.
* 0.0, 0.0, 0.0, 0.0, 7.78, 30.01, 0.70
* 0.0, 0.0, 0.0, 0.0, 0.0, 40.931, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

C COST OF SLOWING DOWN IN AN URBAN AREA

	DATA CCSU/	7,395,	14,829,	24,570,	37,838,	56,703,	85,514,
*	0.0,	7,059,	16,200,	28,896,	47,066,	74,330,	
*	0.0,	0.0,	8,191,	20,130,	37,309,	61,884,	
*	0.0,	0.0,	0.0,	10,845,	27,024,	50,705,	
*	0.0,	0.0,	0.0,	0.0,	14,939,	36,994,	
*	0.0,	0.0,	0.0,	0.0,	0.0,	20,704,	0.0, 0.0, 0.0, 0.0, 0.0, 0.0

C COST OF OPERATING AT A REDUCED SPEED

DATA CURS/	495.77,	270.31,	196.62,	162.58,	145.54,	138.80,
* 456.66,	248.30,	179.64,	147.22,	130.08,	121.88	/

C COST OF DELAY
DATA COD/ 4 409.70, 4 111.52 /

C TRAFFIC MODELS AND THEIR ASSOCIATED CAPACITY TABLES DOCUMENTED BY
C REPORT 123-11, APPENDIX II, PART 3.
C RUTFOY-RURAL TRAFFIC IN OVERLAY ZONE (NO. OF LANES OPEN SUBSCRIPT)

DATA RUTFOV/1350., 2700., 4350., 6000., 7650., 9300./
C RUTFRY-RURAL TRAFFIC IN RECOVERY ZONE ONE LESS THAN NUMBER OF LANES.
C ONE-DIRECTION (NORMAL TRAFFIC) FOR A SUBSCRIPT)

DATA RUTFRV/3000., 4500., 6200., 7900., 9600., 11300./

C URTFOV AND URTFRV-SIMILAR TO ABOVE FOR URBAN TRAFFIC.

DATA URTFOV/1400.,	2800.,	4500.,	6200.,	7900.,	9600./
DATA URTFRV/3000.,	4700.,	6400.,	8100.,	9800.,	11500./

C--HPSY-PRODUCTION RATE IN HOURS PER SQ. YARD OF OVERLAY.

```
.....HPSY = ACCD * (DELD + UPLEVL) / ACPR.....
```

C--RESTRICTED SPEED SUBSCRIPTS FOR STOPPING-SLOWING TABLES.

$$L0 = (AS0/10.0) + 0.5$$

C--APPROACH SPEED SUBSCRIPT FOR STOPPING-SLOWING TABLES.

$$K = (AAS/10.0) + 0.5$$

C--SUBSCRIPTS GREATER THAN ZERO, LESS THAN 7.

```

      LO=MAX(1, MIN(6, LO) )
      LN=MAX(1, MIN(6, LO) )
      K =MAX(1, MIN(6, K) )
      TIPH = ADT * PROP

```

```

C--FROM COMMON THE FOLLOWING TRAFFIC VARIABLES ARE USED.
PO2 IS THE PROPORTION OF THE OVERLAY DIRECTION OF THE AVER DAILY TRAF
PN2 IS THE PROPORTION IN THE NON-OVERLAY DIRECTION WHICH WILL BE STOP
DN2 IS THE TIME STOPPED IN HOURS OF VEHICLES IN OVERLAY DIRECTION.
DN2 IS THE TIME STOPPED IN HOURS OF VEHICLES IN NON-OVERLAY DIRECTION
NLO IS THE NUMBER OF LANES IN THE OVERLAY DIRECTION.
NLO IS THE NUMBER OF LANES, RESTRICTED ZONE, OVERLAY DIRECTION.
C--MODEL 1

```

```

P01 = 0.
PNI = 0.
OOI = 0.
ONI = 0.
O = 1. / 12.

```

```
.....GO TO (60,20, 10, 10, 10) ; MODEL
```

USER

PAGE 2

C--CAPACITY TABLES SUBSCRIPTS, ALSO LIMITED FROM 1 TO 6.

10 MLRO = MAXO(1, MINO(6, NLRO))
MLO = MAXO(1, MINO(6, MLO-1))

IF(ITYPE .EQ. 2) GO TO 11

C RURAL (MODELS 3, 4, AND 5)
C OUTPUT AND RECOVERY RATES, BUT DO NOT EXCEED ARRAY MAXIMUMS

OUTRAT = RUTFOV(MLRO)
RECOVY = RUTFRV(MLO)

GO TO 12

C URRAN (MODELS 3, 4, AND 5)
C OUTPUT AND RECOVERY RATES, BUT DO NOT EXCEED ARRAY MAXIMUMS

11 OUTRAT = URTFOV(MLRO)
RECOVY = URTFRV(MLO)

12 IF(MODEL-4) 30, 40, 50

C--MODEL 2

20 AQ = XLSD* TIPH / ASD
PO1 = 0.5*(1. - EXP(-AQ))**2
PNI = PO1
DOI = (1. + EXP(2.*AQ))*(EXP(AQ) - AQ - 1.) /
1 (2.*TIPH*PO1*(EXP(2.*AQ) - EXP(AQ) + 1.))
DNI = DOI

GO TO 60

C--MODEL 3

30 IF(TIPH .LE. OUTRAT) GO TO 60

PO1 = HPD*(TIPH - OUTRAT)/(2.*TIPH*DOI)
IF(PO1 .GT. 1.) PO1 = 1.
DOI = HPD*(TIPH - OUTRAT) * (RECOVY - OUTRAT) /
1 (2.*TIPH*PO1*(RECOVY - TIPH))

GO TO 60

C--MODEL 4

40 IF(TIPH .LE. OUTRAT) GO TO 44

PO1 = HPD*(TIPH - OUTRAT)/(2.*TIPH*DOI)
IF(PO1 .GT. 1.) PO1 = 1.
DOI = HPD*(TIPH - OUTRAT) * (RECOVY - OUTRAT) /
1 (2.*TIPH*PO1*(RECOVY - TIPH))

44 OUTRAT = RUTFOV(MLRN)
IF(ITYPE .EQ. 2) OUTRAT = URTFOV(MLRN)

IF(TIPH .LE. OUTRAT) GO TO 60

PNI = HPD*(TIPH - OUTRAT)/(2.*TIPH*DOI)
IF(PNI .GT. 1.) PNI = 1.
DOI = HPD*(TIPH - OUTRAT) * (RECOVY - OUTRAT) /
1 (2.*TIPH*PNI*(RECOVY - TIPH))

USER

PAGE 3

```

..... GO TO 60 .....
C--MODEL 5
OK-----
50 IF ( TIPH .LE. OUTRAT ) GO TO 60
.....
PO1 = MPD*(TIPH - OUTRAT)/(2.*TIPH*D)
IF ( PO1 .GT. 1 ) PO1 = 1
DO1 = MPD*(TIPH - OUTRAT) * (RECOVY - OUTRAT) /
1 (2.*TIPH*PO1*(RECOVY - TIPH) )
.....
C--NOW COLLECT ALL PERTINENT INFORMATION SO THAT THE USER COST
C FOR THE OVERLAY CAN BE COMPUTED.
OK-----
60 GO TO (65,68),ITYPE
.....
C--COST OF STOPPING FROM APPROACH SPEED IN A RURAL AREA.
65 CO1 = CCSRIK,11/1000.
CN1 = CO1
.....
C COST OF SLOWING TO THRU SPEED IN A RURAL AREA.
CO4 = CCSRIK,10*11/1000.
CN4 = CCSRIK,1N*11/1000.
.....
GO TO 70
.....
C--COST OF STOPPING FROM APPROACH SPEED IN AN URBAN AREA.
OK-----
68 CO1 = CCSUIK,11 / 1000.
CN1 = CO1
.....
C CCST OF SLOWING TO THRU SPEED IN AN URBAN AREA.
CO4 = CCSUIK,10*11/1000.
CN4 = CCSUIK,1N*11/1000.
.....
C CCST OF DELAY DUE TO CONGESTION OUTSIDE THE RESTRICTED AREA.
OK-----
70 CO2 = DO1 * COD(1,ITYPE) / 1000.
CN2 = DN1 * COD(1,ITYPE) / 1000.
.....
C CCST OF DRIVING AT A REDUCED SPEED.
CO3 = (CURS(LO,ITYPE) - CURS(K,ITYPE)) * XLSO / 1000.
IF ( MODEL .EQ. 5 ) CO3 =
1 (CURS(LO,ITYPE)*XLSO - CURS(K,ITYPE)*XLSO) / 1000.
CN3 = (CURS(LN,ITYPE) - CURS(K,ITYPE)) * XLSN / 1000.
.....
C EXCESS COST OF STOPPING FROM THRU SPEED + COST OF IDLE TIME, ALL
C WITHIN THE RESTRICTED AREA.
GO TO (80,90),ITYPE
.....
80 COS = CCSRILO,11/1000. + DO2*COD(1,ITYPE)/1000.
CNS = CCSRI1N,11/1000. + DN2*COD(1,ITYPE)/1000.
.....
GO TO 100
.....
OK-----
90 COS = CCSUILO,11/1000. + DO2*COD(1,ITYPE)/1000.
CNS = CCSUI1N,11/1000. + DN2*COD(1,ITYPE)/1000.
.....
OK-----
100 TUCH = TIPH * PO1 * (CO1 + CO2 + CO3) + (1 - PO1) * (CO3 + CO4) + PO2 * COS
1 TIPH * PN1 * (CN1 + CN2 + CN3) + (1 - PN1) * (CN3 + CN4) + PN2 * CNS
TUCSY = HPSY * TUCH
ITIME = TPRIM + 0.5

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PAGE 4

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.....PNTSY = TOCS9711 : RATE 1 % TIME.....
.....T.....|.....T.....
T RETURN T
.....END.....
```

APPENDIX V

OUTPUT OF FPS-9 EXAMPLE DATA

The following output is that produced by FPS-9 with the data listed in the section INPUT DATA FOR FPS-9 and the execution time for these four test problems is given in the section PROGRAM RUNNING TIME.

INPUT DATA

THE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE							
LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A	ASPHALTIC CONCRET	10.00	0.82	1.00	10.00	45.00
2	L	CR. LIMESTONE-1	5.00	0.55	6.00	16.00	75.00
2	G	GRAVEL-1	3.00	0.35	6.00	16.00	100.00
3	G	GRAVEL-1	3.00	0.35	6.00	16.00	100.00
		SUBGRADE	-----	0.22	-----	-----	-----

NUMBER OF SUMMARY OUTPUT PAGES DESIRED(8 DESIGNS/PAGE)	3
TOTAL NUMBER OF INPUT MATERIALS, EXCLUDING SUBGRADE	4
LENGTH OF THE ANALYSIS PERIOD (YEARS)	20.0
WIDTH OF EACH LANE (FEET)	12.0
NUMBER OF LANES (BOTH DIRECTIONS)	4

DISTRICT TEMPERATURE CONSTANT	30.0
SERVICEABILITY INDEX OF THE INITIAL STRUCTURE	4.2
SERVICEABILITY INDEX P1 AFTER AN OVERLAY	4.2
MINIMUM SERVICEABILITY INDEX P2	3.0
SWELLING CLAY PARAMETERS -- P2 PRIME	1.50
B1	0.0700
GAMMA	0.02

ONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)	12000.
ONE-DIRECTION ADT AT END OF TWENTY YEARS (VEHICLES/DAY)	18000.
ONE-DIRECTION 20.-YR ACCUMULATED NO. OF EQUIVALENT 18-KIP AXLES	2000000.
PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)	6.0
THE ROAD IS IN A RURAL AREA.	1

MINIMUM TIME TO FIRST OVERLAY (YEARS)	2.0
MINIMUM TIME BETWEEN OVERLAYS (YEARS)	5.0
TIME TO FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS)	5.0
TIME BETWEEN SEAL COATS (YEARS)	3.0
MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)	5.00
MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)	36.0
MINIMUM OVERLAY THICKNESS (INCHES)	0.5
ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES)	8.0

INPUT DATA (CONTINUED)

ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	75.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	1.80
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.D. (MILES)	0.50
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE N.O.D. (MILES)	0.50
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	0.0
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	10.0
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.	1
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.	2
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN O.D. (PERCENT)	2.00
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN N.O.D. (PERCENT)	0.0
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN O.D. (HOURS)	0.100
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS)	0.100
AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH)	60.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH)	40.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)	55.0
TRAFFIC MODEL USED IN THE ANALYSIS	3
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE MILE)	50.00
INCREMENTAL INCREASE IN MAINT. COST PER YEAR (DOLLARS/LANE MILE)	20.00
COST OF A SEAL COAT (DOLLARS/LANE MILE)	1500.00
INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)	5.0

DESIGN TYPE 1 WITH 1 LAYERS, MATERIALS A

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRET	10.00	0.82	1.00	10.00	45.00	0.25
		SUBGRADE	-----	0.22	-----	-----	-----	-----
		OVERLAYS	10.00	0.96	0.50	8.00	45.00	0.50

DESIGN TYPE 1 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRET 8.75 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.503

THE LIFE OF THE INITIAL STRUCTURE = 5.00 YEARS

THE OVERLAY SCHEDULE IS

2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 5.00 YEARS.

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 12.15 YEARS.

TOTAL LIFE = 21.12 YEARS

SEAL COATS SHOULD OCCUR AFTER

(1) 10.00 YEARS

(2) 17.15 YEARS

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 2.431

TOTAL ROUTINE MAINTENANCE COST 0.190

TOTAL OVERLAY CONSTRUCTION COST 0.667

TOTAL USER COST DURING

OVERLAY CONSTRUCTION 0.241

TOTAL SEAL COAT COST 0.224

SALVAGE VALUE -0.483

TOTAL=OVERALL COST

3.270

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE A

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

NONE

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 16

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

37 INITIAL DESIGNS

37 INITIAL DESIGNS CONSIDERED

16 WHICH WERE FEASIBLE TO FIRST OVERLAY

840 OVERLAYS

788 WHICH WERE FEASIBLE

420 OVERLAY POLICIES

384 WHICH WERE FEASIBLE

16 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 2 WITH 2 LAYERS, MATERIALS AL

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A	ASPHALTIC CONCRET	10.00	0.82	1.00	10.00	45.00	0.25
2	L	CR. LIMESTONE-1	5.00	0.55	6.00	16.00	75.00	0.50
		SUBGRADE	-----	0.22	-----	-----	-----	-----
		OVERLAYS	10.00	0.96	0.50	8.00	45.00	0.50

DESIGN TYPE 2 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRET 1.00 INCHES
CR. LIMESTONE-1 12.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.516

THE LIFE OF THE INITIAL STRUCTURE = 4.91 YEARS

THE OVERLAY SCHEDULE IS

2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 4.91 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 11.78 YEARS.
TOTAL LIFE = 20.39 YEARS

SEAL COATS SHOULD OCCUR AFTER

(1) 9.91 YEARS
(2) 16.78 YEARS
(3) 19.78 YEARS

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	1.944
TOTAL ROUTINE MAINTENANCE COST	0.190
TOTAL OVERLAY CONSTRUCTION COST	0.667
TOTAL USER COST DURING	
OVERLAY CONSTRUCTION	0.240
TOTAL SEAL COAT COST	0.304
SALVAGE VALUE	-0.589

TOTAL=OVERALL COST 2.757

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AL

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 57

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

777 INITIAL DESIGNS

61 INITIAL DESIGNS CONSIDERED

57 WHICH WERE FEASIBLE TO FIRST OVERLAY

904 OVERLAYS

855 WHICH WERE FEASIBLE

473 OVERLAY POLICIES

439 WHICH WERE FEASIBLE

57 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 3 WITH 3 LAYERS, MATERIALS ALG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRET	10.00	0.82	1.00	10.00	45.00	0.25
2	L	CR. LIMESTONE-1	5.00	0.55	6.00	16.00	75.00	0.50
3	G	GRAVEL-1	3.00	0.35	6.00	16.00	100.00	0.75
		SUBGRADE	-----	0.22	-----	-----	-----	-----
		OVERLAYS	10.00	0.96	0.50	8.00	45.00	0.50

DESIGN TYPE 3 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRET 1.00 INCHES
CR. LIMESTONE-1 6.50 INCHES
GRAVEL-1 8.25 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.645

THE LIFE OF THE INITIAL STRUCTURE = 4.02 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 4.02 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 9.02 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 15.07 YEARS.
TOTAL LIFE = 22.29 YEARS

SEAL COATS SHOULD OCCUR AFTER

(1) 14.02 YEARS

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 1.868
TOTAL ROUTINE MAINTENANCE COST 0.163
TOTAL OVERLAY CONSTRUCTION COST 0.812
TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.299
TOTAL SEAL COAT COST 0.108
SALVAGE VALUE -0.632

TOTAL=OVERALL COST 2.617

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE ALG

THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MINIMUM TIME BETWEEN OVERLAYS

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 221

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

9960	INITIAL DESIGNS
221	INITIAL DESIGNS CONSIDERED
221	WHICH WERE FEASIBLE TO FIRST OVERLAY
2570	OVERLAYS
2453	WHICH WERE FEASIBLE
1388	OVERLAY POLICIES
1286	WHICH WERE FEASIBLE
221	FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 4 WITH 2 LAYERS, MATERIALS AG

AYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRET	10.00	0.82	1.00	10.00	45.00	0.25
2	G	GRAVEL-1	3.00	0.35	6.00	16.00	100.00	0.75
		SUBGRADE	-----	0.22	-----	-----	-----	-----
		OVERLAYS	10.00	0.96	0.50	8.00	45.00	0.50

DESIGN TYPE 4 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRET 4.50 INCHES
GRAVEL-1 10.50 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.647

THE LIFE OF THE INITIAL STRUCTURE = 4.02 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 4.02 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 9.02 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 15.13 YEARS.
TOTAL LIFE = 22.44 YEARS

SEAL COATS SHOULD OCCUR AFTER

(1) 14.02 YEARS

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 2.125
TOTAL ROUTINE MAINTENANCE COST 0.163
TOTAL OVERLAY CONSTRUCTION COST 0.812
TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.299
TOTAL SEAL COAT COST 0.108
SALVAGE VALUE -0.612

TOTAL=OVERALL COST

2.894

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AG

T THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM TIME BETWEEN OVERLAYS

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 251

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

555 INITIAL DESIGNS
292 INITIAL DESIGNS CONSIDERED
251 WHICH WERE FEASIBLE TO FIRST OVERLAY

8285 OVERLAYS
7765 WHICH WERE FEASIBLE

4186 OVERLAY POLICIES
3830 WHICH WERE FEASIBLE

251 FEASIBLE COMPLETE DESIGNS

PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE
IN ORDER OF INCREASING TOTAL COST

DESIGN TYPE	TOTAL COST
3	2.617
2	2.757
4	2.894
1	3.270

ALL MATERIAL COMBINATIONS HAVE AT LEAST ONE FEASIBLE DESIGN.

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	1	2	3	4	5	6	7	8

MATERIAL ARRANGEMENT	ALG	ALG	ALG	ALG	ALG	ALG	AL	ALG
INIT. CONST. COST	1.868	1.743	1.958	2.014	1.944	1.875	1.944	1.889
OVERLAY CONST. COST	0.812	0.926	0.743	0.667	0.764	0.802	0.667	0.789
USER COST	0.299	0.333	0.281	0.240	0.287	0.296	0.240	0.294
SEAL COAT COST	0.108	0.188	0.228	0.304	0.233	0.245	0.304	0.240
ROUTINE MAINT. COST	0.163	0.163	0.175	0.190	0.170	0.167	0.190	0.166
SALVAGE VALUE	-0.632	-0.609	-0.640	-0.667	-0.648	-0.628	-0.589	-0.620

TOTAL COST	2.617	2.745	2.746	2.748	2.751	2.757	2.757	2.758

NUMBER OF LAYERS	3	3	3	3	3	3	2	3

LAYER DEPTH (INCHES)								
D(1)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D(2)	6.50	6.50	8.50	8.00	7.50	7.00	12.00	8.00
D(3)	8.25	6.75	6.00	7.50	7.50	7.50		6.00

NO.OF PERF.PERIODS	4	4	4	3	4	4	3	4

PERF. TIME (YEARS)								
T(1)	4.0	3.5	4.7	4.9	4.5	4.2	4.9	4.3
T(2)	9.0	8.5	10.6	11.8	10.2	9.3	11.8	9.7
T(3)	15.1	14.6	17.8	20.3	17.0	15.5	20.4	16.3
T(4)	22.3	22.0	26.4		25.2	22.9		24.1

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	1.5	2.0	1.5	2.0	1.5	1.5	2.0	1.5
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(3)	1.5	1.5	1.5		1.5	1.5		1.5

NUMBER OF SEAL COATS	1	2	2	3	2	2	3	2

SEAL COAT SCHEDULE								
(YEARS)								
SC(1)	14.0	13.5	9.7	9.9	9.5	9.2	9.9	9.3
SC(2)		19.6	15.6	16.8	15.2	14.3	16.8	14.7
SC(3)				19.8			19.8	

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	9	10	11	12	13	14	15	16

MATERIAL ARRANGEMENT	ALG	AL	ALG	ALG	AL	ALG	ALG	ALG
INIT. CONST. COST	2.021	1.875	1.951	2.007	1.806	2.153	1.882	2.090
OVERLAY CONST. COST	0.667	0.764	0.764	0.743	0.802	0.532	0.802	0.558
USER COST	0.241	0.288	0.288	0.282	0.297	0.196	0.298	0.204
SEAL COAT COST	0.304	0.233	0.233	0.228	0.245	0.380	0.245	0.391
ROUTINE MAINT. COST	0.190	0.170	0.170	0.175	0.167	0.190	0.167	0.190
SALVAGE VALUE	-0.663	-0.569	-0.644	-0.671	-0.550	-0.683	-0.624	-0.660

TOTAL COST	2.760	2.761	2.763	2.764	2.767	2.768	2.769	2.775

NUMBER OF LAYERS	3	2	3	3	2	3	3	3

LAYER DEPTH (INCHES)								
D(1)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D(2)	8.50	11.50	8.00	7.50	11.00	9.00	7.50	9.00
D(3)	6.75		6.75	8.25		7.50	6.75	6.75

NO.OF PERF.PERIODS	3	4	4	4	4	3	4	3

PERF. TIME (YEARS)								
T(1)	5.0	4.6	4.6	4.8	4.2	5.5	4.3	5.3
T(2)	12.0	10.3	10.4	10.8	9.4	12.7	9.5	12.1
T(3)	20.6	17.2	17.4	18.0	15.8	21.4	15.9	20.4
T(4)		25.5	25.7	26.6	23.3		23.4	

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	2.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(3)		1.5	1.5	1.5	1.5		1.5	

NUMBER OF SEAL COATS	3	2	2	2	2	3	2	3

SEAL COAT SCHEDULE								
(YEARS)								
SC(1)	10.0	9.6	9.6	9.8	9.2	5.0	9.3	5.0
SC(2)	17.0	15.3	15.4	15.8	14.4	10.5	14.5	10.3
SC(3)	20.0					17.7		17.1

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	17	18	19	20	21	22	23	24

MATERIAL ARRANGEMENT	ALG	AL	ALG	ALG	ALG	AL	ALG	ALG
INIT. CONST. COST	1.937	2.083	2.160	2.097	2.167	1.667	2.146	2.215
OVERLAY CONST. COST	0.789	0.532	0.532	0.558	0.532	0.962	0.558	0.532
USER COST	0.295	0.196	0.197	0.205	0.198	0.346	0.205	0.198
SEAL COAT COST	0.240	0.380	0.380	0.391	0.380	0.193	0.391	0.380
ROUTINE MAINT. COST	0.166	0.190	0.190	0.190	0.190	0.167	0.190	0.190
SALVAGE VALUE	-0.652	-0.605	-0.679	-0.656	-0.675	-0.534	-0.687	-0.707

TOTAL COST	2.776	2.778	2.780	2.786	2.791	2.801	2.803	2.809

NUMBER OF LAYERS	3	2	3	3	3	2	3	3

LAYER DEPTH (INCHES)								
D(1)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D(2)	7.00	13.00	9.50	9.50	10.00	10.00	8.50	9.00
D(3)	8.25		6.75	6.00	6.00		8.25	8.25

NO.OF PERF.PERIODS	4	3	3	3	3	4	3	3

PERF. TIME (YEARS)								
T(1)	4.4	5.6	5.7	5.4	5.8	3.5	5.4	5.8
T(2)	9.9	12.8	12.9	12.3	13.2	8.5	12.4	13.2
T(3)	16.5	21.6	21.9	20.7	22.2	14.5	20.9	22.5
T(4)	24.4					21.8		

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	1.5	1.5	1.5	1.5	1.5	2.0	1.5	1.5
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(3)	1.5					1.5		

NUMBER OF SEAL COATS	2	3	3	3	3	2	3	3

SEAL COAT SCHEDULE								
(YEARS)								
SC(1)	9.4	5.0	5.0	5.0	5.0	13.5	5.0	5.0
SC(2)	14.9	10.6	10.7	10.4	10.8	19.5	10.4	10.8
SC(3)		17.8	17.9	17.3	18.2		17.4	18.2

THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS

545

INPUT DATA

THE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE							
MATERIALS		COST	STR.	MIN.	MAX.	SALVAGE	
LAYER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.
1	A	ACP	16.00	0.95	1.50	2.00	50.00
2	B	ASPH STAB BASE	11.00	0.85	2.00	8.50	60.00
2	X	EXISTING BASE	0.0	0.46	14.00	14.00	100.00
3	X	EXISTING BASE	0.0	0.46	14.00	14.00	100.00
		SUBGRADE	-----	0.24	-----	-----	-----

NUMBER OF SUMMARY OUTPUT PAGES DESIRED(8 DESIGNS/PAGE)	3
TOTAL NUMBER OF INPUT MATERIALS, EXCLUDING SUBGRADE	4
LENGTH OF THE ANALYSIS PERIOD (YEARS)	20.0
WIDTH OF EACH LANE (FEET)	12.0
NUMBER OF LANES (BOTH DIRECTIONS)	4

DISTRICT TEMPERATURE CONSTANT	22.0
SERVICEABILITY INDEX OF THE INITIAL STRUCTURE	4.2
SERVICEABILITY INDEX P1 AFTER AN OVERLAY	4.2
MINIMUM SERVICEABILITY INDEX P2	3.0
SWELLING CLAY PARAMETERS -- P2 PRIME	1.50
B1	0.0600
GAMMA	0.05

ONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)	1600.
ONE-DIRECTION ADT AT END OF TWENTY YEARS (VEHICLES/DAY)	3200.
ONE-DIRECTION 20.-YR ACCUMULATED NO. OF EQUIVALENT 18-KIP AXLES	800000.
PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)	5.0
THE ROAD IS IN A RURAL AREA.	1

MINIMUM TIME TO FIRST OVERLAY (YEARS)	5.0
MINIMUM TIME BETWEEN OVERLAYS (YEARS)	5.0
TIME TO FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS)	22.0
TIME BETWEEN SEAL COATS (YEARS)	22.0
MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)	7.50
MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)	24.0
MINIMUM OVERLAY THICKNESS (INCHES)	0.5
ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES)	4.5

INPUT DATA (CONTINUED)

ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	80.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	2.00
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.D. (MILES)	1.00
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE N.O.D. (MILES)	1.00
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	0.0
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	10.0
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.	1
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.	1
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN O.D. (PERCENT)	1.00
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN N.O.D. (PERCENT)	1.00
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN O.D. (HOURS)	0.010
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS)	0.010
AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH)	60.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH)	20.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)	30.0
TRAFFIC MODEL USED IN THE ANALYSIS	5
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE MILE)	50.00
INCREMENTAL INCREASE IN MAINT. COST PER YEAR (DOLLARS/LANE MILE)	20.00
COST OF A SEAL COAT (DOLLARS/LANE MILE)	0.0
INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)	7.0

DESIGN TYPE 1 WITH 1 LAYERS, MATERIALS A

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A	ACP	16.00	0.95	1.50	2.00	50.00	0.25
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	16.00	0.96	0.50	4.50	50.00	0.50

THE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO OBTAIN A STRUCTURE THAT WILL MEET THE MINIMUM TIME TO THE FIRST OVERLAY RESTRICTION.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

3 INITIAL DESIGNS
 3 INITIAL DESIGNS CONSIDERED
 0 WHICH WERE FEASIBLE TO FIRST OVERLAY

 0 OVERLAYS
 0 WHICH WERE FEASIBLE

 0 OVERLAY POLICIES
 0 WHICH WERE FEASIBLE

 0 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 2 WITH 2 LAYERS, MATERIALS AB

AYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ACP	16.00	0.95	1.50	2.00	50.00	0.25
2	B	ASPH STAB BASE	11.00	0.85	2.00	8.50	60.00	0.25
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	16.00	0.96	0.50	4.50	50.00	0.50

DESIGN TYPE 2 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ACP 1.75 INCHES
ASPH STAB BASE 4.75 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.593

THE LIFE OF THE INITIAL STRUCTURE = 5.52 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 5.52 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 12.22 YEARS.
TOTAL LIFE = 20.07 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	2.229
TOTAL ROUTINE MAINTENANCE COST	0.161
TOTAL OVERLAY CONSTRUCTION COST	0.740
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.030
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.383

TOTAL=OVERALL COST 2.778

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AB

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MAXIMUM DEPTH OF LAYER 1

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 52

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

81 INITIAL DESIGNS

81 INITIAL DESIGNS CONSIDERED

52 WHICH WERE FEASIBLE TO FIRST OVERLAY

1010 OVERLAYS

906 WHICH WERE FEASIBLE

531 OVERLAY POLICIES

427 WHICH WERE FEASIBLE

52 FEASIBLE COMPLETE DESIGNS

SIGN TYPE 3 WITH 3 LAYERS, MATERIALS ABX

LAYER CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A ACP	16.00	0.95	1.50	2.00	50.00	0.25
2	B ASPH STAB BASE	11.00	0.85	2.00	8.50	60.00	0.25
3	X EXISTING BASE	0.0	0.46	14.00	14.00	100.00	0.25
	SUBGRADE	-----	0.24	-----	-----	-----	-----
OVERLAYS		16.00	0.96	0.50	4.50	50.00	0.50

DESIGN TYPE 3 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ACP 1.50 INCHES
ASPH STAB BASE 2.00 INCHES
EXISTING BASE 14.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.228

THE LIFE OF THE INITIAL STRUCTURE = 7.44 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 7.44 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 17.06 YEARS.
TOTAL LIFE = 28.54 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 1.278
TOTAL ROUTINE MAINTENANCE COST 0.180
TOTAL OVERLAY CONSTRUCTION COST 0.626
TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.027
TOTAL SEAL COAT COST 0.0
SALVAGE VALUE -0.238

TOTAL=OVERALL COST 1.873

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE ABX

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MINIMUM DEPTH OF LAYER 2
3. THE MINIMUM DEPTH OF LAYER 3
4. THE MAXIMUM DEPTH OF LAYER 3

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 78

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

78 INITIAL DESIGNS
78 INITIAL DESIGNS CONSIDERED
78 WHICH WERE FEASIBLE TO FIRST OVERLAY

1482 OVERLAYS
1326 WHICH WERE FEASIBLE

780 OVERLAY POLICIES
624 WHICH WERE FEASIBLE

78 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 4 WITH 2 LAYERS, MATERIALS AX

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A	ACP	16.00	0.95	1.50	2.00	50.00	0.25
2	X	EXISTING BASE	0.0	0.46	14.00	14.00	100.00	0.25
		SUBGRADE	-----	0.24	-----	-----	-----	-----
OVERLAYS			16.00	0.96	0.50	4.50	50.00	0.50

DESIGN TYPE 4 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ACP 1.50 INCHES
EXISTING BASE 14.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.392

THE LIFE OF THE INITIAL STRUCTURE = 6.59 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 6.59 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 14.74 YEARS.
TOTAL LIFE = 24.28 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	0.667
TOTAL ROUTINE MAINTENANCE COST	0.169
TOTAL OVERLAY CONSTRUCTION COST	0.657
TOTAL USER COST DURING	
OVERLAY CONSTRUCTION	0.028
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.144

TOTAL=OVERALL COST 1.377

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AX

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MINIMUM DEPTH OF LAYER 2
3. THE MAXIMUM DEPTH OF LAYER 2

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 3

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 3 INITIAL DESIGNS
- 3 INITIAL DESIGNS CONSIDERED
- 3 WHICH WERE FEASIBLE TO FIRST OVERLAY

- 57 OVERLAYS
- 51 WHICH WERE FEASIBLE

- 30 OVERLAY POLICIES
- 24 WHICH WERE FEASIBLE

- 3 FEASIBLE COMPLETE DESIGNS

PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE
IN ORDER OF INCREASING TOTAL COST

DESIGN TYPE	TOTAL COST
4	1.377
3	1.873
2	2.778

THE MATERIALS ASSOCIATED WITH EACH OF THE FOLLOWING DESIGN
TYPES DO NOT HAVE AT LEAST ONE FEASIBLE DESIGN.

1

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	1	2	3	4	5	6	7	8

MATERIAL ARRANGEMENT	AX	AX	AX	ABX	ABX	ABX	ABX	ABX
INIT. CONST. COST	0.667	0.778	0.889	1.278	1.354	1.389	1.431	1.465
OVERLAY CONST. COST	0.657	0.657	0.657	0.626	0.599	0.599	0.585	0.585
USER COST	0.028	0.028	0.028	0.027	0.026	0.026	0.026	0.026
SEAL COAT COST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROUTINE MAINT. COST	0.169	0.169	0.169	0.180	0.181	0.181	0.187	0.187
SALVAGE VALUE	-0.144	-0.158	-0.172	-0.238	-0.250	-0.253	-0.262	-0.265

TOTAL COST	1.377	1.474	1.571	1.873	1.910	1.943	1.967	1.999

NUMBER OF LAYERS	2	2	2	3	3	3	3	3

LAYER DEPTH (INCHES)								
D(1)	1.50	1.75	2.00	1.50	1.50	1.75	1.50	1.75
D(2)	14.00	14.00	14.00	2.00	2.25	2.00	2.50	2.25
D(3)				14.00	14.00	14.00	14.00	14.00

NO.OF PERF.PERIODS	3	3	3	3	3	3	3	3

PERF. TIME (YEARS)								
T(1)	6.6	6.8	6.9	7.4	7.5	7.5	7.6	7.6
T(2)	14.7	15.2	15.5	17.1	17.2	17.2	17.5	17.5
T(3)	24.3	25.1	25.7	28.5	28.7	28.9	29.3	29.3

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

NUMBER OF SEAL COATS	0	0	0	0	0	0	0	0

SEAL COAT SCHEDULE								
(YEARS)								

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	9	10	11	12	13	14	15	16

MATERIAL ARRANGEMENT	ABX	ABX	ABX	ABX	ABX	ABX	ABX	ABX
INIT. CONST. COST	1.500	1.507	1.542	1.576	1.583	1.618	1.653	1.660
OVERLAY CONST. COST	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585
USER COST	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
SEAL COAT COST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROUTINE MAINT. COST	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187
SALVAGE VALUE	-0.267	-0.274	-0.276	-0.279	-0.286	-0.288	-0.291	-0.298

TOTAL COST	2.031	2.031	2.064	2.096	2.096	2.128	2.160	2.161

NUMBER OF LAYERS	3	3	3	3	3	3	3	3

LAYER DEPTH (INCHES)								
D(1)	2.00	1.50	1.75	2.00	1.50	1.75	2.00	1.50
D(2)	2.00	2.75	2.50	2.25	3.00	2.75	2.50	3.25
D(3)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00

NO.OF PERF.PERIODS	3	3	3	3	3	3	3	3

PERF. TIME (YEARS)								
T(1)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.7
T(2)	17.5	17.5	17.5	17.5	17.5	17.5	17.6	17.8
T(3)	29.3	29.3	29.5	29.5	29.5	29.5	29.6	29.8

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

NUMBER OF SEAL COATS	0	0	0	0	0	0	0	0

EAL COAT SCHEDULE								
(YEARS)								

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	17	18	19	20	21	22	23	24

MATERIAL ARRANGEMENT	ABX	ABX	ABX	ABX	ABX	ABX	ABX	ABX
INIT. CONST. COST	1.694	1.729	1.736	1.771	1.806	1.812	1.847	1.882
OVERLAY CONST. COST	0.585	0.585	0.585	0.585	0.585	0.585	0.585	0.585
USER COST	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
SEAL COAT COST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROUTINE MAINT. COST	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187
SALVAGE VALUE	-0.300	-0.303	-0.309	-0.312	-0.314	-0.321	-0.324	-0.326

TOTAL COST	2.193	2.225	2.225	2.257	2.290	2.290	2.322	2.354

NUMBER OF LAYERS	3	3	3	3	3	3	3	3

LAYER DEPTH (INCHES)								
D(1)	1.75	2.00	1.50	1.75	2.00	1.50	1.75	2.00
D(2)	3.00	2.75	3.50	3.25	3.00	3.75	3.50	3.25
D(3)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00

NO.OF PERF.PERIODS	3	3	3	3	3	3	3	3

PERF. TIME (YEARS)								
T(1)	7.7	7.7	7.7	7.7	7.7	7.8	7.8	7.8
T(2)	17.9	17.9	17.9	17.9	17.9	18.0	18.0	18.0
T(3)	29.9	29.9	29.9	30.1	30.1	30.3	30.3	30.3

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

NUMBER OF SEAL COATS	0	0	0	0	0	0	0	0

SEAL COAT SCHEDULE								
(YEARS)								

THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS

133

INPUT DATA

THE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE							
MATERIALS			COST	STR.	MIN.	MAX.	SALVAGE
LAYER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	6.00	25.00
2	S	CRUSHED STONE	4.00	0.65	4.00	20.00	100.00
3	G	GRAVEL-1	3.00	0.35	6.00	20.00	80.00
		SUBGRADE	-----	0.24	-----	-----	-----

NUMBER OF SUMMARY OUTPUT PAGES DESIRED(8 DESIGNS/PAGE)

TOTAL NUMBER OF INPUT MATERIALS,EXCLUDING SUBGRADE

LENGTH OF THE ANALYSIS PERIOD (YEARS)

WIDTH OF EACH LANE (FEET)

NUMBER OF LANES (BOTH DIRECTIONS)

DISTRICT TEMPERATURE CONSTANT

SERVICEABILITY INDEX OF THE INITIAL STRUCTURE

SERVICEABILITY INDEX P1 AFTER AN OVERLAY

MINIMUM SERVICEABILITY INDEX P2

SWELLING CLAY PARAMETERS -- P2 PRIME

B1

GAMMA

ONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)

ONE-DIRECTION ADT AT END OF TWENTY YEARS (VEHICLES/DAY)

ONE-DIRECTION 20.-YR ACCUMULATED NO. OF EQUIVALENT 18-KIP AXLES

PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)

THE ROAD IS IN AN URBAN AREA.

MINIMUM TIME TO FIRST OVERLAY (YEARS)

MINIMUM TIME BETWEEN OVERLAYS (YEARS)

TIME TO FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS)

TIME BETWEEN SEAL COATS (YEARS)

MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)

MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)

MINIMUM OVERLAY THICKNESS (INCHES)

ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES)

INPUT DATA (CONTINUED)

ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	75.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	2.00
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.D. (MILES)	1.00
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE N.O.D. (MILES)	0.0
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	1.10
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	8.0
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.	2
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.	3
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN O.D. (PERCENT)	10.00
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN N.O.D. (PERCENT)	0.0
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN O.D. (HOURS)	0.017
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS)	0.0
AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH)	50.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH)	30.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)	50.0
TRAFFIC MODEL USED IN THE ANALYSIS	5
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE MILE)	25.00
INCREMENTAL INCREASE IN MAINT. COST PER YEAR (DOLLARS/LANE MILE)	10.00
COST OF A SEAL COAT (DOLLARS/LANE MILE)	1500.00
INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)	6.0

SIGN TYPE 1 WITH 1 LAYERS, MATERIALS A

ITEM CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A ASPHALTIC CONCRETE	24.00	0.90	1.00	6.00	25.00	0.25
	SUBGRADE	-----	0.24	-----	-----	-----	-----
	OVERLAYS	24.00	0.96	1.00	5.00	25.00	0.50

DESIGN TYPE 1 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 6.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.666

THE LIFE OF THE INITIAL STRUCTURE = 2.54 YEARS

THE OVERLAY SCHEDULE IS

3.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 2.54 YEARS.
2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 7.74 YEARS.
2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 14.99 YEARS.
TOTAL LIFE = 24.75 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	4.000
TOTAL ROUTINE MAINTENANCE COST	0.077
TOTAL OVERLAY CONSTRUCTION COST	3.072
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.445
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.520

TOTAL=OVERALL COST 7.074

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE A

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MAXIMUM DEPTH OF LAYER 1
2. THE MAXIMUM FUNDS AVAILABLE FOR INITIAL CONSTRUCTION
3. THE MINIMUM TIME BETWEEN OVERLAYS

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 3

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

21	INITIAL DESIGNS
21	INITIAL DESIGNS CONSIDERED
3	WHICH WERE FEASIBLE TO FIRST OVERLAY
119	OVERLAYS
66	WHICH WERE FEASIBLE
57	OVERLAY POLICIES
12	WHICH WERE FEASIBLE
3	FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 2 WITH 2 LAYERS, MATERIALS AS:

AYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	20.00	100.00	1.50
		SUBGRADE	-----	0.24	-----	-----	-----	-----
OVERLAYS			24.00	0.96	1.00	5.00	25.00	0.50

DESIGN TYPE 2 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 1.00 INCHES
CRUSHED STONE 11.50 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.248

THE LIFE OF THE INITIAL STRUCTURE = 5.66 YEARS

THE OVERLAY SCHEDULE IS

2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 5.66 YEARS.

2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 13.75 YEARS.

TOTAL LIFE = 24.62 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	1.944
TOTAL ROUTINE MAINTENANCE COST	0.089
TOTAL OVERLAY CONSTRUCTION COST	1.530
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.237
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.554

TOTAL=OVERALL COST

3.246

PROB T-3 *HEAVIER TRAFFIC, FRONTAGE ROAD WITH LIGHT.

* P

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AS

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 16

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

150 INITIAL DESIGNS

18 INITIAL DESIGNS CONSIDERED

16 WHICH WERE FEASIBLE TO FIRST OVERLAY

360 OVERLAYS

292 WHICH WERE FEASIBLE

187 OVERLAY POLICIES

121 WHICH WERE FEASIBLE

16 FEASIBLE COMPLETE DESIGNS

PROB T-3 *HEAVIER TRAFFIC, FRONTAGE ROAD WITH LIGHT.

* P

DESIGN TYPE 3 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	20.00	100.00	1.50
3	G	GRAVEL-1	3.00	0.35	6.00	20.00	80.00	2.00
		SUBGRADE	-----	0.24	-----	-----	-----	-----
OVERLAYS			24.00	0.96	1.00	5.00	25.00	0.50

DESIGN TYPE 3 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE	1.00 INCHES
CRUSHED STONE	10.00 INCHES
GRAVEL-1	6.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.208

THE LIFE OF THE INITIAL STRUCTURE = 6.09 YEARS

THE OVERLAY SCHEDULE IS

2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 6.09 YEARS.
2.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 14.87 YEARS.
TOTAL LIFE = 26.72 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	2.278
TOTAL ROUTINE MAINTENANCE COST	0.091
TOTAL OVERLAY CONSTRUCTION COST	1.496
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.236
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.627

TOTAL=OVERALL COST 3.474

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE ASG

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MINIMUM DEPTH OF LAYER 3

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 15

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

383 INITIAL DESIGNS
15 INITIAL DESIGNS CONSIDERED
15 WHICH WERE FEASIBLE TO FIRST OVERLAY

333 OVERLAYS
266 WHICH WERE FEASIBLE

172 OVERLAY POLICIES
109 WHICH WERE FEASIBLE

15 FEASIBLE COMPLETE DESIGNS

PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE
IN ORDER OF INCREASING TOTAL COST

DESIGN TYPE	TOTAL COST
2	3.246
3	3.474
1	7.074

ALL MATERIAL COMBINATIONS HAVE AT LEAST ONE FEASIBLE DESIGN.

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	1	2	3	4	5	6	7	8

MATERIAL ARRANGEMENT	AS	AS	AS	AS	AS	ASG	ASG	ASG
INIT. CONST. COST	1.944	1.778	2.111	2.278	2.444	2.278	2.111	2.444
OVERLAY CONST. COST	1.530	1.659	1.465	1.382	1.382	1.496	1.621	1.412
USER COST	0.237	0.249	0.232	0.222	0.225	0.236	0.249	0.227
SEAL COAT COST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROUTINE MAINT. COST	0.089	0.087	0.095	0.098	0.098	0.091	0.088	0.094
SALVAGE VALUE	-0.554	-0.502	-0.606	-0.658	-0.710	-0.627	-0.575	-0.679

TOTAL COST	3.246	3.271	3.297	3.321	3.439	3.474	3.494	3.498

NUMBER OF LAYERS	2	2	2	2	2	3	3	3

LAYER DEPTH (INCHES)								
D(1)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D(2)	11.50	10.00	13.00	14.50	16.00	10.00	8.50	11.50
D(3)						6.00	6.00	6.00

NO.OF PERF.PERIODS	3	3	3	3	3	3	3	3

PERF. TIME (YEARS)								
T(1)	5.7	4.8	6.3	6.6	7.0	6.1	5.4	6.5
T(2)	13.8	11.6	15.5	16.6	17.4	14.9	13.1	16.2
T(3)	24.6	20.8	28.0	30.0	31.6	26.7	23.4	29.2

OVERLAY POLICY(INCH)								
(INCLUDING LEVEL-UP)								
O(1)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
O(2)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

NUMBER OF SEAL COATS	0	0	0	0	0	0	0	0

SEAL COAT SCHEDULE								
(YEARS)								

THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS

34

INPUT DATA

THE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00
2	S	CRUSHED STONE	4.00	0.65	4.00	4.00	100.00
2	S	CRUSHED STONE	4.00	0.65	20.00	20.00	100.00
3	G	GRAVEL-1	3.00	0.35	20.00	20.00	80.00
3	G	GRAVEL-1	3.00	0.35	6.00	6.00	80.00
		SUBGRADE	-----	0.24	-----	-----	-----

NUMBER OF SUMMARY OUTPUT PAGES DESIRED(8 DESIGNS/PAGE)	1
TOTAL NUMBER OF INPUT MATERIALS, EXCLUDING SUBGRADE	6
LENGTH OF THE ANALYSIS PERIOD (YEARS)	20.0
WIDTH OF EACH LANE (FEET)	12.0
NUMBER OF LANES (BOTH DIRECTIONS)	6

DISTRICT TEMPERATURE CONSTANT	26.0
SERVICEABILITY INDEX OF THE INITIAL STRUCTURE	4.2
SERVICEABILITY INDEX P1 AFTER AN OVERLAY	4.2
MINIMUM SERVICEABILITY INDEX P2	3.0
SWELLING CLAY PARAMETERS -- P2 PRIME	1.50
B1	0.0800
GAMMA	0.03

ONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)	15000.
ONE-DIRECTION ADT AT END OF TWENTY YEARS (VEHICLES/DAY)	25000.
ONE-DIRECTION 20.-YR ACCUMULATED NO. OF EQUIVALENT 18-KIP AXLES	3450000.
PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)	5.5
THE ROAD IS IN AN URBAN AREA.	2

MINIMUM TIME TO FIRST OVERLAY (YEARS)	2.0
MINIMUM TIME BETWEEN OVERLAYS (YEARS)	5.0
TIME TO FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS)	30.0
TIME BETWEEN SEAL COATS (YEARS)	30.0
MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)	*****
MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)	26.0
MINIMUM OVERLAY THICKNESS (INCHES)	0.5
ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES)	10.0

INPUT DATA (CONTINUED)

ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	75.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	2.0
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.D. (MILES)	1.00
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE N.O.D. (MILES)	0.0
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	1.10
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	8.0
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.	2
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.	2
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN O.D. (PERCENT)	10.00
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN N.O.D. (PERCENT)	0.0
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN O.D. (HOURS)	0.017
AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS)	0.0
AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH)	50.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH)	30.0
AVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)	50.0
TRAFFIC MODEL USED IN THE ANALYSIS	
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE MILE)	25.00
INCREMENTAL INCREASE IN MAINT. COST PER YEAR (DOLLARS/LANE MILE)	10.0
COST OF A SEAL COAT (DOLLARS/LANE MILE)	1500.00
INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)	6.0

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P

DESIGN TYPE 1 WITH 1 LAYERS, MATERIALS A

LAYER CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
	SUBGRADE	-----	0.24	-----	-----	-----	-----
	OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

THE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO OBTAIN A STRUCTURE THAT WILL MEET THE MINIMUM TIME TO THE FIRST OVERLAY RESTRICTION.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P

DESIGN TYPE 2 WITH 2 LAYERS, MATERIALS AS

LAYER CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
2	S CRUSHED STONE	4.00	0.65	4.00	4.00	100.00	1.50
	SUBGRADE	-----	0.24	-----	-----	-----	-----
	OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

THE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO OBTAIN A STRUCTURE THAT WILL MEET THE MINIMUM TIME TO THE FIRST OVERLAY RESTRICTION.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P 5

DESIGN TYPE 3 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	4.00	100.00	1.50
3	G	GRAVEL-1 SUBGRADE	3.00 -----	0.35 0.24	20.00 -----	20.00 -----	80.00 -----	2.00 -----
OVERLAYS			24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 3 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 1.00 INCHES
CRUSHED STONE 4.00 INCHES
GRAVEL-1 20.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.363

THE LIFE OF THE INITIAL STRUCTURE = 4.53 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 4.53 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 10.35 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 17.53 YEARS.
TOTAL LIFE = 26.11 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	2.778
TOTAL ROUTINE MAINTENANCE COST	0.081
TOTAL OVERLAY CONSTRUCTION COST	1.656
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.260
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.684

TOTAL=OVERALL COST 4.091

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE ASG

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 2
4. THE MAXIMUM DEPTH OF LAYER 2
5. THE MINIMUM DEPTH OF LAYER 3
6. THE MAXIMUM DEPTH OF LAYER 3

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 1 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 53 OVERLAYS
- 51 WHICH WERE FEASIBLE
- 27 OVERLAY POLICIES
- 25 WHICH WERE FEASIBLE
- 1 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P

DESIGN TYPE 4 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	4.00	100.00	1.50
3	G	GRAVEL-1	3.00	0.35	6.00	6.00	80.00	2.00
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 4 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 1.00 INCHES
CRUSHED STONE 4.00 INCHES
GRAVEL-1 6.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.772

THE LIFE OF THE INITIAL STRUCTURE = 2.09 YEARS

THE OVERLAY SCHEDULE IS

3.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 2.09 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 7.22 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 13.72 YEARS.
TOTAL LIFE = 21.64 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 1.611
TOTAL ROUTINE MAINTENANCE COST 0.078
TOTAL OVERLAY CONSTRUCTION COST 3.184
TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.443
TOTAL SEAL COAT COST 0.0
SALVAGE VALUE -0.497

TOTAL=OVERALL COST 4.819

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE ASG

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 2
4. THE MAXIMUM DEPTH OF LAYER 2
5. THE MINIMUM DEPTH OF LAYER 3
6. THE MAXIMUM DEPTH OF LAYER 3
7. THE MINIMUM TIME BETWEEN OVERLAYS

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

1	INITIAL DESIGNS
1	INITIAL DESIGNS CONSIDERED
1	WHICH WERE FEASIBLE TO FIRST OVERLAY
149	OVERLAYS
137	WHICH WERE FEASIBLE
73	OVERLAY POLICIES
65	WHICH WERE FEASIBLE
1	FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P

DESIGN TYPE 5 WITH 2 LAYERS, MATERIALS AS

LAYER CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
2	S CRUSHED STONE	4.00	0.65	20.00	20.00	100.00	1.50
	SUBGRADE	-----	0.24	-----	-----	-----	-----
	OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 5 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 1.00 INCHES

CRUSHED STONE 20.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.076

THE LIFE OF THE INITIAL STRUCTURE = 7.19 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 7.19 YEARS.

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 18.16 YEARS.

TOTAL LIFE = 32.98 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 2.889

TOTAL ROUTINE MAINTENANCE COST 0.102

TOTAL OVERLAY CONSTRUCTION COST 1.015

TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.166

TOTAL SEAL COAT COST 0.0

SALVAGE VALUE -0.797

TOTAL=OVERALL COST 3.376

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AS

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 2
4. THE MAXIMUM DEPTH OF LAYER 2

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 1 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 41 OVERLAYS
- 39 WHICH WERE FEASIBLE
- 21 OVERLAY POLICIES
- 19 WHICH WERE FEASIBLE
- 1 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P 1

DESIGN TYPE 6 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	20.00	20.00	100.00	1.50
3	G	GRAVEL-1 SUBGRADE	3.00 -----	0.35 0.24	20.00 -----	20.00 -----	80.00 -----	2.00 -----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

EACH OF THE MATERIALS AT THEIR MINIMUM DEPTH RESULTS
IN A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM
ALLOWED TOTAL THICKNESS.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 0 INITIAL DESIGNS
- 0 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P

DESIGN TYPE 7 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	1.00	1.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	20.00	20.00	100.00	1.50
3	G	GRAVEL-1 SUBGRADE	3.00 -----	0.35 0.24	6.00 -----	6.00 -----	80.00 -----	2.00 -----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

EACH OF THE MATERIALS AT THEIR MINIMUM DEPTH RESULTS
IN A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM
ALLOWED TOTAL THICKNESS.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 0 INITIAL DESIGNS
- 0 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 8 WITH 1 LAYERS, MATERIALS A

LAYER CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
	SUBGRADE	-----	0.24	-----	-----	-----	-----
	OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 8 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 6.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.666

THE LIFE OF THE INITIAL STRUCTURE = 2.54 YEARS

THE OVERLAY SCHEDULE IS

3.00 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 2.54 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 7.74 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 14.24 YEARS.
TOTAL LIFE = 22.09 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	4.000
TOTAL ROUTINE MAINTENANCE COST	0.076
TOTAL OVERLAY CONSTRUCTION COST	2.749
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.392
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.468

TOTAL=OVERALL COST 6.748

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE A

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM TIME BETWEEN OVERLAYS

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

1	INITIAL DESIGNS
1	INITIAL DESIGNS CONSIDERED
1	WHICH WERE FEASIBLE TO FIRST OVERLAY
130	OVERLAYS
121	WHICH WERE FEASIBLE
64	OVERLAY POLICIES
58	WHICH WERE FEASIBLE
1	FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 9 WITH 2 LAYERS, MATERIALS AS

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	4.00	100.00	1.50
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 9 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 6.00 INCHES
CRUSHED STONE 4.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.258

THE LIFE OF THE INITIAL STRUCTURE = 5.55 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 5.55 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 12.98 YEARS.
TOTAL LIFE = 22.28 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 4.444
TOTAL ROUTINE MAINTENANCE COST 0.088
TOTAL OVERLAY CONSTRUCTION COST 1.174
TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.181
TOTAL SEAL COAT COST 0.0
SALVAGE VALUE -0.502

TOTAL=OVERALL COST 5.384

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AS

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 2
4. THE MAXIMUM DEPTH OF LAYER 2

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 1 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 41 OVERLAYS
- 39 WHICH WERE FEASIBLE
- 21 OVERLAY POLICIES
- 19 WHICH WERE FEASIBLE
- 1 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 10 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	4.00	100.00	1.50
3	G	GRAVEL-1	3.00	0.35	20.00	20.00	80.00	2.00
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

EACH OF THE MATERIALS AT THEIR MINIMUM DEPTH RESULTS
IN A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM
ALLOWED TOTAL THICKNESS.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 0 INITIAL DESIGNS
- 0 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 11 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	4.00	4.00	100.00	1.50
3	G	GRAVEL-1	3.00	0.35	6.00	6.00	80.00	2.00
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 11 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 6.00 INCHES
CRUSHED STONE 4.00 INCHES
GRAVEL-1 6.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.156

THE LIFE OF THE INITIAL STRUCTURE = 6.64 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 6.64 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 16.18 YEARS.
TOTAL LIFE = 28.46 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	4.944
TOTAL ROUTINE MAINTENANCE COST	0.094
TOTAL OVERLAY CONSTRUCTION COST	1.059
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.170
TOTAL SEAL COAT COST	0.0
SALVAGE VALUE	-0.627

TOTAL=OVERALL COST 5.640

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE ASG

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 2
4. THE MAXIMUM DEPTH OF LAYER 2
5. THE MINIMUM DEPTH OF LAYER 3
6. THE MAXIMUM DEPTH OF LAYER 3

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 1 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 41 OVERLAYS
- 39 WHICH WERE FEASIBLE
- 21 OVERLAY POLICIES
- 19 WHICH WERE FEASIBLE
- 1 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

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DESIGN TYPE 12 WITH 2 LAYERS, MATERIALS AS

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCREMENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	20.00	20.00	100.00	1.50
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

DESIGN TYPE 12 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE

ASPHALTIC CONCRETE 6.00 INCHES
CRUSHED STONE 20.00 INCHES

THE SCI OF THE INITIAL STRUCTURE = 0.029

THE LIFE OF THE INITIAL STRUCTURE = 7.41 YEARS

THE OVERLAY SCHEDULE IS

1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 7.41 YEARS.
1.50 INCH(ES) (INCLUDING 1.0 INCH LEVEL-UP) AFTER 18.90 YEARS.
TOTAL LIFE = 34.79 YEARS

NO SEAL COATS SCHEDULED.

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST 6.222
TOTAL ROUTINE MAINTENANCE COST 0.107
TOTAL OVERLAY CONSTRUCTION COST 0.996
TOTAL USER COST DURING
OVERLAY CONSTRUCTION 0.164
TOTAL SEAL COAT COST 0.0
SALVAGE VALUE -1.057

TOTAL=OVERALL COST 6.432

FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE AS

AT THE OPTIMAL SOLUTION, THE FOLLOWING BOUNDARY RESTRICTIONS ARE ACTIVE--

1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 2
4. THE MAXIMUM DEPTH OF LAYER 2
5. THE MAXIMUM THICKNESS OF INITIAL CONSTRUCTION

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 1

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 1 INITIAL DESIGNS
- 1 INITIAL DESIGNS CONSIDERED
- 1 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 41 OVERLAYS
- 39 WHICH WERE FEASIBLE
- 21 OVERLAY POLICIES
- 19 WHICH WERE FEASIBLE
- 1 FEASIBLE COMPLETE DESIGNS

DESIGN TYPE 13 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	20.00	20.00	100.00	1.50
3	G	GRAVEL-1	3.00	0.35	20.00	20.00	80.00	2.00
		SUBGRADE	-----	0.24	-----	-----	-----	-----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

EACH OF THE MATERIALS AT THEIR MINIMUM DEPTH RESULTS
IN A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM
ALLOWED TOTAL THICKNESS.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 0 INITIAL DESIGNS
- 0 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

* P 2

DESIGN TYPE 14 WITH 3 LAYERS, MATERIALS ASG

LAYER	CODE	MATERIALS NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.	INCRE- MENT
1	A	ASPHALTIC CONCRETE	24.00	0.90	6.00	6.00	25.00	0.25
2	S	CRUSHED STONE	4.00	0.65	20.00	20.00	100.00	1.50
3	G	GRAVEL-1 SUBGRADE	3.00 -----	0.35 0.24	6.00 -----	6.00 -----	80.00 -----	2.00 -----
		OVERLAYS	24.00	0.96	0.50	10.00	25.00	0.50

EACH OF THE MATERIALS AT THEIR MINIMUM DEPTH RESULTS
IN A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM
ALLOWED TOTAL THICKNESS.

NO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY = 0

COUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE

- 0 INITIAL DESIGNS
- 0 INITIAL DESIGNS CONSIDERED
- 0 WHICH WERE FEASIBLE TO FIRST OVERLAY
- 0 OVERLAYS
- 0 WHICH WERE FEASIBLE
- 0 OVERLAY POLICIES
- 0 WHICH WERE FEASIBLE
- 0 FEASIBLE COMPLETE DESIGNS

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.

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PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE
IN ORDER OF INCREASING TOTAL COST

DESIGN TYPE	TOTAL COST
5	3.376
3	4.091
4	4.819
9	5.384
11	5.640
12	6.432
8	6.748

THE MATERIALS ASSOCIATED WITH EACH OF THE FOLLOWING DESIGN
TYPES DO NOT HAVE AT LEAST ONE FEASIBLE DESIGN.

1
2
6
7
10
13
14

PROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS
IN ORDER OF INCREASING TOTAL COST

	1	2	3	4	5	6	7

MATERIAL ARRANGEMENT	AS	ASG	ASG	AS	ASG	AS	A
INIT. CONST. COST	2.889	2.778	1.611	4.444	4.944	6.222	4.000
OVERLAY CONST. COST	1.015	1.656	3.184	1.174	1.059	0.996	2.749
USER COST	0.166	0.260	0.443	0.181	0.170	0.164	0.392
SEAL COAT COST	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROUTINE MAINT. COST	0.102	0.081	0.078	0.088	0.094	0.107	0.076
SALVAGE VALUE	-0.797	-0.684	-0.497	-0.502	-0.627	-1.057	-0.468

TOTAL COST	3.376	4.091	4.819	5.384	5.640	6.432	6.748

NUMBER OF LAYERS	2	3	3	2	3	2	1

LAYER DEPTH (INCHES)							
D(1)	1.00	1.00	1.00	6.00	6.00	6.00	6.00
D(2)	20.00	4.00	4.00	4.00	4.00	20.00	
D(3)		20.00	6.00		6.00		

NO. OF PERF. PERIODS	3	4	4	3	3	3	4

PERF. TIME (YEARS)							
T(1)	7.2	4.5	2.1	5.5	6.6	7.4	2.5
T(2)	18.2	10.4	7.2	13.0	16.2	18.9	7.7
T(3)	33.0	17.5	13.7	22.3	28.5	34.8	14.2
T(4)		26.1	21.6				22.1

OVERLAY POLICY (INCH)							
(INCLUDING LEVEL-UP)							
O(1)	1.5	1.5	3.5	1.5	1.5	1.5	3.0
O(2)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O(3)		1.5	1.5				1.5

NUMBER OF SEAL COATS	0	0	0	0	0	0	0

SEAL COAT SCHEDULE							
(YEARS)							

THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS

7