FLEXIBLE PAVEMENT SYSTEM COMPUTER PROGRAM DOCUMENTATION

by

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Research Report Number 123-11

A System Analysis of Pavement Design
and Research Implementation

Research Project 1-8-69-123

conducted

in cooperation with the
U. S. Department of Transportation
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by the

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Texas Transportation Institute
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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.

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:

R. L. Lewis, Chairman
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 TEXLIS 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'.

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 *

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* 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

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 CONPACTED DENSITY (TONS/COMPACTED CY).
COLUMNS 11-20

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

XLSN-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*************************************
DDITIONAL PARAMETERS ABOUT USER COSTS ASSOCIATED WITH OVERLAYS
ORMAT(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

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* 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-8COLUMNS-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 CBVIOUS 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, PRECEEDED 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
....5....0....5....0....5....0....5....0....5....0....5....0--------
                                                            7       8
------------------------------------------------------------....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     --------
------------------------------------------------------------    0.02
    12000.    18000.     2.0E06     6.0           1                --------
------------------------------------------------------------
    2.0       5.0        5.0        3.0        5.0        36.0     --------
------------------------------------------------------------       0.5     8.0
    75.0      1.80       0.5        0.5                   10.0     --------
------------------------------------------------------------          1       2
    2.0       0.0        0.1        0.1        60.0       40.0     --------
------------------------------------------------------------    55.0          3
    50.0      20.0       1500.0     5.0                            --------
------------------------------------------------------------
   1  A     ASPHALTIC CONCRET 10.0 .82       1.00     10.0         --------
------------------------------------------------------------45.0
   2  L      CR. LIMESTONE-1    5.0 .55       6.00     16.0         --------
------------------------------------------------------------75.0
   2  G     GRAVEL-1           3.0  0.35      6.00     16.0         --------
------------------------------------------------------------100.0
   3  G     GRAVEL-1           3.0  0.35      6.00     16.0         --------
------------------------------------------------------------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 ADVANGAGE OF THIS CAPABILITY IN FPS-9.

IN THE RESULTS IT MAY BE NOTICED THAT A WIDE RANGE IN DEPTH OF THE ASPHALTIC CONCRETE GAVE A LARGE NUMBER OF INITIAL DESIGNS, NEARLY 10,000 FOR ONE COMBINATION OF MATERIALS, AND REQUIRED ABOUT 1.5 MINUTES OF COMPUTER TIME FOR THE ENTIRE PROBLEM.

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.

PROBLEM T-2

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

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--------
---------------------------------------------------- 0.05
     1600.     3200.   800000.        5.0        1              --------
----------------------------------------------------
    5.0      5.0           22.        22.      7.50    24.00--------
----------------------------------------------------    0.50      4.5
      80         2.00      1.0        1.0      0.0      10   --------
----------------------------------------------------     1          1
      1.00       1.00    0.01       0.01        60       20   --------
----------------------------------------------------    30          5
     50.00      20.00      0.00       7.0                     --------
----------------------------------------------------
   1   A                   ACP 16.00     0.95     1.50    2.00 --------
---------------------------------------------------- 50.0
   2   B         ASPH STAB BASE 11.00    0.85     2.00    8.50 --------
---------------------------------------------------- 60.0
   2   X          EXISTING BASE  0.00    0.46    14.00   14.00 --------
---------------------------------------------------- 100.0
   3   X          EXISTING BASE  0.00    0.46    14.00   14.00 --------
---------------------------------------------------- 100.0
                       SUBGRADE          0.24                  --------
----------------------------------------------------
```

AN EXISTING SUBGRADE WAS INCLUDED IN THE CHOICE OF MATERIALS FOR THIS PROBLEM BY GIVING THE COST AS 0.0 DOLLARS PER CUBIC YARD.

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

OF ASPHALTIC CONCRETE LAYER THICKNESSES.

SEAL COAT EXPENSES WERE INCLUDED IN ANNUAL MAINTENANCE. THE DELETION OF THE SEAL COAT SCHEDULE WAS ACCOMPLISHED BY EXTENDING THE INPUT DATA RELATING TO SEAL COAT SCHEDULES.

PROBLEM T-3.

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

T-3       HEAVIER TRAFFIC, FRONTAGE ROAD WITH LIGHT.             --------
------------------------------------------------
         1         2    20.0      12.0           6               --------
------------------------------------------------
    26.00      4.20      4.20     3.0       1.50      0.08       --------
------------------------------------------------     0.05
  15000.    25000.    3.45E+06    5.5            2               --------
------------------------------------------------
     2.0       5.0      30.0      30.0       4.0      25.0       --------
------------------------------------------------      1.0       5.0
    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     6.0      --------
------------------------------------------------ 25.0
   2   S   CRUSHED   STONE     4.0     0.65     4.0    20.0      --------
------------------------------------------------ 100.0
   3   G   GRAVEL-1            3.0     0.35     6.0    20.       --------
------------------------------------------------ 80.0
                     SUBGRADE          0.24                      --------
------------------------------------------------
```

THIS PROBLEM ILLUSTRATES HOW A DETOUR ONTO A FRONTAGE ROAD WITH A TRAFFIC LIGHT MAY BE SIMULATED BY SUBSTITUTING INTO THE PROPORTION OF VEHICLES STOPPED BY OVERLAY EQUIPMENT THE PROPORTION OF VEHICLES STOPPED BY A TRAFFIC LIGHT ON THE FRONTAGE ROAD DETOUR.

PROBLEM T-4

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

CALLED EXTERNAL NAME	CALLING PROGRAM NAME: MAIN	INPUT	SOLVE2	OUTPUT	OVRLAY	CALC	USER	TIME	PWRM	SEAL	SUMARY	HEADNG	LAYIDX
INPUT	X												
SOLVE2	X												
OUTPUT	X												
OVRLAY				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

VARIABLES IN COMMON	PROGRAM NAME: MAIN	INPUT	SOLVE2	OUTPUT	OVRLAY	CALC	USER	TIME
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	---	---	---

VARIABLES IN COMMON	MAIN	INPUT	SOLVE2	OUTPUT	OVRLAY	CALC	USER	TIME
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	---	---	---	---

VARIABLES IN COMMON	MAIN	INPUT	SOLVE2	OUTPUT	OVRLAY	CALC	USER	TIME	
OVCOST	---	S	---	---	F	---	---	---	
OVINC	---	S	---	---	F	---	---	---	
OVMAX	---	SF	---	F	F	---	---	---	
OVMIN	---	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.

VARIABLES IN COMMON	MAIN	INPUT	SOLVE2	OUTPUT	OVRLAY	CALC	USER	TIME
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	---
XLSN	---	SF	---	---	---	---	F	---
XLSO	---	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 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 'OVRLAY' AND 'OUTPUT', USED IN 'TIME'.

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

BONE NON-TRAFFIC DETERIORATCN 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 CF 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 ALLOW-ABLE 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 'OVRLAY' 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 CCMPLETE 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 ILAYER 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).

UPLEVL IT IS ASSUMED THAT EACH TIME THAT AN OVERLAY IS CONSTRUCTED THERE IS AN ADDITIONAL CHARGE, THE 'LEVEL-UP' COST EQUAL TO UPLEVL THICKNESS OF OVERLAY, NOMINALLY ONE INCH (EXPRESSED IN YARDS). UPLEVL 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 'OVRLAY'.

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.

XLSO 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'

PROBLEM	DESIGN	CPU SEC.	INITIAL DESIGNS ALL	INITIAL DESIGNS CONSIDERED	OVERLAYS ALL	OVERLAYS FEASIBLE	OVERLAY POLICIES ALL	OVERLAY POLICIES 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 CALCULATICNS 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,

$i = 1, 2, \ldots, n + 1.$

DOVER(J) (in yards) — D_i = the thickness of the i^{th} layer in inches.

$D_{n+1} = \infty.$

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.

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

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 = ADT (one direction) when $t = 0$.

RC — r_c = ADT (one direction) when $t = C$.

D. Performance Variables

P — P = the serviceability index at time, t.

PSI initial or P1 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 kth 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:

$$S = W_1 - W_2$$

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

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

$C_o = 0.891,$

$C_1 = 4.503,$

$C_2 = 6.25,$

$a_o = D_o = 0,$

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.

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

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.

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

SUBROUTINE TIME solves for t by iteration until $|P - P_2| \leq$ 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.

Past Experience In Area	Value of b_1
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 OVRLAY)
    - 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 OVRLAY)

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 $\quad C_1$ = routine maintenance cost/square yard during the first year after initial or overlay construction.

m = number of years after initial or overlay construction.

CM2 $\quad C_2$ = 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

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

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

RATE $\quad i$ = interest rate.

N $\quad M_K$ = 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 OVRLAY)

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)

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

```
TUCH = TIPH*(PO1*(CO1+CO2+CO3) + (1.0-PO1)*(CO3+CO4) + PO2*CO5)
       + TIPH*(PN1*(CN1+CN2+CN3) + (1.0-PN1)*(CN3+CN4) + PN2*CN5)
```

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)

```
PWTSY = (HPSY*TUCH)/((1. + RATE) ** 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. <u>Seal Coat Costs (SUBROUTINE SEAL)</u>

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 SCC = cost/square yard of a seal coat,

RATE i = interest rate,

NUM 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 $x = \left[t_{k-1} + \tau_1 + (j-1)\ \tau_2\right]$, where t_{k-1} is the number of years, after initial construction, that elapse before the beginning of the k^{th} performance period, with $t_o = 0$, 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:

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

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. <u>Salvage Value (SUBROUTINE OVRLAY)</u>

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 LSØ 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", LSØ and LSN respectively.

The length LSØ of the restricted area generally will be longer than the length LØ of the actual overlay operation. The amount by which LSØ is longer than LØ 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 LSØ or LSN; 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 LSØ or LSN, 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).

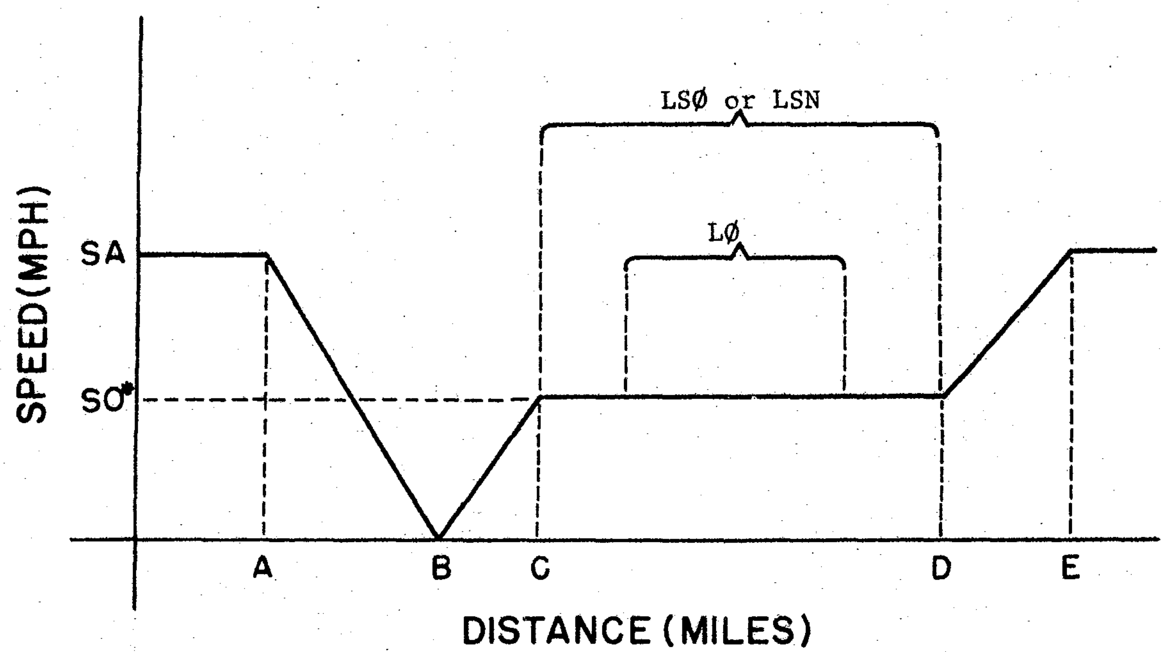


Figure AII-1: Speed profile for vehicles which are stopped during overlay.

* This speed is SO in the overlay direction but would be SN in the non-overlay direction. LØ is length of overlay work. **LSØ** 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	Dollars Per 1000 Cycles, By Speed Reduced To And Returned From (MPH)					
MPH	0	10	20	30	40	50
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) 0	10	20	30	40	50
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

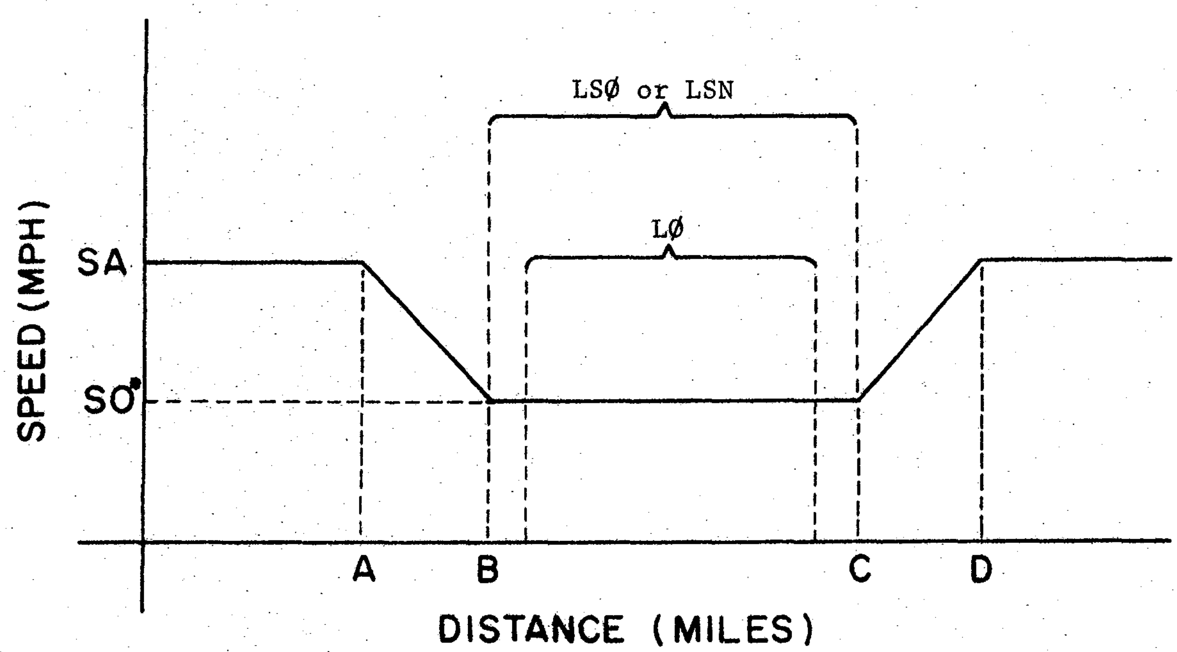


Figure AII-2: Speed profile for vehicles which are not stopped but are slowed during overlay.

* 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, MPH	Dollars Per 1000 Miles	
	Rural Roads	Urban Roads
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 Cost	Dollars Per 1000 Hours	
	Rural Roads	Urban Roads
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 LØ, LSØ, and LSN are shown. LØ is the amount of road which is overlayed at any one time -- not the total overlay job length. LSØ 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, LSØ and LSN are only slightly longer than LØ by say one-tenth of a mile, but in the situations depicted in Figures AII-6 and 7, LSØ may be considerably longer than LØ. LSØ and LSN are input variables provided by the program user. LØ is not used in the calculation of user costs and is included only for illustration. (Note: The variable LO used as a subscript in SUBROUTINE USER is not LØ as illustrated in these figures.) In the figures, the "overlay direction" is always to the left.

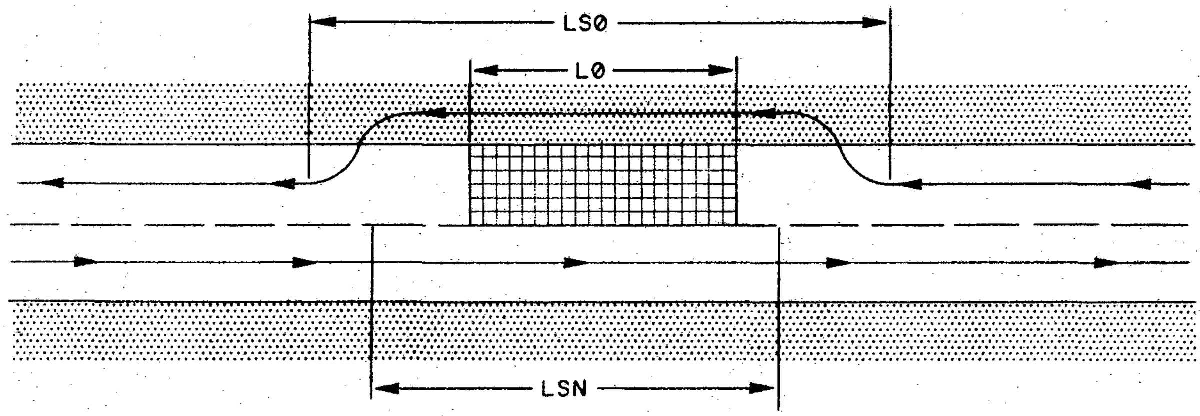


Figure AII-3. MODEL=1: traffic routed to shoulder.

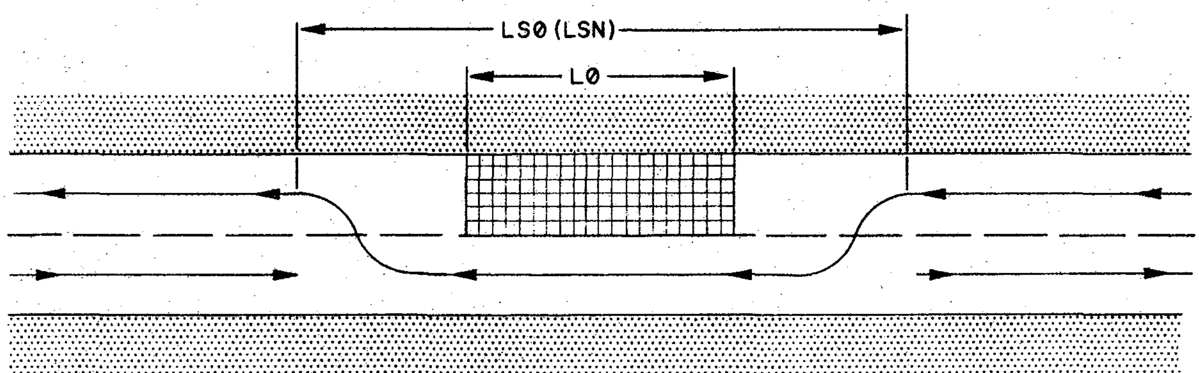


Figure AII-4. MODEL=2: alternating traffic in one lane.

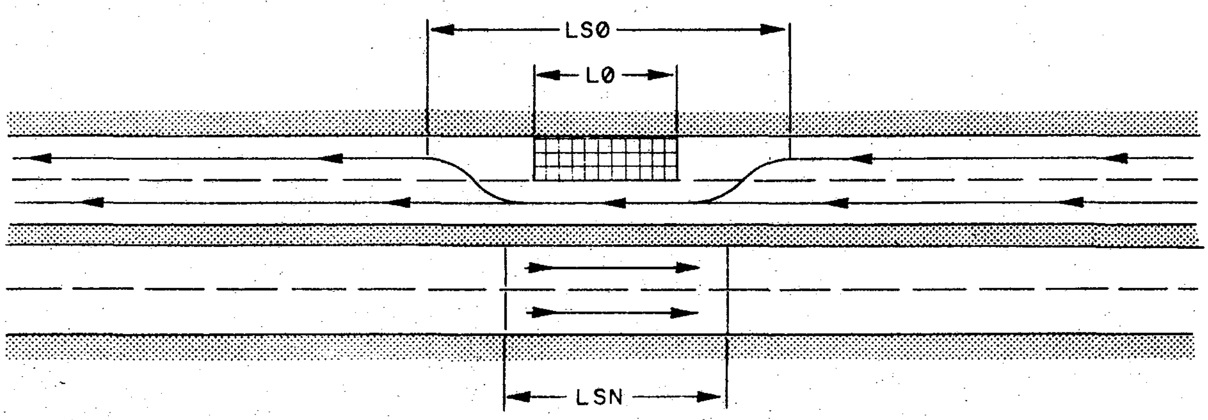


Figure AII-5. MODEL=3: two lanes merge, non-overlay direction not affected.

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 LSØ 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 LSØ and LSN in these latter two cases would bear approximately the same relation to LØ as is the relation where MODEL = 1, 2, or 3 instead of being the distance between

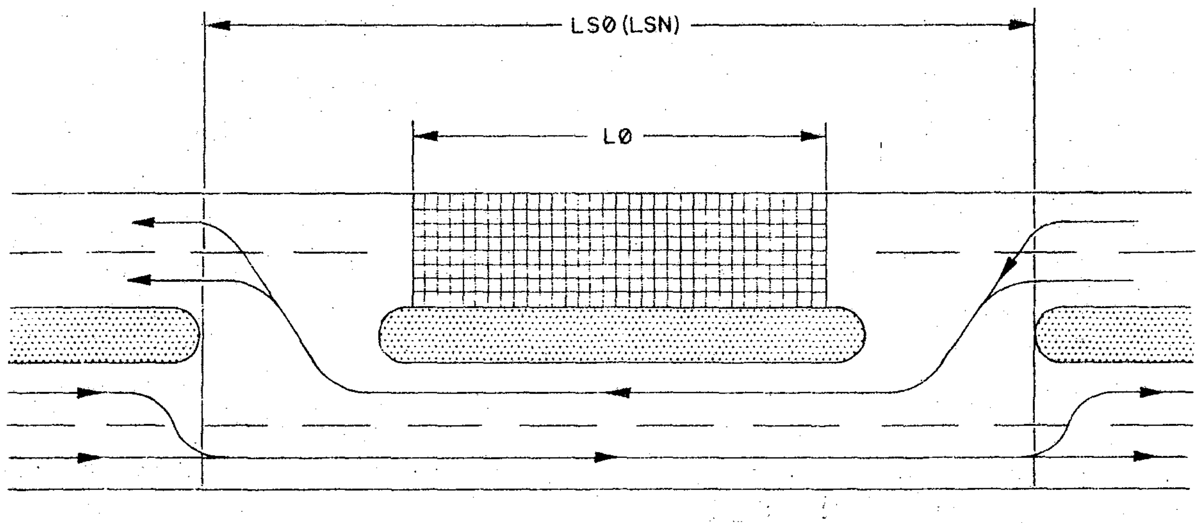


Figure AII-6 MODEL=4: overlay direction traffic routed to non-overlay lanes.

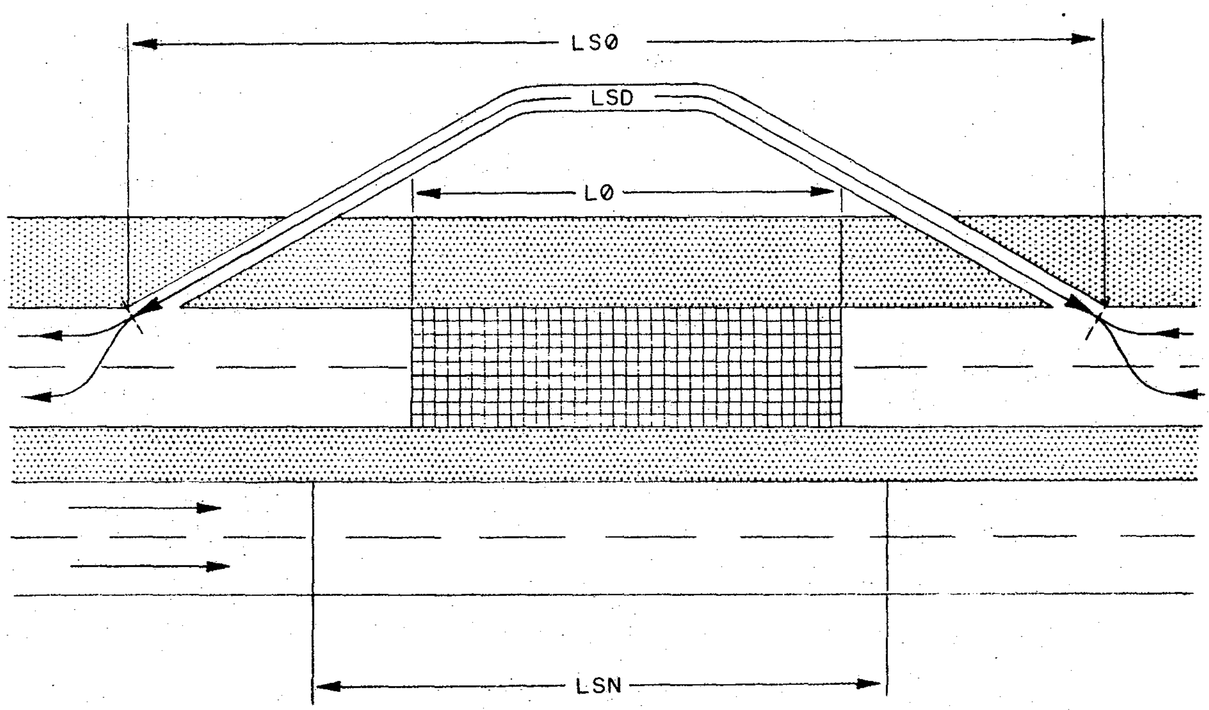


Figure AII-7. MODEL=5: overlay direction traffic routed to frontage road or other parallel route.

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 (Ø) 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):

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

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

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

R = the recovery rate in vehicles per hour,

∅ = 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) 1	2	3	4	5	6	7
RUTFOV	10+	RU	Ø	1350	2700	4350	6000	7650	9300	na
RUTFRV	10+	RU	R	na	3000	4500	6200	7900	9600	11300
URTFOV	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 Ø 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-Ø). The average number of vehicles which will be stopped at any one time during overlay will be H(Q-Ø)/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 x 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 SE-QUENTIAL 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.

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 ØN ØNE LINE.

THE FØLLØWING PARAGRAPH ØN ØVERPRINTING APPLIES IF A '+' IN CØLUMN ØNE AS CARRIAGE CØNTRØL WILL CAUSE THE PRINTER TØ PRINT WITHØUT SKIPPING TØ A NEW LINE.

MULTIPLE TEXT CARDS CAN BE ØVER-PRINTED ØN A SINGLE LINE BY PLACING A PLUS SIGN (+) IN COLUMN 72 FOR NØ CARD 2, ØR IN CØLUMN 66 ØF CARD 2 FØR USE WITH THE CARD 2 ØPTIØN.

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

```
      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)
```

```
 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
```

```
     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
```

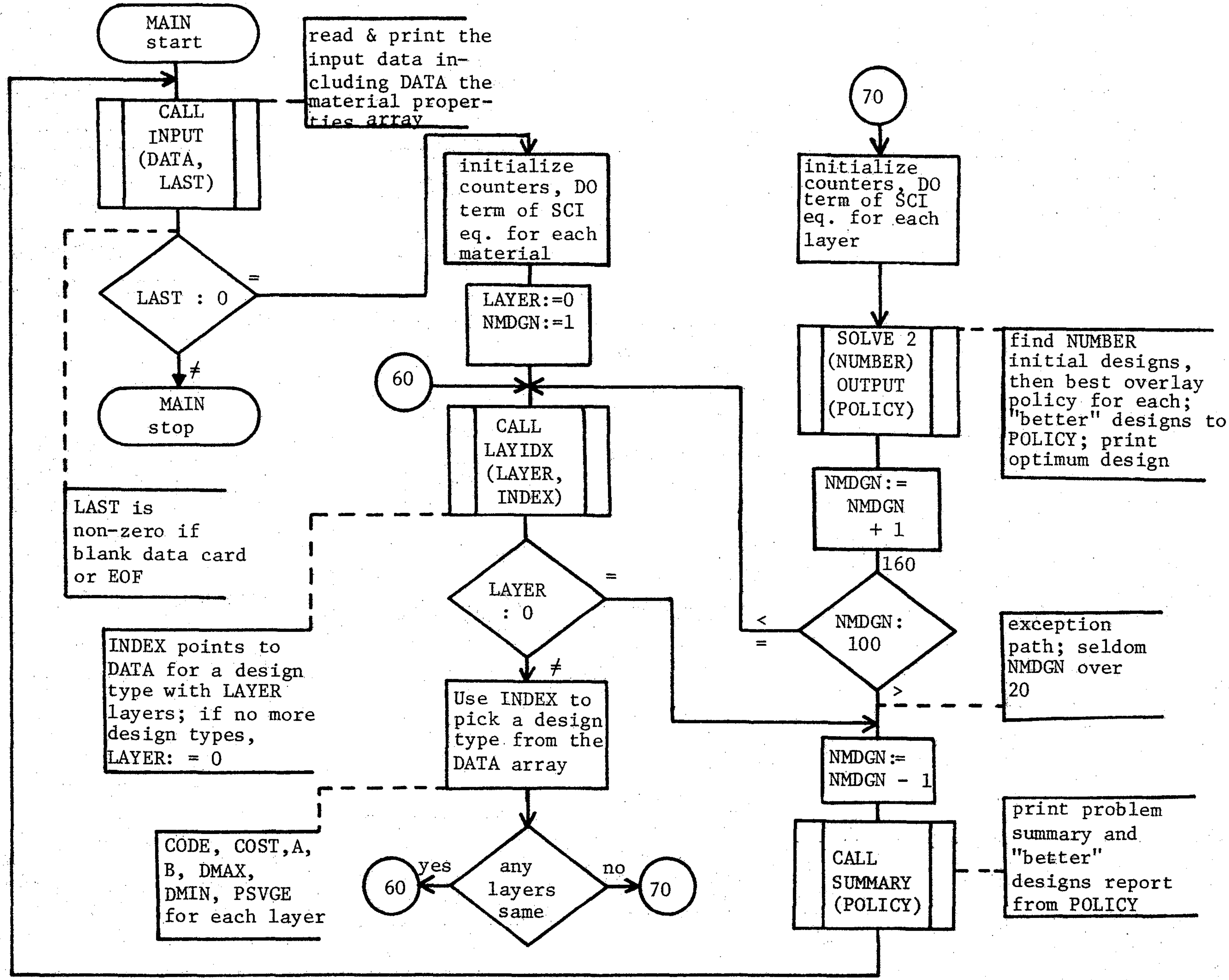
APPENDIX IV

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

SYMBOL KEY

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

MAIN

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C
C                        FPS - 9
C                FLEXIBLE PAVEMENT SYSTEM
C              COMPUTER PROGRAM - VERSION 9
C
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      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   DN2, DO2, DMAX(6), DMIN(6), DOVER(6), GAMMA, HPO, INDEX(10),
     3   IPAGE, ITYPE, KT(9), LAYER, MATYPE, MODEL, NLO, NLRN, NLRO, NM
      COMMON NMB, NPROB, OVCOST, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1   PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2   SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3   XLSD, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)

C--DATA STATEMENT AND DIMENSIONS ALLOW A 6 LAYER DESIGN, 11 MATERIALS
C--INCLUDING SUBGRADE.

      DIMENSION IDUMMY(24), CODE(6), POLICY(50,24)
      DIMENSION OCOST(100),IPOSS(100),NPOSS(100)
      DIMENSION XNDKP(6,24),ILAYER(11)
      DATA  LAYD/6/, NMD/11/, NSUMD/24/, NPD/50/, NKTD/9/
      DATA BLANK/1H /

C**********************************************************************

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
E     LAST = 0                                                        E
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE

C--READ IN PROGRAM AND PROBLEM IDENTIFICATION
                                  OK

   10 CONTINUE

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     CALL INPUT(ILAYER, NDP, LAST)                                   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      IF(LAST.NE.0) GO TO 540

      NK = 0
      NPOS = 0

C--NUMBER OF BETTER DESIGNS MUST NOT EXCEED DIMENSIONS.

      NMBEST = MIN0(NSUMD, NMB*NDP)

      DO 13 J = 1, NMBEST

      DO 11 I = 1, NPD

   11 POLICY(I,J) = 0.0

      DO 12 I = 1, LAYD

   12 XNDKP(I,J) = BLANK

   13 CONTINUE

C--KNTOL IS A COUNTER FOR THE NUMBER OF COMPLETED FEASIBLE DESIGNS.

      KNTOL = 0

C--NMP IS THE SUBGRADE IN THE DATA ARRAY

      NMP = NM + 1

      DO 50 J=1,NMP

C     CALCULATION OF A TERM IN THE SCI FORMULA

   50 BB(J) = 0.891087 / DATA(J,10)**4.50292

C--SUBROUTINE LAYIDX SELECTS ALL POSSIBLE DESIGN TYPES WITH A GIVEN
C--SET OF MATERIALS, WITH THE LIMITATIONS OF LAYER NO. IN ILAYER.
C--AN OPTIMUM DESIGN IS CALCULATED IF POSSIBLE FOR EACH DESIGN TYPE
C--WITHIN THIS HIERARCHY UNLESS SUCCESIVE LAYERS HAVE THE SAME
C--MATERIAL CODE LETTER.  THE ARRAY INDEX POINTS TO THE DATA ARRAY
C--FOR THE MATERIAL TYPES UNDER CONSIDERATION IN THE CURRENT DESIGN.
```

2 . 1

```
      LAYER = 0

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

      DO 150 NMDGN  = 1, 100

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   60 CALL   LAYIDX     (NM, ILAYER, NMD, LAYER, INDEX, LAYD)           C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

      IF(LAYER .EQ. 0) GO TO 170

      DO 90 J = 1, LAYER

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

      IF(J.EQ.1) GO TO 90

C--THE SAME MATERIAL MAY NOT BE USED IN SUCCESIVE 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) = IFIX(0.5+COST(1)/COST(J) )* XINC(1)

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

   90 XINC(J) =AMAX1(1./144., XINC(J) )

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

      DO 110  IK = 1, NKTD

  110 KT(IK) = 0

C--INCLUDE THE PROPERTIES OF THE SUBGRADE.

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

C OVCOST-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.

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       CALL SOLVE2(ISKIP,ICOST,NUMBER,SCOST)                           C
C       CALL OUTPUT(BCOST,NMDGN,KNTOL,KOUNT,POLICY,NMBEST,ISKIP,ICOST,  C
C     1          NUMBER,SCOST,XNOKP,ILAYER, CODE)                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C

      IF( KOUNT  .EQ. 0 )  GO TO 140

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

      NK = NK + 1
      IPOSS(NK) = NMDGN
      BCOST(NK) = BCOST
```

```
      GO TO 150

C-THE FOLLOWING DESIGNS ARE IMPOSSIBLE UNDER THE CRITERION.

                                   OK

  140 NPOS = NPOS + 1
      NPOSS(NPOS) = NMDGN

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

  150 CONTINUE

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

      NMDGN = 101

                                   OK

  170 NMDGN = NMDGN -1

C--PRINT THE PROBLEM SUMMARY

C     CALL SUMARY       (NDP, NMB, NPROB, AN2, IPAGE, UPLEVL,
C    *            KNTOL, XNDKP, POLICY, NPOS, NPOSS, NK, IPOSS, OCOS))

      GO TO 10

                                   OK

  540 CONTINUE

      STOP

      END
```

HEADNG

SYMBOL KEY

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

```
      SUBROUTINE HEADNG(NPROB, AN2, IPAGE)
C  SUBROUTINE 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
      DIMENSION AN2(16)
      IPAGE = IPAGE + 1
      WRITE(6,875)NPROB, (AN2(I), I=1,16), IPAGE
      RETURN
  875 FORMAT(6H1PROB , A4, 1H*, 16A4, 3H* P, I3, 4X,   10HI-----TRIM /)
      END
```

CALC

SYMBOL KEY

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

```
      SUBROUTINE CALC(SS)
      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   DN2, DO2, 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, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1   PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2   SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3   XLSD, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
C  GIVES SCI FOR ANY SET OF DEPTHS. CINT IS THE FIRST TERM OF THE
C  DEFLECTION EQUATION.
      TERM = 0.
      SS = CINT
      DO 60 J=1,LAYER
C  DOVER, THE THICKNESS OF THE JTH LAYER, IS CONVERTED TO INCHES.
      TERM = TERM + A(J)*DOVER(J) * 36.0
      PART = 6.25*TERM**2
   60 SS = SS + (B(J+1) - B(J))*144./((100.+PART)*(244.+PART))
      RETURN
      END
```

SYMBOL KEY

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

INPUT

```
      SUBROUTINE INPUT(ILAYER, NDP, LAST)

      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   DN2, DO2, 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, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1   PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2   SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3   XLSD, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
      DIMENSION ILAYER(11)

CCC A BLANK CARD WILL SERVE AS A JOB DELIMITER

      DATA BLANK/1H /, NBLANK/1H /

C--THE MAXIMUM NUMBER OF LAYERS INCLUDING SUBGRADF IS NMPD.

      DATA NMPD/11/

C
C******************************CARD 1*************************************
C  READ THE HEADING CARD(BLANK CARD ASSUMED TO BE END OF DATA)

      READ(5,780,END=540)  NPROB,(AN2(N), N=1,16)

C******* FOR STANDARD FORTRAN REPLACE READ WITH 'END=' WITH THE FOLLOW-
C******* ING READ STATEMENT BY REMOVING THE 'C' IN COLUMN ONE.
C     READ(5,780)          NPROB,(AN2(N), N=1,16)
C******* BLANK CARDS READ AS A HEADER WILL FLAG THE END OF DATA

      IF(NPROB.EQ.NBLANK .AND. AN2(1).EQ.BLANK) GO TO 540

C  CALL SUBROUTINE HEADNG TO WRITE THE HEADING

      IPAGE = 0

      CALL HEADNG(NPROB, AN2, IPAGE)

      WRITE(6,900)

C******************************CARD 2*************************************
C  READ MISCELLANEOUS INPUTS
C  NDP THE NUMBER OF DESIGNS PER SUMMARY PAGE(DEPENDENT ON SUBROUTINE
C        SUMARY)

      NDP = 8

      READ(5,790)  NMB,NM,CL,XLW, NL

C  NMB-THE NUMBER OF OUTPUT PAGES FOR THE SUMMARY TABLE(8 DESIGNS/PAGE).
C  NM-THE TOTAL NUMBER OF MATERIALS AVAILABLE,EXCLUDING SUBGRADE.
C      NM IS NOT REQUIRED IN THIS VERSION OF FPS.  THE ILAYER FIELD
C      MUST BE BLANK OR ZERO FOR THE SUBGRADE(THE LAST MATERIAL
C      PROPERTY CARD).
C  CL-THE LENGTH OF THE ANALYSIS PERIOD IN YEARS.
C  XLW-THE WIDTH OF EACH LANE(FEET).
C  NL-THE NUMBER OF LANES ON THE HIGHWAY, BOTH DIRECTIONS

      NLO = NL/2

C******************************CARD 3*************************************
C READ IN THE PERFORMANCE VARIABLES.

      READ(5,793) ALPHA,PSI,P1,P2,P2P,BONE,GAMMA

C  ALPHA-THE DISTRICT OR REGIONAL TEMPERATURE CONSTANT.
C  PSI-THE SERVICEABILITY INDEX OF THE INITIAL STRUCTURE.
C  P1-THE BEGINNING SERVICEABILITY INDEX OF THE PAVEMENT
C      AFTER AN OVERLAY.
C  P2-THE MINIMUM ALLOWED VALUE OF THE SERVICEABILITY INDEX
C      (POINT AT WHICH AN OVERLAY MUST BE APPLIED).
C  P2P-NON-TRAFFIC DETERIORATION PARAMETER-THE LOWER BOUND ON THE
C       SERVICEABILITY INDEX WHICH WOULD BE ACHIEVED IN INFINITE
C       TIME WITH NO TRAFFIC.
C  BONE-NON-TRAFFIC DETERIORATION PARAMETER-THE CONSTANT WHICH
C        DETERMINES THE EFFECT THAT SWELLING CLAY WILL HAVE UPON THE
C        SERVICEABILITY LOSS OF THE PAVEMENT DURING A FINITE
C        TIME INTERVAL.
C******************************CARD 4*************************************
C READ IN THE TRAFFIC VARIABLES.

      READ(5,795)  RO, R20, XN20, PROPCT, ITYPE

C  RO-THE ONE-DIRECTION AVERAGE DAILY TRAFFIC AT THE BEGINNING OF THE
C      ANALYSIS PERIOD.
C  R20 IS ADT AT END OF 20 YEAR PERIOD.

      RC = RO + CL * (R20-RO) *0.05
```

INPUT


```
C   RC-THE ONE-DIRECTION AVERAGE DAILY TRAFFIC AT THE END OF THE
C       ANALYSIS PERIOD.
C   XN20 IS THE 20 YEAR ACCUM. 18-KIP AXLE EQUIV.
C   XNC-THE ONE-DIRECTION ACCUMULATED NUMBER OF EQUIVALENT 18-KIP AXLES
C        DURING THE ANALYSIS PERIOD (CONVERTED TO MILLIONS)
C   THE TRAFFIC EQUATION CONVERTS XNC FOR CL YEARS FROM XN20.

      XNC = (XN20/(20.0*(R0+R20)) * (2.0*R0*CL+((R20-R0)/20.0)*CL**2))
     1              * 1.0E-06

C   PROPCT-  PERCENT OF ADT WHICH WILL PASS THROUGH THE OVERLAY ZONE
C         DURING EACH HOUR WHILE OVERLAYING TAKES PLACE(NORMALLY ABOUT
C         6 PERCENT FOR RURAL AREAS , 5.5 PERCENT FOR URBAN AREAS, AND
C         ABOUT 4.2 IF TRAFFIC IS EVENLY DISTRIBUTED DURING THE 24 HOURS).
C   ITYPE-IS A CODE FOR THE TYPE OF ROAD UNDER CONSIDERATION.
C           ITYPE=1 DESIGNATES A RURAL ROAD AND ITYPE=2 DESIGNATES AN
C           URBAN ROAD.
C   PROP IS THE PROPORTION EXPRESSED AS PERCENTAGE BY PROPCT.

      PROP = PROPCT * 0.01

C****************************CARD 5*************************************
C   READ IN THE VALUES OF THE RESTRICTION VARIABLES.

      READ(5,798)  XTTO,XTBO,TTSC,TBSC,CMAX, TMAXIN, OMININ, OMAXIN

      TCKMAX = TMAXIN / 36.0
      OVMIN = OMININ/36.0
      OVMAX = OMAXIN/36.0

C   XTTO-THE MINIMUM ALLOWED TIME TO THE FIRST OVERLAY.
C   XTBO-THE MINIMUM ALLOWED TIME BETWEEN OVERLAYS PERMITTED.
C   TTSC-THE MINIMUM TIME TO THE FIRST SEAL COAT AFTER INITIAL
C         OR UVERLAY CONSTRUCTION.
C   TBSC-THE MINIMUM TIME BETWEEN SEAL COATS.
C   CMAX-THE MAXIMUM COST PER SQUARE YARD THAT IS TO BE ALLOWED FOR
C         INITIAL CONSTRUCTION.
C   TCKMAX-THE MAXIMUM ALLOWABLE TOTAL THICKNESS OF INITIAL CONSTRUCTION.
C   OVMIN-THE MINIMUM THICKNESS OF AN INDIVIDUAL OVERLAY.
C   OVMAX-THE ACCUMULATED MAXIMUM THICKNESS OF ALL OVERLAYS.
C****************************CARD 6*************************************
C   READ IN OVERLAY PARAMETERS ASSOCIATED WITH OVERLAY
C   AND ROAD GEOMETRICS.

      READ(5,800)  ACPR,ACCD,XLSO,XLSN,XLSD,HPD,NLRO,NLRN

C   ACPR-ASPHALTIC CONCRETE PRODUCTION RATE(TONS PER HOUR)
C   ACCD-ASPHALTIC CONCRETE CONPACTED DENSITY(TONS/COMPACTED CY)
C   XLSO-THE DISTANCE,MEASURED ALONG THE C.L.,OVER WHICH TRAFFIC IS
C         SLOWED IN THE OVERLAY DIRECTION.
C   XLSN-THE DISTANCE,MEASURED ALONG THE C.L.,OVER WHICH TRAFFIC IS
C         SLOWED IN THE NON-OVERLAY DIRECTION.
C   XLSD-THE DISTANCE ,MEASURED ALONG THE DETOUR,AROUND THE OVERLAY ZONE.
C   HPD-THE NUMBER OF HOURS PER DAY THAT OVERLAY CONSTRUCTION TAKES PLACE
C   THE PRODUCT OF PROP*HPD SHOULD NOT BE GREATER THAN 1.  IF THE STRIP
C   IS UNDER CONSTRUCTION FOR 24 HOURS EACH DAY, PROP*HPD = 1.
C   NLRO-THE NUMBER OF OPEN LANES IN THE OVERLAY DIRECTION IN THE
C         RESTRICTED ZONE.
C   NLRN-THE NUMBER OF OPEN LANES IN THE NON-OVERLAY DIRECTION IN THE
C         RESTRICTED ZONE.

      IF( (PROP*HPD) .GT. 1.00)  WRITE(6,803)

C****************************CARD 7*************************************
C   READ IN OTHER OVERLAY PARAMETERS ASSOCIATED WITH TRAFFIC
C   SPEEDS AND DELAYS.

      READ(5,805) PPO2,PPN2,DO2, DN2, AAS,ASO,ASN,MODEL

      PO2 = PPO2 * 0.01
      PN2 = PPN2 * 0.01

C   PO2-PROPORTION  OF VEHICLES THAT WILL BE STOPPED IN THE OVERLAY
C         DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT.
C   PN2-PROPORTION  OF VEHICLES THAT WILL BE STOPPED IN THE
C         NON-OVERLAY DIRECTION BECAUSE OF PERSONNEL OR EQUIPMENT.
C   DO2-THE AVERAGE DELAY PER VEHICLE STOPPED IN THE OVERLAY DIRECTION
C         BECAUSE OF MOVEMENT OF OVERLAY PERSONNEL AND EQUIPMENT IN THE
C         RESTRICTED ZONE.
C   DN2-THE AVERAGE DELAY PER VEHICLE STOPPED IN THE NON-OVERLAY
C         DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT.
C   AAS-THE AVERAGE APPROACH SPEED TO THE OVERLAY AREA,ASSUMED TO BE
C         THE SAME FOR BOTH DIRECTIONS.
C   ASO-THE AVERAGE SPEED THROUGH THE OVERLAY AREA,IN THE OVERLAY
C         DIRECTION.
C   ASN-THE AVERAGE SPEED THROUGH THE OVERLAY AREA,IN THE
C         NON-OVERLAY DIRECTION.
C   MODEL-THE MODEL NUMBER WHICH DESCRIBES THE TRAFFIC SITUATION.
C****************************CARD 8*************************************
C   COST CONSIDERATIONS

      READ(5,807)  CM1,CM2,SC, PCTRAT

C   RATE CHANGED FROM THE PERCENTAGE RATE (PCTRAT).

      RATE = PCTRAT * 0.01
```

```
C  CM1-ANNUAL ROUTINE MAINTENANCE COST PER LANE MILE FOR THE FIRST YEAR
C       AFTER CONSTRUCTION OR AN OVERLAY.
C  CM2-ANNUAL INCREMENTAL INCREASE IN ROUTINE MAINTENANCE COST PER
C       LANE MILE.
C  SC -THE COST OF A SEAL COAT PER LANE MILE.
C  RATE-THE INTEREST RATE OR TIME VALUE OF MONEY.
C--COST PER LANE MILE IS CONVERTED TO COST PER SQ. YD.

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

C**********************************************************************
C*******MATERIAL PROPERTY CARDS (TWO OR MORF STARTING WITH CARD 9)******
C**********************************************************************
C  READ IN THE CONSTRUCTION MATERIALS AND THEIR PROPFRTIES.

      DO 20 J=1,NMPD

      READ(5,818) ILAYER(J),(DATA(J,K),K=2,10), DAT11, DAT12, DAT13

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

C  THE COLUMN DESCRIPTIONS ARE AS FOLLOWS--
C     THREE BLANK SPACES.
C     FIRST FIELD--1 COLUMN-LAYER ID (THE LAYER NUMBER IN WHICH
C                              THE MATERIAL MAY BE USED.)
C     **** NOTE ***** FIRST FIELD MUST BE BLANK OR ZERO FOR SUBGRADE****
C     THREE BLANK SPACES.
C     SECOND FIELD-1 COLUMN-CODE LETTER OF THE MATERIAL.
C     THREE BLANK SPACES.
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.
C     SIXTH FIELD--8 COLUMNS-THE MINIMUM LAYER THICKNESS ALLOWED.
C     SEVENTH FIELD-8COLUMNS-THF 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
C  PROPORTION.

      DATA(J,11) = DAT11 / 36.0
      DATA(J,12) = DAT12 / 36.0
      DATA(J,13) = DAT13 * 0.01

C  DATA(J,1) IS THE INCREMENT IN LAYER THICKNESS, MAY BE RECALCULATED
C       IN 'MAIN'.
C  ONE FOURTH INCH INCREMENTS IN ALL LAYERS ASSUMED RATHER THAN READING
C       THE INCREMENTS FROM INPUT CARDS.

      DATA(J,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.

      IF(P1 .NE. PSI) P1 = 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

      UPLEVL = 1.0 / 36.0

C--OVSTR IS THE STRENGTH COEFFICIENT OF THE OVERLAY MATERIAL.

      OVSTR = 0.956

C TMIN THE MINIMUM TIME IN YEARS BETWEEN A SEAL COAT AND AN OVERLAY

      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.

      IF( NLO .GT. 0 ) GO TO 29
```

```
      NLO=1
      IF(MODEL .LT.3) GO TO 29
      NLO = MAX0(2, NLRO+1)
   29 CONTINUE
C***********************************************************************
C  LIST THE INPUT DATA
C
      WRITE(6,901)
      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
   30 WRITE(6,902)  ILAYER(IJK),(DATA(IJK,LK),LK=2,10), D11, D12, D13
C--WRITE THE PROPERTIES OF THE SUBGRADE.
      WRITE(6,903) (DATA(NM+1,LK),LK=3, 8), DATA(NM+1,10)
C  LANES FOR OUTPUT AS TOTAL LANES, BOTH DIRECTIONS
      NL = NLO*2
      WRITE(6,919) NDP, NMB, NM, CL, XLW, NL
      WRITE(6,924) ALPHA,PSI,P1,P2,P2P,BONE,GAMMA
C     PROPORTION CHANGED TO PERCENT FOR PRINTING OUT
C  THIS VERSION PRINTS TRAFFIC VARIABLES IN 20 YEAR VALUES AS INPUT
      PROPCT = PROP * 100.0
      WRITE(6,927) R0, R20, XN20, PROPCT
      IF( ITYPE .EQ. 2 )  GO TO 37
      WRITE(6,938) ITYPE
      GO TO 39
   37 WRITE(6,939) ITYPE
   39 CONTINUE
      WRITE (6,930) XTTO,XTBO,TTSC,TBSC
      WRITE(6,931) CMAX,TPAXIN, OMININ, OMAXIN
C     CALL HEADNG(NPROB, AN2, IPAGE)
      WRITE(6,920) ACPR,ACCO,XLSO,XLSN
      WRITE(6,933)  XLSO,HPD
      WRITE(6,932)  NLRO,NLRN
      WRITE(6,943)  PPO2,PPN2, DO2, DN2
      WRITE(6,944) AAS,ASO,ASN,MODEL
```

```
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

  540 LAST = 1

  550 RETURN

C
  780 FORMAT(A4,6X,16A4)
  790 FORMAT(2I10,2F10.2, I10)
  793 FORMAT(5F10.2,2F10.4)
  795 FORMAT(3F10.0,F10.2,I10)
  798 FORMAT(4F10.1,4F10.2)
  800 FORMAT(6F10.2,2I10)
  803 FORMAT(1H0,5X,13H***WARNING***/10X,47HAS INPUT,THE PRODUCT OF HPD
     1AND PROP IS GREATER/10X,39HTHAN 100.0 PERCENT -- PROGRAM CONTINUES
     2)
  805 FORMAT(2F10.2,2F10.4,3F10.2,I10)
  807 FORMAT(4F10.2)
  818 FORMAT(3X,I1,3X,A1,3X,6A3,F6.2,5F8.2)
  900 FORMAT(11H0INPUT DATA /)
  901 FORMAT(  12X,50HTHE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE
     1     /10X,9HMATERIALS,12X,4HCOST,4X,4HSTR.,4X,4HMIN.,4X,4HMAX.,2X,
     2     8HSALVAGE /1X,5HLAYER,5H CODE,7X,4HNAME,8X,6HPER CY,2X,
     3     6HCOEFF.,2X,5HDEPTH,3X,5HDEPTH,4X,4HPCT.)
  902 FORMAT(3X,I1,4X,A1,2X,6A3,F6.2,5F8.2)
  903 FORMAT( 11X, 6A3, 6H -----, F8.2, 3(8H  ------) )
  919 FORMAT(/ 4X, 39HNUMBER OF SUMMARY OUTPUT PAGES DESIRED(, I2,
     *   14H DESIGNS/PAGE), 15X,
     1   I5/4X,50HTOTAL NUMBER OF INPUT MATERIALS,EXCLUDING SUBGRADE,20X,
     2   I5/4X,37HLENGTH OF THE ANALYSIS PERIOD (YEARS),33X,F5.1/4X,
     3   25HWIDTH OF EACH LANE (FEET),45X,F5.1,/, 4X,
     4    33HNUMBER OF LANES (BOTH DIRECTIONS), 37X, I5)
  920 FORMAT(20X, 22HINPUT DATA (CONTINUED)      /
     *    1H0, 3X,46HASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR),24X,
     1  F5.1/4X,48HASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.),22X,
     2  F5.2/ 4X,62HC.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.
     3D. (MILES), 8X,F5.2/ 4X,64HC.L. DISTANCE OVER WHICH TRAFFIC IS SLO
     4WED IN THE N.O.D. (MILES), 6X,F5.2)
  924 FORMAT( /4X,29HDISTRICT TEMPERATURE CONSTANT,41X,F5.1/ 4X,
     1   45HSERVICEABILITY INDEX OF THE INITIAL STRUCTURE,25X,F5.1/4X,
     2   40HSERVICEABILITY INDEX P1 AFTER AN OVERLAY,30X,F5.1/ 4X,
     3   31HMINIMUM SERVICEABILITY INDEX P2,39X,F5.1/ 4X,36HSWELLING CLAY
     4 PARAMETERS -- P2 PRIME,33X,F6.2/ 32X,2HB1,38X,F7.4,
     5  /32X,  5HGAMMA,35X,F7.2)
  927 FORMAT( /4X,64HONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (
     1VEHICLES/DAY), 3X,F8.0/ 4X,56HONE-DIRECTION ADT AT END OF TWENTY Y
     2EARS (VEHICLES/DAY)  ,  11X,F8.0/4X,17HONE-DIRECTION 20., 46H-YR AC
     3CUMULATED NO. OF EQUIVALENT 18-KIP AXLES, 2X,F10.0/4X,62HPROPORTIO
     4N OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT),8X,F5.1)
  930 FORMAT(/ 4X,37HMINIMUM TIME TO FIRST OVERLAY (YEARS),34X,F4.1/ 4X,
     1   37HMINIMUM TIME BETWEEN OVERLAYS (YEARS),33X,F5.1/ 4X,62HTIME TO
     2 FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS),8X,
     3   F5.1/ 4X,31HTIME BETWEEN SEAL COATS (YEARS),39X,F5.1)
  931 FORMAT(4X,59HMAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DO
     1LLARS),11X,F5.2/ 4X,58HMAXIMUM ALLOWED THICKNESS OF INITIAL CONSTR
     2UCTION (INCHES),12X,F5.1/4X,34HMINIMUM OVERLAY THICKNESS (INCHES),
     336X,F5.1/4X,50HACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES),
     420X,F5.1)
  932 FORMAT( 4X,47HNUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.,23X,
     1   I5/4X,49HNUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.,
     2   21X,I5)
  933 FORMAT(4X,47HDETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES),
     1    23X,F5.2/4X,37HOVERLAY CONSTRUCTION TIME (HOURS/DAY),33X,F5.1)
  938 FORMAT(44X,29HTHE ROAD IS IN A RURAL AREA.   ,I6)
  939 FORMAT(44X,29HTHE ROAD IS IN AN URBAN AREA. , I6)
  943 FORMAT( /4X,66HPROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN
     1 O.D. (PERCENT), 4X,F5.2/ 4X,68HPROPORTION OF VEHICLES STOPPED BY
     2ROAD EQUIPMENT IN N.O.D. (PERCENT),2X,F5.2/ 4X,54HAVERAGE TIME STO
     3PPED BY ROAD EQUIPMENT IN O.D. (HOURS),15X,F6.3/ 4X,56HAVERAGE TIM
     4E STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS),13X,F6.3)
  944 FORMAT(4X,48HAVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH),22X,
     1   F5.1/4X,48HAVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH),
     2   22X,F5.1/4X,50HAVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH
     3),20X,F5.1/4X,34HTRAFFIC MODEL USED IN THE ANALYSIS,38X,I3)
  948 FORMAT( /4X,58HFIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LAN
     1E MILE),10X,F7.2/ 4X,64HINCREMENTAL INCREASE IN MAINT. COST PER YE
     2AR (DOLLARS/LANE MILE), 4X,F7.2/ 4X,39HCOST OF A SEAL COAT (DOLLAR
     3S/LANE MILE),29X,F7.2/ 4X,46HINTEREST RATE OR TIME VALUE OF MONEY
     4(PERCENT),24X,F5.1)

      END
```

SYMBOL KEY

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

LAYIDX

```
      SUBROUTINE LAYIDX(NM, ILAYER, NMD, LAYER, INDEX, LAYD)

C--'LAYIDX' IS A LAYER INDEXING SUBROUTINE.  EACH CALL TO 'LAYIDX'
C--RETURNS A UNIQUE LAYER INDEXING ARRAY UNTIL ALL COMBINATIONS
C--ARE EXAUSTED AND 'LAYER' IS RETURNED AS ZERO.  THE FIRST CALL TO
C--LAYIDX MUST HAVE 'LAYER' EQUAL ZERO FOR INITIALIZATION.
C
C--GIVEN . . .
C     NM  THE NUMBER OF MATERIALS, MUST BE GREATER THAN ZERO, NOT
C          GREATER THAN NMD.
C
C     ILAYER   AN ARRAY WITH THE LAYERS WHICH EACH MATERIAL MAY
C              OCCUR.  ILAYER MUST BE SORTED IN ASCENDING ORDER WITH
C              AT LEAST ONE MATERIAL PER LAYER.
C     NMD  THE DIMENSION OF THE ILAYER ARRAY.
C     LAYER   MUST BE EQUAL ZERO THE FIRST CALL FOR A GIVEN SET OF
C             MATERIALS, OTHERWISE MUST BE RETURNED WITH THE VALUE FROM
C             THE LAST CALL TO LAYIDX.
C
C--RETURNED
C     LAYER   THE NUMBER OF LAYERS FOR THIS DESIGN TYPE, OR LAYER SET
C             EQUAL ZERO IF NO MORE DESIGN TYPES FOR THIS SET OF
C             MATERIALS.
C     INDEX   AN ARRAY, ONE PER LAYER, POINTING TO THE ILAYER ARRAY
C             AND THE 'DATA' ARRAY) FOR THE SELECTION OF MATERIALS
C             FOR THIS DESIGN TYPE.
C

      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

      NN(I) = 0

   30 NMBMAT(I) = 0

      DO 40 J = 1, NM

      LAY = ILAYER(J)

C--------OPTIONAL, CHECK OF SORTING AND MAXIMUM VALUES OF ILAYER

   40 NMBMAT(LAY) = NMBMAT(LAY)+ 1

      MAXLAY = LAY

   50 IF(LAYER .GE. MAXLAY) GO TO 55

      LAYER = LAYER + 1

      GO TO 60

   55 IF( NN(LAYER) .LT. NMBMAT(LAYER)) GO TO 60

      IF( LAYER .EQ. 1) GO TO 170

      NN(LAYER) = 0
      LAYER = LAYER -1

      GO TO 55
```

LAYIDX

PAGE 2

```
60    NN(LAYER) = NN(LAYER) +1

      DO 90 J = 1, MAXLAY

      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) + NMBMAT(I-1)

OK

90    CONTINUE

OK

100   RETURN

OK

170   LAYER = 0

      RETURN

      END
```

SYMBOL KEY

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

OUTPUT

```
      SUBROUTINE OUTPUT(BCOST,NMDGN,KNTOL,KOUNT,POLICY,NMBEST,ISKIP,
     1        ICUST, NUMBER,SCOST,XNDKP,ILAYER, CODE)

      COMMON A(7), AAS, ACCO, ACPR, ALPHA, AN2(16), ASN, ASO, B(7),
     1    BB(11), B-ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
     2    DN2, DO2, 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, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1    PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2    SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3    XLSO, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
      DIMENSION BTT(20),BDEXT(20),POLICY(50,24),XNDKP(6,24),ILAYER(11)
      DIMENSION BBTT(20),BBDEXT(20), CODE(6),BTSC(20),BBTSC(20)

C--DATA STATEMENT, 2ND DIMENSION OF POLICY AND XNDKP ARRAYS

      DATA NPD/50/, LAYD/6/

C  PAGE HEADING DESCRIBING THE MATERIALS UNDER CONSIDERATION.

      CALL HEADNG(NPROB, AN2, IPAGE)

      WRITE(6,959) NMDGN, LAYER, (CODE(L), L=1,LAYER)
      WRITE(6,960)

      DO 42 L=1,LAYER

      J = INDEX(L)

C  CONVERT DATA TO INCHES AND PERCENTAGE.

      DAT11 = DMIN(L) * 36.0
      DAT12 = DMAX(L) * 36.0
      DAT13 = PSVGE(L) * 100.0
      DAT1 = XINC(L) * 36.0

   42 WRITE(6, 902) L, (DATA(J,K), K=2,10), DAT11, DAT12, DAT13, DAT1

C--WRITE THE SUBGRADE PROPERTIES.

      WRITE(6,903)  (DATA(NM+1,K), K=3,8), DATA(NM+1,10)

C--WRITE OVERLAY PROPERTIES

      OMININ = OVMIN*36.0
      OMAXIN = OVMAX * 36.0
      OPCTSL = OVSALV * 100.0
      OINCIN = OVINC * 36.0

      WRITE(6,904) OVCOST, OVSTR, OMININ, OMAXIN, OPCTSL, OINCIN

C  OVERLAY POLICIES MUST NOW BE EXAMINED FOR EACH OF THE INITIAL
C  CONSTRUCTION DESIGNS. THIS IS DONE IN DO LOOP 69 BELOW
C

      KOUNT = 0

C  BEST COST INITIALIZED AT A VERY HIGH VALUE

      BCOST = 1.0E20

C***KOUNT IS A COUNTER THAT KEEPS TRACK OF THE NUMBER OF FEASIBLE
C    DESIGNS FOR THIS SET OF MATERIALS.

      IF( ICOST .EQ. 1 )  GO TO 93

      IF( ISKIP .EQ. 1 )  GO TO 95

      IF( NUMBER .EQ. 0 )  GO TO 85

      IMESS = 1

C--ISWIN & ISWOV SET ZERO, NO CONSTRAINT FAILURES YET.

      ISWIN = 0
      ISWOV=0
```

3 . 2 . 1

```
      DO 69 JL=1,NUMBER
      SS = Z(JL,1)
      XIC = Z(JL,2)
      BISS = SS
      DO 46 KK=1,LAYER
   46 DOVER(KK) = Z(JL,KK+2)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     CALL OVRLAY(IBT,SS,NOK,BPTUC,BPOCCT,BPRM,BPWSCC,                        C
C    1   AMINCT,BTT,BDEXT,NBSC,BTSC,BSAL, ISWIN, ISWOV)                        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IF( NOK .EQ. 1 )  GO TO 69
      IF( IMESS .EQ. 2 )  GO TO 50
      IMESS = 0
   50 IF( NOK .EQ. 0 )  GO TO 69
      KT(7) = KT(7) +1
      IMESS = 2
      KOUNT = KOUNT + 1
      KNTOL = KNTOL + 1
      AMINCT = AMINCT + XIC
      IF(KNTOL .NE. 1) GO TO 205
      NEW = 1
      GO TO 265
  205 INUM = MIN0(NMBEST, KNTOL-1)
C  NOW CHECK TO SEE IF THE TOTAL COST(AMINCT) OF THE CURRENT DESIGN
C  RANKS AMONG THE BEST NMBEST DESIGNS SO FAR.
  210 IF (AMINCT .LT. POLICY(8,INUM)) GO TO 215
      IF (INUM .EQ. NMBEST) GO TO 300
      NEW = INUM + 1
      GO TO 265
  215 DO 220 NEW = 1, INUM
      IF (AMINCT .LT. POLICY (8,NEW)) GO TO 225
  220 CONTINUE
C-- INSERT DESIGN IN COLUMN NEW OF POLICY.
  225 IF (NEW .EQ. NMBEST) GO TO 265
C--ALL MORE COSTLY DESIGNS SHIFTED DOWN ONE.
      II = MIN0(NMBEST-1, INUM)
      JCONST = II+NEW
```

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, LAYO
  235 XNDKP(I  ,JJ+1) = XNDKP(I  ,JJ)
  260 CONTINUE
C--NOW INSERT THE CURRENT DESIGN IN COLUMN NEW OF THE ARRAY POLICY.
  265 POLICY (1,NEW) = NMOGN
      POLICY (2,NEW) = XIC
      POLICY (3,NEW) = BPOCCT
      POLICY (4,NEW) = BPTUC
      POLICY (5,NEW) = BPWSCC
      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
      XNDKP(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 290I=1,KK
  290 POLICY (I+40,NEW) = BTSC(I)
```

```
  300 CONTINUE
      IF (AMINCT .GE. BCOST ) GO TO 69
C--BCOST IS THE TOTAL COST OF THE BEST DESIGN SO FAR FOR THE SET OF
C--MATERIALS UNDER CONSIDERATION. IF AMINCT IS LESS THAN BCOST THIS BEST
C--IS REPLACED BY THE CURRENT DESIGN UNDER CONSIDERATION.
      JBEST = JL
      BCOST = AMINCT
      BICC = XIC
      BBISS = BISS
      BBPOCC = BPOCCT
      BBPTUC = BPTUC
      BBPSCC = BPWSCC
      BBPRM = BPRM
      BBSAL = BSAL
      NBBSC = NBSC
C--SET THE OVERLAY TIME CONSTRAINT FLAG, FOR THE CURRENT BEST DESIGN.
      ISWINB = ISWIN
      ISWOVB = ISWOV
C--RESET CONSTRAINT FLAG IN CASE A BETTER DESIGN NOT FLAGGED.
      ISWIN=0
      ISWOV=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,NBBSC
   61 BBTSC(KN) = BTSC(KN)
C--IBBT WILL BE THE OPTIMAL NUMBER OF PERFORMANCE PERIODS.
   62 IBBT = IBT
      DO 63 KN=1,IBBT
      IF(  KN  .GT.1) BBDEXT(KN) = BDEXT(KN)
   63 BBTT(KN) = BTT(KN)
   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.
      WRITE(6,967) NMDGN
      DO 71 K=1,LAYER
      I = INDEX(K)
C--THE LAYER THICKNESS IS CONVERTED TO INCHES FOR PRINTING.
      BALLK = 36.0 * Z(JBEST,K+2)
   71 WRITE(6,968) (DATA(I,J),J=3,8),BALLK
```

```
      WRITE(6,970)  BBISS
      WRITE(6,969) BBTT(1)
      IF( IBBT .EQ. 1 )  GO TO 140
      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, BBTT(IM)
  140 IF( NBBSC .EQ. 0 )  GO TO 73
      WRITE(6,981) BBTT(IBBT),(I,BBTSC(I),I=1,NBBSC)
      GO TO 74
   73 WRITE(6,982) BBTT(IBBT)
   74 WRITE(6,983) BICC,BBPRM,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.
C     CALL HEADNG(NPROB, AN2, IPAGE)
      WRITE(6,1000) (CODE(L), L=1, LAYER)
      WRITE(6,1001)
      STK = 0
      J = 0
      DO 308 K=1,LAYER
      STK = STK + Z(JBEST,K+2)
C--A MINIMUM CONSTRINT IF (WITHIN ROUNDING ERROR) EQUAL LAYER MINIMUM.
      IF( ABS( Z(JBEST,K+2) - DMIN(K)  ) .GT. 0.001) GO TO 305
      J = J + 1
      WRITE(6,1002)  J,K
C--IF ADDITION OF ANOTHER INCREMENT WOULD EXCEED MAX., CONSTRAINED.
  305 IF( Z(JBEST,K+2) + XINC(K) .LT. DMAX(K) ) GO TO 308
      J = J + 1
      WRITE(6,1005)  J,K
```

```
308 CONTINUE
      IF( (STK+XINC(I)-0.001) .LT. TCKMAX )  GO TO 311
      J = J + 1
      WRITE(6,1008)  J
311 IF( ABS(BICC-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( ISWINB .EQ. 0 ) GO TO 317
      J = J + 1
      WRITE(6,1014)  J
C--CHECK FOR OVERLAY TIME CONSTRAINT IF AN OVERLAY DESIGN.
317 IF(IBBT.EQ.1) GO TO 323
      IF( ISWOVB .EQ. 0 ) GO TO 323
      J = J + 1
      WRITE(6,1017)  J
323 IF( IBBT .EQ. 1 )  GO TO 330
      SOVER = 0.0
      DO 326 I=2,IBBT
326 SOVER = SOVER + BBOEXT(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
```

OUTPUT

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W    85 WRITE(6,996)
.       GO TO 99
OK
W    92 WRITE(6,998)
.       GO TO 99
OK
W    93 WRITE(6,820)
.       GO TO 99
OK
W    95 WRITE(6,999)
OK
W    99 WRITE(6,985)   KOUNT
W       WRITE(6,1099) KT(1), KT(8), (KT(J), J=2,7)
T       RETURN

  820 FORMAT(61HOFOR THE DESIGN TYPES CONSIDERED,   THE FUNDS AVAILABLE
     1TO BE/58H SPENT PER SQ. YD. ARE NOT ENOUGH TO COVER THE DESIGN WIT
     2H/39H ALL MATERIALS AT THEIR MINIMUM DEPTHS.)
  902 FORMAT(3X,I1,4X,A1,2X,6A3,F6.2,5F8.2)
  903 FORMAT( 11X, 6A3, 6H -----, F8.2, 4(8H  ------) )
  904 FORMAT(/11X, 8HOVERLAYS, 10X, F6.2, 5F8.2)
  959 FORMAT(12H DESIGN TYPE, I3,    5H WITH, I2,  9H LAYERS,
     1    10HMATERIALS , 6A1)
  960 FORMAT(                               /10X,9HMATERIALS, 12X, 4HCOST,
     1    4X, 4HSTR., 4X, 4HMIN., 4X, 4HMAX., 2X,16HSALVAGE  INCRE-  /
     2    1X, 5HLAYER, 5H CODE, 7X, 4HNAME, 8X, 6HPER CY, 2X,
     3    6HCOEFF., 2X,5HDEPTH,3X,5HDEPTH,4X,12HPCT.    MENT    )
  967 FORMAT( 12HODESIGN TYPE, I3,
     1                   3X,58HTHE OPTIMAL DESIGN FOR THE MATERIALS UNDER CO
     2NSIDERATION--/ 8X,45HFOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
     3  / )
  968 FORMAT( 15X,6A3,F8.2, 7H INCHES)
  969 FORMAT(/8X,35HTHE LIFE OF THE INITIAL STRUCTURE =, F6.2,6H YEARS)
  970 FORMAT(/8X,35HTHE SCI OF THE INITIAL STRUCTURE  =,F7.3)
  972 FORMAT(/8X,23HTHE OVERLAY SCHEDULE IS)
  975 FORMAT(15X,F5.2,21H  INCH(ES) (INCLUDING ,F4.1, 21H INCH LEVEL-UP)
     * AFTER, F6.2, 7H YEARS. )
  981 FORMAT( 15X,12HTOTAL LIFE =,5X,F6.2, 6H YEARS// 8X,29HSEAL COATS S
     1HOULD OCCUR AFTER /(14X,2H (,I1,1H),F7.2,6H YEARS) )
  982 FORMAT(15X,12HTOTAL LIFE =,5X,F6.2,6H YEARS//
     1    8X, 24HNO SEAL COATS SCHEDULED.  )
  983 FORMAT( /8X,56HTHE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATION
     1S ARE/ 15X,25HINITIAL CONSTRUCTION COST, 9X,F6.3/15X, 30HTOTAL ROU
     2TINE MAINTENANCE COST, 4X,F6.3/15X, 31HTOTAL OVERLAY CONSTRUCTION
     3COST, 3X,F6.3/15X,22HTOTAL USER COST DURING/25X, 20HOVERLAY CONSTR
     4UCTION, 3X,F7.3/15X,20HTOTAL SEAL COAT COST,14X,F6.3/15X,13HSALVAG
     5E VALUE,20X,F7.3/48X,7H-------/9X,18HTOTAL=OVERALL COST,21X,F7.3)
  985 FORMAT(51HONO. INITIAL DESIGNS EXAMINED FOR OVERLAY POLICY =  , I4)
  996 FORMAT(//4X, 67HTHE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO O
     1BTAIN A STRUCTURE/ 4X,65HTHAT WILL MEET THE MINIMUM TIME TO THE FI
     2RST OVERLAY RESTRICTION.)
  998 FORMAT(//4X, 52HTHE MINIMUM TIME BETWEEN OVERLAYS IS TOO LONG AND/
     1OR/ 4X,52HTHE MAXIMUM ALLOWABLE TOTAL OVERLAY THICKNESS IS TOO/
     2   4X,52HSMALL TO OBTAIN A FEASIBLE OVERLAY POLICY FOR ANY OF/ 4X,
     3   20HTHE INITIAL DESIGNS.)
  999 FORMAT(//4X, 52HEACH OF THE MATERIALS AT THEIR MINIMUM DEPTH RESUL
     1TS/ 4X,49HIN A TOTAL DEPTH THAT IS GREATER THAN THE MAXIMUM/ 4X,
     2   24HALLOWED TOTAL THICKNESS.)
 1000 FORMAT( 42HOFPS PROGRAM ACTIVITY REPORT, DESIGN TYPE  , 6A1)
 1001 FORMAT(1HO,  39HAT THE OPTIMAL SOLUTION, THE FOLLOWING   ,34HBOUND
     2ARY RESTRICTIONS ARE ACTIVE--)
 1002 FORMAT( 20X,I2,28H. THE MINIMUM DEPTH OF LAYER,I3)
 1005 FORMAT( 20X,I2,28H. THE MAXIMUM DEPTH OF LAYER,I3)
 1008 FORMAT( 20X,I2,47H. THE MAXIMUM THICKNESS OF INITIAL CONSTRUCTION)
 1011 FORMAT( 20X,I2,54H. THE MAXIMUM FUNDS AVAILABLE FOR INITIAL CONSTR
     1UCTION)
 1014 FORMAT( 20X,I2,39H. THE MINIMUM TIME TO THE FIRST OVERLAY)
 1017 FORMAT(20X,I2,35H. THE MINIMUM TIME BETWEEN OVERLAYS)
 1020 FORMAT( 20X,I2,50H. THE MAXIMUM ALLOWED CUMULATIVE OVERLAY THICKNE
     1SS)
 1023 FORMAT( /20X,4HNONE)
 1099 FORMAT(1HO, 50HCOUNT OF DESIGN OPTIONS CALCULATED FOR THIS TYPE
     1   / 1HO, I10, 45H  INITIAL DESIGNS
     *   / 1H , I10, 45H  INITIAL DESIGNS CONSIDERED
     2   / 1H , I10, 45H  WHICH WERE FEASIBLE TO FIRST OVERLAY
     3   / 1HO, I10, 45H  OVERLAYS
     4   / 1H , I10, 45H  WHICH WERE FEASIBLE
     5   / 1HO, I10, 45H  OVERLAY POLICIES
     6   / 1H , I10, 45H  WHICH WERE FEASIBLE
     7   / 1HO, I10, 45H  FEASIBLE COMPLETE DESIGNS
        END
```

OVRLAY

SYMBOL KEY

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

```
      SUBROUTINE OVRLAY(IBT,SS,NOK,BPTUC,BPOCCT,BPRM,
     1  BPWSCC,AMINCT,BTT,BDEXT,NBSC,BTSC,BSAL, ISWIN, ISWOV)

      COMMON A(7), AAS, ACCD, ACPR, ALPHA, AN2(16), ASN, ASO, B(7),
     1  B8(11), B ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
     2  DN2, DO2, 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, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1  PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2  SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3  XLSD, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
      DIMENSION DADD(20),TN(20),XBI(20),DEXT(20),USERCT(20),RM(20),
     1  OCCT(20),BTT(20),BDEXT(20),TSC(20),BTSC(20)
C--NPERFD IS MAXIMUM PERFORMANCE PERIODS, DIM. OF TT AND ABOVE ARRAYS.
      DATA NPERFD/20/
C
      TPRIM = 0.0
      XNPRIM = 0.0
C  THE MINIMUM COST IS INITIALIZED AT A VERY HIGH VALUE(100,000,000)
      AMINCT = 1.0E 08
      NOK = 0
      USERCT(1) = 0.0
      OCCT(1) = 0.
C  DETERMINE THE SALVAGE VALUE OF THIS DESIGN WITHOUT OVERLAYS.
      SALV = 0.0
      DO 1 J = 1, LAYER
    1 SALV = SALV - DOVER(J) * COST(J) * PSVGE(J)
C  DETERMINE THE COST OF LEVEL-UP OF AN OVERLAY
      CTLVUP = UPLEVL * OVCOST
      DADD(1) = 0.0
      BI = BONE
      I = 1
C DETERMINE HOW MANY YEARS THE INITIAL DESIGN WILL LAST AND THE
C ACCUMULATED NUMBER OF EQUIVALENT 18-KIP AXLES.
      P = PSI
      CALL TIME(I,T,SS,XN,TPRIM,XNPRIM,ISW,BI,BIP,P)
C IF ISW EQUAL 1, THEN T(1) IS LESS THAN THE MINIMUM TIME TO OVERLAY.
      IF( ISW .EQ. 0 )  GO TO 5
      ISWIN=1
      NOK = 1
      GO TO 60
C DETERMINE THE COST OF ROUTINE MAINTENANCE DURING THE FIRST
C PERFORMANCE PERIOD.
    5 CALL PWRM(RMAINT,RATE,T,TPRIM,C1,C2,CL)
      KT(2) = KT(2) +1
      KT(5) = KT(5) +1
      RM(I) = RMAINT
      TT(I) = T
      TN(I) = XN
      XBI(I) = BIP
C ABDD IS THE ACCUMULATED DEPTH OF ALL PREVIOUS OVERLAYS.
      ABDD = 0.0
```

```
      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 = DOVER(1)
      TPRIM = T
      XNPRIM = XN
      BI = BIP
      I = 2

                                   OK

    8 DELD = OVMIN

C THE DEPTH OF LAYER 1 IS = ORIGINAL D(1) + SUM OF PREVIOUS OVERLAYS +
C   CURRENT OVERLAY DEPTH.

                                   OK

   10 DOVER(1) = DSAV + ABDD + DELD
      KT(3) = KT(3) +1

      IF( (ABDD + DELD) .GT. OVMAX )  GO TO 34

C DETERMINE THE NEW SCI AFTER THE OVERLAY OF DELD THICKNESS.

      CALL CALC(SS)

C DETERMINE HOW LONG THIS OVERLAYED PAVEMENT WILL LAST.

      P = P1

      CALL TIME(I,T,SS,XN,TPRIM,XNPRIM,ISW,BI,BIP,P)

      IF( ISW .EQ. 0 )  GO TO 15

C--INCREASE OVERLAY THICKNESS TO PREVENT FAILURE, SET FAILURE SWITCH

      ISWOV = 1 + ISWOV
      DELD = DELD + OVINC

      GO TO 10

C--FEASIBLF OVERLAY, SAVE THICKNESS FOR LATER

                                   OK

   15 DEXT(I) = DELD
      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).

      CALL  USER (ADT,T,TPRIM,PWTSY,ITIME,DELD)

      USERCT(I) = PWTSY

C DETERMINE THE PRESENT WORTH OF OVERLAY CONSTRUCTION COST INCLUDING
C   THE COST OF LEVEL-UP DURING THE I'TH PERFORMANCE PERIOD.

      OCCT(I) = (DEXT(I)* OVCOST +CTLVUP) /       (1.+RATE)**ITIME

C DETERMINE THE PRESENT WORTH OF ROUTINE MAINTENANCE DURING THE
C   I TH PERF. PERIOD.

      CALL PWRM(RMAINT,RATE,T,TPRIM,C1,C2,CL)

      RM(I) = RMAINT
      DADD(I) = DELD
      TT(I) = T
      TN(I) = XN
      XBI(I) = BIP

C  INCREMENT THE OVERLAY THICKNESS, THEN TEST FOR COMPLETION.

      ABDD = ABDD + DELD
```

5 . 4 . 3 . 2 . 1

```
C THE PREVIOUS OVERLAY WAS NOT SUFFICIENT TO LAST THROUGH THE ANALYSIS
C PERIOD IF T IS LESS THAN CL.

      IF( T .GE. CL )  GO TO 23

C--IF EXCESSIVE NUMBER OF OVERLAYS OR THICKNESS EXCESSIVE, SELECT
C--ANOTHER POLICY.

      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 8

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

                                    OK

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   23 CALL SEAL(TTSC,TBSC,TT,SCC,I,CL,RATE,PWSCC,NSC,TSC, TMIN)      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

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

      KT(6) = KT(6) +1
      SALVGE = (SALV-ABDD*OVCOST*OVSALV) / (RATE+1.0)**CL
      POCCT = 0.
      PRM = 0.0
      PTUC = 0.0

      DO 27 J=1,I

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

   27 PTUC = PTUC + USERCT(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+SALVGE

      IF( AMINCT .LE. TC )  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,NBSC

   28 BTSC(J) = TSC(J)

C  I=IBT = NUMBER OF PERFORMANCE PERIODS.
                                    OK

   29 IBT = I

      DO 30 JK=1,I
```

```
   30 BTT(JK) = TT(JK)

      IF( I .EQ. 1 ) GO TO 34

      DO 31 JK=2,I

   31 BDEXT(JK) = DEXT(JK)

C SELECT A DIFFERENT OVERLAY POLICY(ANOTHER BRANCH OF THE TREE) AND
C GO BACK TO STATEMENT 10 TO DETERMINE THE OVERLAY COSTS.

   34 IF( I .LE. 2 ) GO TO 60

      KT(5) = KT(5) +1
      I = I - 1
      DELD = DADD(I) + OVINC
      IM = I - 1
      ABDD = 0.0

      DO 35 K=1,IM

   35 ABDD = ABDD + DADD(K)

      TPRIM = TT(IM)
      XNPRIM = TN(IM)
      BI = XBI(IM)

      GO TO 10

   60 RETURN

      END
```

PWRM

SYMBOL KEY

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

```
      SUBROUTINE PWRM(RMAINT,RATE,T,TPRIM,C1,C2,CL)

C THIS SUBROUTINE DETERMINES THE PRESENT WORTH PER SQ. YD. OF ROUTINE
C MAINTENANCE(WHICH INCREASES LINEARLY) WHICH IS PERFORMED DURING THE
C I TH OVERLAY PERIOD.

      IT = T + 0.5
      IF( T .GT. CL )  IT = CL
      ITIME = TPRIM + 0.5
      N = IT - ITIME
      RMAINT = 0.

      IF( N .EQ. 0 )  GO TO 20

      IF( RATE .GT. 0. )  GO TO 15

      DO 10 J=1,N

   10 RMAINT = RMAINT + C1 + (J-1)*C2

      GO TO 20

   15 AN = N
      RP1 = 1.0 + RATE
      CONCT = C1*(RP1**N-1.)/(RATE*RP1**(N-1) )
      AINCT = C2*(RP1**N-RATE*AN-1.)/(RATE**2*RP1**(N-1) )
      RMAINT =(CONCT + AINCT)/(1. + RATE)**ITIME

   20 RETURN

      END
```

SEAL

SYMBOL KEY

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

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

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--NSC 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(1)
      IF( YEARS .GT. CL )  YEARS = CL

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

    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

   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.

   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
```

```
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 = TT(K)

      RETURN

      END
```

SYMBOL KEY

```
EEEEE = ENTRY
TTTTT = TERMINAL
CCCCC = CALL
RRRRR = READ
WWWWW = WRITE
```

SOLVE2

```
      SUBROUTINE SOLVE2(ISKIP,ICOST,NUMBER,SCOST)

      COMMON A(7), AAS, ACCO, 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, NLO, NLRN, NLRO, NM
      COMMON NMA, NPROB, OVCOST, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1   PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2   SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3   XLSD, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
      DIMENSION  IIX(6),XIINC(6)

C--NUMBRD 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/ 1.0001/

      DO 2 J=1,LAYER

      XIINC(J) = XINC(J)

    2 IIX(J) = 0

      TK = 0.
      CT = 0.
      SCOST = 0.
      ISKIP = 0
      ICOST = 0
      NUMBER = 0
      LZ = LAYER +2

      DO 5 J=1,LAYER

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

    5 DOVER(J) = DMIN(J)

      IF( TK .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
   15 CALL CALC(SS)

      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 (SS 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
                                                    4 . 3 . 2 . 1
```

SOLVE2


```
      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, LZ
         Z(J,L) = Z(J+1,L)
 157  CONTINUE
         IN = IN -1
                                    OK
 158  IN = IN + 1
                                    OK
 159  NUMNOW = NUMNOW +1
      IF( NUMNOW .GT. NUMBRD) GO TO 35
C--INSERT THE DESIGN AT 'IN'.
      IF( IN .GE. NUMNOW) GO TO 16
      NUM = NUMNOW-1
      JCONST = NUM + IN
      DO 160 J = IN, NUM
      JJ = JCONST - J
      DO 160 L = 1, LZ
  160 Z(JJ+1,L) = Z(JJ,L )
```

```
16   DO 161 L = 1, LAYER
161  Z(IN,L+2) = DOVER(L)
     Z(IN,1) = SS
     Z(IN,2) = CT
170  KT(I) = KT(I) +1
     NUMBER = NUMNOW
     XNCOST = CT + COST(I)*XINC(I)
     IF( XNCOST .GT. CMAX + FUZZ) GO TO 20
     IF( XNCOST .GT.SCOST )  SCOST = XNCOST
     IF( (TK+XINC(I)) .GT.TCKMAX + FUZZ) GO TO 20
     IF( (DOVER(I)+XINC(I) )+ FUZZ .GT. DMAX(I)) GO TO 19
18   DOVER(I) = DOVER(I) + XINC(I)
     TK = TK + XINC(I)
     CT = CT + COST(I)*XINC(I)
     GO TO 15
19   IF( IIX(I) .EQ. 1 )  GO TO 20
     IF( DMAX(I) .EQ. DMIN(I) )  GO TO 20
     XINC(I) = DMAX(I) - DOVER(I)
     IIX(I) = 1
     GO TO 18
20   IF( I .EQ. LAYER )  GO TO 30
     DO 120 J=1,I
     IIX(J) = 0
120  XINC(J) = XIINC(J)
     DOVER(I) = DMIN(I)
     I = I + 1
     TK = 0.
     CT = 0.
     DO 25 K=1,LAYER
     CT = CT + COST(K) * DOVER(K)
25   TK = TK + DOVER(K)
     XNCOST = CT + COST(I)*XINC(I)
```

SOLVE2

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```
      IF( XNCOST .GT. CMAX * FUZZ) GO TO 20
      IF( XNCOST .GT. SCOST )  SCOST = XNCOST
      IF( (TK+XINC(I)) .GT. TCKMAX * FUZZ) GO TO 20
      IF( (DOVER(I)+XINC(I) )*FUZZ .GT. DMAX(I)  ) GO TO 22
   21 DOVER(I) = DOVER(I) + XINC(I)
      TK = TK + XINC(I)
      CT = CT + COST(I)*XINC(I)
      GO TO 10
   22 IF( IIX(I) .EQ. 1 )  GO TO 20
      IF( DMAX(I) .EQ. DMIN(I) )  GO TO 20
      XINC(I) = DMAX(I) - DOVER(I)
      IIX(I) = 1
      GO TO 21
   30 DO 31 L = 1, LAYER
   31 XINC(L) = XIINC(L)
      GO TO 36
   35 WRITE(6,900) NUMBRD
      NUMBER = NUMBRD
   36   KT(8) = NUMBER
      RETURN
  900 FORMAT(1H1,19HTHERE ARE MORE THAN,I5,52H FEASIBLE INITIAL DESIGNS
     1FOR THIS SET OF MATERIALS. )
      END
```

SUMARY

SYMBOL KEY

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

```
      SUBROUTINE SUMARY(NDP, NMB, NPROB, AN2, IPAGE, UPLEVL,
     *            KNTOL, XNDKP, POLICY, NPOS, NPOSS, NK, IPOSS, OCOST)

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)/4H(7X,/,  F850(2)/4H2HD(/,  F850(3)/4H,I1,/,
     1     F850(4)/4H1H),/,  F850(5)/4H12X,/,  F850(22)/3H1X) /
      DATA F854(1)/4H(7X,/,  F854(2)/4H2HT(/,  F854(3)/4H,I1,/,
     1     F854(4)/4H1H),/,  F854(5)/4H11X,/,  F854(22)/3H1X)  /
      DATA F858(1)/4H(7X,/,  F858(2)/4H2HO(/,  F858(3)/4H,I1,/,
     1     F858(4)/4H1H),/, F858(5)/4H11X,/, F858(22)/3H1X) /
      DATA F864(1)/4H(6X,/,  F864(2)/4H3HSC/,  F864(3)/4H(,I1/,
     1     F864(4)/4H,2H)/, F864(5)/4H ,12/, F864(6)/2HX,/,
     2     F864(22)/3H  ) /
      DATA  ABLK/2HA6/,  F4/4HF6.1/,  COM/4H,1X,/, F6/4HF6.2/,
     1      COM1/4H,1X,/
      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(II) .LT. OCOST(JJ) )  GO TO 190

      STORE = OCOST(II)
      OCOST(II) = OCOST(JJ)
      OCOST(JJ) = STORE
      IS = IPOSS(II)
      IPOSS(II) = IPOSS(JJ)
      IPOSS(JJ) = IS

  190 CONTINUE

  200 CONTINUE

      CALL HEADNG(NPROB, AN2, IPAGE)

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

      IF( NPOS .EQ. 0 )  GO TO 220

      WRITE(6,827)  (NPOSS(I),I=1,NPOS)

      GO TO 230

  220 WRITE(6,829)

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

```
  230 NMBEST = MINO(NMB*NDP, KNTOL)
      DO 520 L = 1,NMBEST, NDP
      LL = MINO( 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-L)*7 + 31 ) / 4
C     CALL HEADNG(NPROB, AN2, IPAGE)
      WRITE (6,830) (I, I = L,LL)
      DO 240 I = L,LL
  240 IDUMMY(I) = POLICY(9,I)
      DO 270 I=1,5
      NKOUNT = 0
      DO 260 K = L,LL
      IF( IDUMMY(K) .GE. I ) GO TO 250
      POLICY(I+9,K) = 0.0
      XNDKP(I,K) = BLANK
      GO TO 260
  250 NKOUNT = NKOUNT + 1
  260 CONTINUE
      IF( NKOUNT .EQ. 0 ) GO TO 280
      NLINE = I
  270 CONTINUE
  280 WRITE (6,831) (STAR, I = 1, NMBT)
      IF( NLINE .GE. 4 ) GO TO 310
      NLP = NLINE + 2
      DO 300 I=NLP,5
      DO 290 K=L,LL
  290 XNDKP(I,K) = BLANK
  300 CONTINUE
                                        2 .
```

```
  310 WRITE(6,832) ((XNDKP(I,II),I=1,5) ,II=L,LL)
      WRITE (6,834)  (POLICY(2,I), I=L,LL)
      WRITE (6,836)  (POLICY(3,I), I = L,LL)
      WRITE (6,838)  (POLICY(4,I),  I = L,LL)
      WRITE (6,840)  (POLICY(5,I), I = L, LL)
      WRITE (6,842)  (POLICY(6,I), I = L,LL)
      WRITE (6,844) (POLICY(7,I), I = L,LL)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      WRITE (6,846)  (POLICY(8,I), I = L, LL)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      WRITE (6,848)  (IDUMMY(I), I = L,LL)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      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 TC 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+4) = ABLK
      F850(2*M+5) = COM
  330 CONTINUE
      WRITE(6,F850)I,(POLICY(I+9,J),J=L,LL)
  340 CONTINUF
      DO 350 I = L,LL
  350 IDUMMY(I) = POLICY(20,I)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      WRITE (6,852)  (IDUMMY(I),  I=L,LL)
      WRITE (6,831)  (STAR, I = 1, NMBT)
      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

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```
      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)
      WRITE(6,856)
      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
```

```
      WRITE (6,F858) I, (POLICY(I+30,J), J= L,LL)
  440 CONTINUE
  450 DO 460 I = L,LL
  460 IDUMMY(I) = POLICY(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
  480 NKOUNT = NKOUNT + 1
  490 CONTINUE
      IF( NKOUNT .EQ. 0 ) GO TO 510
      WRITE (6,F864) I, (POLICY(I+40,J), J=L,LL)
  500 CONTINUE
  510 CONTINUE
      WRITE (6,831)  (STAR, I = 1, NMBT)
  520 CONTINUE
      WRITE(6,866) KNTOL
      GO TO 540
```

```
                                   OK---------------------------------------------------------------------I---O
                                   I
.....................................................................
.  530 CONTINUE                                                     .
.....................................................................
                                   I
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       CALL HEADNG(NPROB, AN2, IPAGE)                             C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
                                   I
WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
W       WRITE(6,870)                                               W
WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
                                   I
                                   OK---------------------------------------------------------------------O
                                   I
TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
T  540 RETURN                                                      T
TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT

C
C--FORMAT STATEMENTS

  825 FORMAT(49H0PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE
     1 /6X,47H                  IN ORDER OF INCREASING TOTAL COST//11X,
     2    13HDESIGN TYPE   ,4X,10HTOTAL COST)
  826 FORMAT(16X,I2,11X,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  /(25X,I5) )
  829 FORMAT(//5X, 60HALL MATERIAL COMBINATIONS HAVE AT LEAST ONE FEASIB
     1LE DESIGN.)
  830 FORMAT(19X, 46HPROBLEM SUMMARY OF THE BETTER FEASIBLE DESIGNS/26X,
     1   33HIN ORDER OF INCREASING TOTAL COST// 20X,8I7)
  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,19HOVERLAY CONST. COST,2X,8F7.3)
  838 FORMAT( 2X, 9HUSER COST,12X,8F7.3)
  840 FORMAT( 2X,14HSEAL COAT COST,7X,8F7.3)
  842 FORMAT( 2X,19HROUTINE MAINT. COST,2X,8F7.3)
  844 FORMAT( 2X,13HSALVAGE VALUE,8X,8F7.3)
  846 FORMAT( 2X,10HTOTAL CUST,11X,8F7.3)
  848 FORMAT( 2X,16HNUMBER OF LAYERS,2X,8I7)
  849 FORMAT( 2X,20HLAYER DEPTH (INCHES) )
  852 FORMAT( 2X,18HNO.OF PERF.PERIODS,8I7)
  853 FORMAT( 2X,18HPERF. TIME (YEARS) )
  856 FORMAT( 2X,20HOVERLAY POLICY(INCH)/2X, 20H(INCLUDING LEVEL-UP) )
  860 FORMAT( 2X,20HNUMBER OF SEAL COATS,2X,I3,7(4X,I3) )
  862 FORMAT( 2X,18HSEAL COAT SCHEDULE/5X, 7H(YEARS) )
  866 FORMAT(//10X,51HTHE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WA
     1S, I10////)
  870 FORMAT(////10X,60HTHERE WERE NO FEASIBLE DESIGNS FOR THE CONDITION
     1S SPECIFIED.////)

.....................................................................
.       END                                                         .
.....................................................................
```

SYMBOL KEY

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

TIME

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

      COMMON A(7), AAS, ACCO, ACPR, ALPHA, AN2(16), ASN, ASO, B(7),
     1    BB(11), B ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
     2    DN2, DO2, 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, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1    PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2    SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3    XLSD, 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 FSTIMATE 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
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          LOSS OF SERVICEABILITY.
C SS    SURFACE CURVATURE INDEX.
C XN    NUMBER(IN MILLIONS) OF EQUIV. AXLES IN ONE DIRECTION DURI NG TIME
C          T.
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/ACCR))
C         WHERE ALOG2 IS LOGRITHM, BASE TWO.

      ISW = I
      PI  = P
      TI  = TPRIM

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

      TRDELT = (RC-RO) / CL
      TRFTRM = XNC / (CL*(RO+RC))
      RO2 = RO + RO

C--TERMS OR PARTIAL TERMS FROM THE PERFORMANCE EQUATION

      SQRT5P = SQRT(5.-PI)
      SWLTRM = SQRT(5.-P2P) - SQRT5P
      PFRTRM = 53.6 * (SS**2)  /  ALPHA

C--ESTIMATE OF T MADE USING MINIMUM CONSTRAINT TIMES.

      EST T = TI + DELT

C--SOLVE FOR T, UNLESS A CONSTRAINT FAILURE.

      DO 40 ITER=1,MITER

C--TRAFFIC EQUATION

      XN = TRFTRM * (RO2 + TRDELT*EST T)*EST T

C--PERFORMANCE EQUATION (NEXT THREE STATEMENTS)

      TRLOSS = PFRTRM * (XN-XNPRIM)
         SWLOSS=SWLTRM *(  1.0-EXP(-BI*(EST T - TI))  )
         EST P = 5.0- (SQRT5P+TRLOSS+SWLOSS)**2  - GAMMA *(EST T - TI)
         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
           EST T = EST T - DELT
           ISW = 0
   40 CONTINUE
C       CONVERGENCE GUARANTEED IN LESS THAN 20 ITERATION WITH 100 YR
C       T VALUE, EXPECT 3 TO 10 ITERATIONS.
        EST T = TLIM
C
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.
      BIP = BI*EXP(-BI*(EST T-TI))
      RETURN
      END
```

USER

SYMBOL KEY

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

```
      SUBROUTINE USER  (ADT,T,TPRIM,PWTSY,ITIME,DELO)

      COMMON A(7), AAS, ACCC, ACPR, ALPHA, AN2(16), ASN, ASO, B(7),
     1    BB(11), B ONE, CINT, CL, CMAX, C1, C2, COST(6), DATA(11,13),
     2    DN2, DO2, 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, OVINC, OVMAX, OVMIN, OVSALV, OVSTR,
     1    PO2, PN2, PROP, PSI, PSVGE(6), P1, P2, P2P, RATE, RC, RO,
     2    SC, SCC, TBSC, TCKMAX, TMIN, TT(20), TTSC, UPLEVL, XINC(6),
     3    XLSO, XLSN, XLSO, XNC, XTBO, XTTO, Z(750,8)
      DIMENSION CCSR(6,7), CCSU(6,7), CURS(6,2), COD(1,2)
      DIMENSION RUTFOV(6), RUTFRV(6), URTFOV(6), URTFRV(6)

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, 49.907, 83.454, 134.793,
     *   0.0, 0.0, 14.306, 35.812, 67.935, 116.527,
     *   0.0, 0.0, 0.0, 19.902, 50.326, 95.768,
     *   0.0, 0.0, 0.0, 0.0, 28.491, 71.070,
     *   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, 47.046, 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  RUTFOV-RURAL TRAFFIC IN OVERLAY ZONE(NO. OF LANES OPEN SUBSCRIPT)

      DATA RUTFOV/1350., 2700., 4350., 6000., 7650., 9300./

C  RUTFRV-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.

      LO =(ASO/10.0) + 0.5
      LN =(ASN/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=MAXO( 1, MINO(6,LO) )
      LN=MAXO( 1, MINO(6,LO) )
      K =MAXO( 1, MINO(6,K ) )
      TIPH = ADT * PROP

C--FROM COMMON THE FOLLOWING TRAFFIC VARIABLES ARE USED.
C  PO2 IS THE PROPORTION IN THE OVERLAY DIRECTION OF THE AVER DAILY TRAF
C  PN2 IS THE PROPORTION IN THE NON-OVERLAY DIRECTION WHICH WILL BE STOP
C  DO2 IS THE TIME STOPPED IN HOURS OF VEHICLES IN OVERLAY DIRECTION.
C  DN2 IS THE TIME STOPPED IN HOURS OF VEHICLES IN NON-OVERLAY DIRECTION
C  NLO IS THE NUMBER OF LANES IN THE OVERLAY DIRECTION.
C  NLRO IS THE NUMBER OF LANES, RESTRICTED ZONE, OVERLAY DIRECTION.
C--MODEL 1

      PO1 = 0.
      PN1 = 0.
      DO1 = 0.
      DN1 = 0.
      D = 1. / 12.

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

2 . 1

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

   10 MLRO = MAXO( 1, MINO(6,NLRO) )
      MLO  = MAXO( 1, MINO(6,NLO-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    URBAN (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 = XLSO* TIPH / ASO
      PO1 = 0.5*(1. - EXP(-AQ) )**2
      PN1 = PO1
      DO1 = (1. + EXP(2.*AQ) )*(EXP(AQ) - AQ - 1. ) /
     1  (2.*TIPH*PO1*(EXP(2.*AQ) - EXP(AQ) + 1. ) )
      DN1 = DO1

      GO TO 60

C--MODEL 3

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

      PO1 = HPD*(TIPH - OUTRAT)/(2.*TIPH*D)
      IF( PO1 .GT. 1. )  PO1 = 1.
      DO1 = 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*D)
      IF( PU1 .GT. 1. )  PO1 = 1.
      DO1 = HPD*(TIPH - OUTRAT) * (RECOVY - OUTRAT) /
     1   (2.*TIPH*PO1*(RECOVY - TIPH) )

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

      IF( TIPH .LE. OUTRAT )  GO TO 60

      PN1 = HPD*(TIPH - OUTRAT)/(2.*TIPH*D)
      IF( PN1 .GT. 1. )  PN1 = 1.
      DN1 = HPD*(TIPH - OUTRAT) * (RECOVY - OUTRAT) /
     1   (2.*TIPH*PN1*(RECOVY - TIPH) )
```

```
      GO TO 60
C--MODEL 5
   50 IF( TIPH .LE. OUTRAT )  GO TO 60
      PO1 = HPD*(TIPH - OUTRAT)/(2.*TIPH*D)
      IF( PO1 .GT. 1. )  PO1 = 1.
      DO1 = HPD*(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.
   60 GO TO (65,68),ITYPE
C--COST OF STOPPING FROM APPROACH SPEED IN A RURAL AREA.
   65 CO1 = CCSR(K,1)/1000.
      CN1 = CO1
C COST OF SLOWING TO THRU SPEED IN A RURAL AREA.
      CO4 = CCSR(K,LO+1)/1000.
      CN4 = CCSR(K,LN+1)/1000.
      GO TO 70
C--COST OF STOPPING FROM APPROACH SPEED IN AN URBAN AREA.
   68 CO1 = CCSU(K,1) / 1000.
      CN1 = CO1
C CCST OF SLOWING TO THRU SPEED IN AN URBAN AREA.
      CO4 = CCSU(K,LO+1)/1000.
      CN4 = CCSU(K,LN+1)/1000.
C CCST OF DELAY DUE TO CONGESTION OUTSIDE THE RESTRICTED AREA.
   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)*XLSD-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 CO5 = CCSR(LO,1)/1000. + DO2*COD(1,ITYPE)/1000.
      CN5 = CCSR(LN,1)/1000. + DN2*COD(1,ITYPE)/1000.
      GO TO 100
   90 CO5 = CCSU(LO,1)/1000. + DO2*COD(1,ITYPE)/1000.
      CN5 = CCSU(LN,1)/1000. + DN2*COD(1,ITYPE)/1000.
  100 TUCH=TIPH*( PO1*(CO1+CO2+CO3) + (1.-PO1)*(CO3+CO4) + PO2*CO5 ) +
     1      TIPH*( PN1*(CN1+CN2+CN3) + (1.-PN1)*(CN3+CN4) + PN2*CN5 )
      TUCSY = HPSY * TUCH
      ITIME = TPRIM + 0.5
```

USER


```
C DETERMINE THE PRESENT WORTH OF THE USER COSTS.

      PWTSY = TUCSY/(1. + RATE ) ** ITIME

      RETURN

      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	MATERIALS CODE	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

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PROB T-1 *TEST DATA SIMILAR TO 123-1 REPORT ON FPS-3                        * P

DESIGN TYPE  1 WITH 1 LAYERS, MATERIALS A

        MATERIALS               COST    STR.    MIN.    MAX.   SALVAGE  INCRE-
LAYER CODE       NAME          PER CY  COEFF.  DEPTH   DEPTH    PCT.    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
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FPS PROGRAM ACTIVITY REPORT, DESIGN TYPE A

.T 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
```

PROB T-1 *TEST DATA SIMILAR TO 123-1 REPORT ON FPS-3 * P

DESIGN TYPE 2 WITH 2 LAYERS, MATERIALS AL

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
		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

PROB T-1 *TEST DATA SIMILAR TO 123-1 REPORT ON FPS-3 * P

DESIGN TYPE 3 WITH 3 LAYERS, MATERIALS ALG

LAYER	MATERIALS CODE	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

r 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

ESIGN 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		
UMBER 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

LAYER	MATERIALS CODE	NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE 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

	MATERIALS		COST	STR.	MIN.	MAX.	SALVAGE	INCRE-
LAYER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.	MENT
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

'ESIGN TYPE 2 WITH 2 LAYERS, MATERIALS AB

MATERIALS			COST	STR.	MIN.	MAX.	SALVAGE	INCRE-
AYER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.	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
```

I SIGN TYPE 3 WITH 3 LAYERS, MATERIALS ABX

MATERIALS L YER	CODE	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
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

ESIGN TYPE 4 WITH 2 LAYERS, MATERIALS AX

	MATERIALS		COST	STR.	MIN.	MAX.	SALVAGE	INCRE-
AYER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.	MENT
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

T 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

LAYER	MATERIALS CODE	NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE 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)	1
TOTAL NUMBER OF INPUT MATERIALS,EXCLUDING SUBGRADE	3
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)	4.00
MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)	25.0
MINIMUM OVERLAY THICKNESS (INCHES)	1.0
ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES)	5.0

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

) ;IGN TYPE 1 WITH 1 LAYERS, MATERIALS A

MATERIALS			COST	STR.	MIN.	MAX.	SALVAGE	INCRE-
. 'ER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.	MENT
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

)ESIGN 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

PROB T-3 *HEAVIER TRAFFIC, FRONTAGE ROAD WITH LIGHT. * P

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

ESIGN 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	MATERIALS CODE	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

PROB T-3 *HEAVIER TRAFFIC, FRONTAGE ROAD WITH LIGHT. * P

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	MATERIALS CODE	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

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. * P

INPUT DATA (CONTINUED)

ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	75.
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	2.0
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.D. (MILES)	1.0
C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE N.O.D. (MILES)	0.0
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	1.1
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	8.
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.	2
NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.	1
PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN O.D. (PERCENT)	10.0
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.
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)	1500.0
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.	INCRE- MENT
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	MATERIALS CODE	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
		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	MATERIALS CODE	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	20.00	20.00	80.00	2.00
		SUBGRADE	-----	0.24	------	------	------	------
		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

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. * P

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	MATERIALS CODE	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
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PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.                      * P

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.	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
		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

```
PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.                    * 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
                        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	MATERIALS CODE	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	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

DESIGN TYPE 7 WITH 3 LAYERS, MATERIALS ASG

LAYER	MATERIALS CODE	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	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

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	MATERIALS CODE	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
		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

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. * P

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	MATERIALS CODE	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

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. * 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
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
```

)ESIGN TYPE 10 WITH 3 LAYERS, MATERIALS ASG

	MATERIALS		COST	STR.	MIN.	MAX.	SALVAGE	INCRE-
.AYER	CODE	NAME	PER CY	COEFF.	DEPTH	DEPTH	PCT.	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

:OUNT 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

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PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS.                   * P 1(

DESIGN TYPE 11 WITH 3 LAYERS, MATERIALS ASG

         MATERIALS               COST     STR.     MIN.     MAX.   SALVAGE  INCRE-
LAYER CODE       NAME           PER CY   COEFF.   DEPTH    DEPTH    PCT.    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
```

PROB T-4 *SAMF AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. * P

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. * P

DESIGN TYPE 12 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	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
```

PROB T-4 *SAME AS PREVIOUS BUT EXPLICIT MATERIAL THICKNESS. * P 2

DESIGN TYPE 13 WITH 3 LAYERS, MATERIALS ASG

LAYER	MATERIALS CODE	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	MATERIALS CODE	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	6.00	6.00	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

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