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FPS-11

FLEXIBLE PAVEMENT SYSTEM
COMPUTER PROGRAM DOCUMENTATION

RESEARCH REPORT 123-15

PROJECT 1-8-69-123

COOPERATIVE HIGHWAY RESEARCH PROGRAM
WITH U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

TEXAS HIGHWAY DEPARTMENT

CENTER FOR HIGHWAY RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

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16. Abstract

This report gives the documentation of the computer program FPS-11 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) Input data formats,
(2) Cross Reference tables,
(3) A variable name dictionary,
(4) Documentation of mathematical formulas

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

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FPS - 11
FLEXIBLE PAVEMENT SYSTEM COMPUTER PROGRAM DOCUMENTATION

by

Hugo E. Orellana

Research Report Number 123-15

A System Analysis of Pavement Design
and Research Implementation

Research Project 1-8-69-123

conducted

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

by the

Highway Design Division
Texas Highway Department

Texas Transportation Institute
Texas A&M University

Center for Highway Research
The University of Texas at Austin

October 1972

PREFACE

This is the fifteenth report issued under Research Study 1-8-69-123, "A Systems Analysis of Pavement Design and Research Implementation." The study is being conducted by the 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.

The author wishes to acknowledge the work done by Dr. R. L. Lytton in developing the "Swelling Clay Model", and Messrs. Mike Darter, B. Frank McCullough, and James L. Brown for their work on "Reliability Concepts Applied to the Texas Flexible Pavement System - FPS," implemented in this computer program and documented in this report.

LIST OF REPORTS

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

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. 123-7, "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 Coniderations in the Flexible Pavement Design System," by David C. Steitle and B. Frank McCullough, describes skid resistance consideration in the Flexible Pavement System based on the testing of aggregates in the laboratory to predict field performance and presents a nomograph for the field engineer to use to eliminate aggregates which would not provide adequate skid resistance performance.

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

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

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

Report No. 123-13, "Benefit Analysis for Pavement Design Systems," by William F. McFarland, describes a method for relatiing motorists benefits to the serviceability index.

Report 123-14, "Prediction of Low-Temperature and Thermal-Fatigue Cracking in Flexible Pavements," by Mohamed Y. Shahin and B. Frank McCullough, describes the temperature cracking in asphalt concrete surfaces.

Report 123-15, "Flexible Pavement System Computer Program Documentation," by Hugo E. Orellana, provides documentation for version 11 of program FPS.

ABSTRACT

This report gives the documentation of the computer program FPS-11 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. Input data formats,
2. Cross Reference tables,
3. A variable name dictionary,
4. Documentation of mathematical formulas,

Key Words

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

SUMMARY

As part of a System Analysis of Pavement Design and Research, a computer program FPS, for Flexible Pavement System, was developed and tested. This study updates and documents the latest version of the computer program FPS-11. The same tools and procedures used by Mr. Dale L. Schafer, in documenting version 9 of FPS have been used in this documentation.

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.

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

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FLEXIBLE PAVEMENT DESIGN SYSTEM
COMPUTER PROGRAM DOCUMENTATION

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

INTRODUCTION

THE FPS-11 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 THE USERS OF THE FPS COMPUTER PROGRAM.

A NUMBERING CONVENTION FOR THE SUFFIX, SUCH AS THE '11' IN FPS-11, 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 (REF. 3). AT THE TIME OF THE PUBLICATION OF REPORT 123-1 'A SYSTEMS APPROACH APPLIED TO PAVEMENT DESIGN AND RESEARCH,' 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.

FPS-11 IS A MAJOR UPDATING OF FPS-9 WHEREBY SIGNIFICANT IMPROVEMENTS DEVELOPED BY RESEARCH HAVE BEEN INCORPORATED. THE MAJOR CHANGES IN FPS-11 AS COMPARED TO FPS-9 ARE--

1. ADDITION OF STOCHASTIC CALCULATIONS
2. NEW SWELLING CLAY MODEL
3. ADDITION OF AN ACP OVERLAY DESIGN MODE
4. NEW OVERLAY MODEL IN THE FLEXIBLE PAVEMENT DESIGN MODE

THESE CHANGES ARE DOCUMENTED AND EXPLAINED IN DETAIL IN APPENDIX 1 OF THIS REPORT. IN ADDITION TO THESE MAJOR CHANGES SOME MINOR PROGRAMMING REVISIONS HAVE BEEN MADE AND WILL BE PRESENTED IN THE SPECIAL FEATURES SECTION OF VERSION 11 OF FPS.

THE INTENDED AUDIENCE OF THIS REPORT IS THE SYSTEM ANALYST OR PROGRAMMER WHO IS EXPECTED TO MAKE FUTURE CHANGES AND UPDATES OF THE FPS SERIES OF PROGRAMS, SEE FPS-9 DOCUMENTATION, (REF. 1).

SPECIAL FEATURES OF VERSION 11 OF FPS

THE FOLLOWING FEATURES OR CHANGES OF FPS-11, AS COMPARED WITH FPS-9 SHOULD BE NOTED - -

1. THE SWELLING CLAY MODEL USED IN VERSION 9 OF FPS HAS BEEN CHANGED. FOR DETAILS SEE APPENDIX 1.

2. SUBROUTINE TIME HAS BEEN CHANGED TO DECREASE RUNNING TIME OF THE PROGRAM BY IMPROVING THE ITERATION PROCEDURE USING THE NEWTON-RAPHSON CONVERGENCE SCHEME.

3. FPS-11THD AND OVERLAY 2 (A PROGRAM DEVELOPED IN RESEARCH PROJECT 101, 'AN ASPHALTIC CONCRETE OVERLAY DESIGN SUBSYSTEM,' REF. 2) WERE COMBINED. THIS RESULTED IN ONE PROGRAM WITH THE TWO MODES AS FOLLOWS--

   (A) FLEXIBLE PAVEMENT DESIGN MODE -- FOR DESIGNING A NEW FLEXIBLE PAVEMENT STRUCTURE OR COMPLETELY REBUILDING AN EXISTING FLEXIBLE PAVEMENT STRUCTURE.

   (B) ACP OVERLAY DESIGN MODE -- FOR THE SPECIAL CASE WHERE AN ACP OVERLAY WILL BE THE ONLY INITIAL CONSTRUCTION.

4. NON-ALTERNATE FEASIBLE DESIGNS HAVE BEEN DELETED IN BOTH THE FLEXIBLE PAVEMENT DESIGN MODE AND ACP OVERLAY DESIGN MODE, THIS HAS BEEN ACOMPLISHED THROUGH THE USE OF SUBROUTINE CHECK2 AND CHECK RESPECTIVELY.

5. CONFIDENCE LEVELS A, B, C, D, E, AND F HAVE BEEN INCORPORATED.

6. OVERLAY INCREMENTS OF 1/2 INCH FOR CONFIDENCE LEVELS A, B, OR C, AND 1 INCH FOR CONFIDENCE LEVELS D, E, AND F ARE USED WHEN THE ACP OVERLAY DESIGN MODE IS SPECIFIED.

7. LAYER INCREMENTS OF 1/4 INCH OF SURFACING ARE USED FOR CONFIDENCE LEVELS A, B, OR C, 1/2 INCH FOR CONFIDENCE LEVELS D AND E, AND 1 INCH FOR CONFIDENCE LEVEL F, WHEN THE FLEXIBLE PAVEMENT DESIGN MODE IS SPECIFIED.

8. SEAL COATS HAVE BEEN REMOVED FROM CONSIDERATION BY DELETING SUBROUTINE 'SEAL.'

9. SUBROUTINE 'LAYIDX' IS NOT USED IN THIS VERSION OF FPS. LAYER INDEXING IS HANDLED IN MAIN.

10. THE SERVICEABILITY INDEX OF THE INITIAL DESIGN NEED NOT BE THE SAME AS THE SERVICEABILITY INDEX AFTER AN OVERLAY IN THIS VERSION.

SPECIAL FEATURES OF VERSION 11 OF FPS (CONTINUED)

11. SEVERAL CHANGES WERE MADE IN THE OUTPUT INCLUDING --

    A. THE PRESENTATION OF THE LIST OF INPUT DATA HAS BEEN REARRANGED.

    B. A WARNING MESSAGE TO THE USER TO REVISE THE INPUTS WHEN THE NUMBER OF FEASIBLE DESIGNS EXCEEDS 1000 IS INCLUDED.

    C. SCI OF THE INITIAL STRUCTURE, SEAL COAT COSTS, AND SEAL COAT SCHEDULE HAVE BEEN DELETED ON ALL OUTPUT PAGES.

    D. PROBLEM SUMMARY OF OPTIMUMS FOR EACH DESIGN TYPE IN ORDER OF INCREASING TOTAL COST HAS BEEN DELETED

    E. SERVICEABILITY LOSS DUE TO SWELLING CLAY LOSS FOR EACH PERFORMANCE PERIOD IS PRINTED ON ALL OUTPUT PAGES FOR EACH COMBINATION OF MATERIALS IN THE SUMMARY TABLES.

DEFINITION OF TERMS

A BRIEF DEFINITION OF THE FOLLOWING TERMS IS GIVEN BELOW TO AID IN UNDERSTANDING THIS DOCUMENTATION AND THE OUTPUT OF FPS-11.

1. PROBLEM

A PROBLEM IS DEFINED BY ONE SET OF DATA AS INPUT FOR THE FPS-11 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 STRATEGY ON OUTPUT OR A STATEMENT THAT NO DESIGN (STRATEGY) WAS POSSIBLE FOR THAT DESIGN TYPE.

3. DESIGN STRATEGY

A DESIGN STRATEGY IS ANY FEASIBLE INITIAL DESIGN CONBINED WITH REQUIRED FUTURE OVERLAYS AND MAINTENANCE.

4. INITIAL DESIGN

WITHIN EACH DESIGN TYPE, EACH COMBINATION OF DIFFERENT LAYER THICKNESSES POSSIBLE WITH THE GIVEN LIMITS OF THICKNESSES AND INCREMENTS MAKES AN INITIAL DESIGN. IF THE INITIAL DESIGN ALSO MEETS CONSTRAINTS OF COST AND TOTAL INITIAL DESIGN THICKNESS, IT IS A FEASIBLE INITIAL DESIGN.

5. 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 DESIGN STRATEGIES IT IS OF A HIGHER COST.

6. BEST OVERLAY POLICY

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

7. NON-ALTERNATE FEASIBLE DESIGN STRATEGY

A DESIGN STRATEGY THAT HAS ONE OR MORE LAYERS OR OVERLAYS BUILT THICKER WITH NO DECREASE IN THICKNESS OF ANY OTHER LAYERS OR OVERLAYS IS DEFINED AS A NON-ALTERNATE STRATEGY.

8. UNITS OF MEASURE

INPUT AND OUTPUT OF DATA ARE IN UNITS CONVENIENT TO THE USER, BUT AS AN AID TO MODULARIZATION, IN COMMON OR AS SUBROUTINE ARGUMENTS, THE FOLLOWING UNITS ARE CONSISTANT THROUGHOUT THE PROGRAM--

PAVEMENT OR PAVEMENT MATERIALS

YARDS, SQUARE YARDS, OR CUBIC YARDS AS APPLICABLE.

DISTANCE RELATED TO USER COSTS

MILES.

DEFINITION OF TERMS (CONTINUED)

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 (BOTH DIRECTIONS) AT A GIVEN POINT IN TIME.

TRUCK AXLE LOADS

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

INPUT DATA FOR FPS-11

INPUT DATA FOR FPS-11 IS ONE OR MORE SETS OF CARDS, ONE SET FOR EACH PROBLEM.

IN FPS-11 EACH CARD IS NUMBERED IN SEQUENCE FROM 1 THROUGH 10, THIS NUMBER IS THE CARD TYPE IDENTIFIER. A PROBLEM IS DESCRIBED BY A SET OF CARDS CONSISTING OF ONE CARD TYPE EACH WITH THE EXCEPTION OF CARD TYPE 2 WHICH COULD BE CODED UP TO SEVEN TIMES AND CARD TYPE 10 WHICH COULD HAVE A MAXIMUM OF TEN, ONE FOR EACH MATERIAL CONSIDERED IN THE PROBLEM.

THE FPS-11 USER HAS THE OPTION OF RUNNING AN ACP OVERLAY OR A NEW CONSTRUCTION PROBLEM. FOR THE ACP OVERLAY CARD(S) TYPE 10 ARE DELETED, FOR NEW CONSTRUCTION CARD TYPE 9 IS DELETED.

THIS VERSION OF FPS MAKES USE OF THE LIBRARY SUBROUTINE 'CORE' WHICH ALLOWS THE USE OF FORTRAN FORMATTED I/O STATEMENTS (READ AND WRITE) IN CONJUNCTION WITH CORE BUFFERS. IN FPS-11, 'CORE' IS USED TO READ UNDER FORMAT CONTROL FROM AN AREA IN CORE WHICH CONVERTS CHARACTER CODES (A4 FORMAT) OF A 'CARD IMAGE.' 'CORE' CAN THUS BE USED TO CONVERT A TO F OR I FORMAT, OR VICE VERSA.

FOLLOWING THE CALL 'CORE' STATEMENT IS A STANDARD FORTRAN READ STATEMENT WHICH SPECIFIES THE FORMAT TO BE USED AND THE VARIABLES TO RECEIVE.

THE FIRST TWO COLUMNS ON ALL INPUT CARDS HAVE THE CARD TYPE CODE NUMBER. COLUMNS 3-80 OF EACH CARD ARE TO BE FILLED BY THE USER. THE VARIABLE NAMES AND FORMAT INFORMATION FOR EACH INPUT CARD IS GIVEN BELOW.

**************** CARD TYPE 1 - PROJECT IDENTIFICATION *****************

FORMAT(A3,A2,3A4,A2,A4,A2,2A4,A2,3A4)

PROBN-THE PROBLEM NUMBER.
COLUMNS 3-5

DIST-THE DISTRICT NUMBER.
COLUMNS 6-7

COUNTY-THE COUNTY NAME.
COLUMNS 8-21

CONT-THE CONTROL NUMBER.
COLUMNS 22-25

SECT-THE SECTION NUMBER.
COLUMNS 26-27

HWY-THE HIGHWAY NUMBER.
COLUMNS 28-37

DATE-THE DATE THE PROBLEM WAS CODED.
COLUMNS 38-45

INPUT DATA FOR FPS-11 (CONTINUED)

PIE-THE IPE NUMBER FOR THE PROJECT.
COLUMNS 46-49

***************** CARD(S) TYPE 2 - PROJECT COMMENTS ********************
FORMAT(19A4,A2)

COMENT-THE PROJECT COMMENTS.
COLUMNS 3-80

* NOTE - THIS INPUT CARD IS SELF EXPLANATORY. THE USER CAN CODE UP TO SEVEN CARDS TO WRITE THE MOST RELEVANT INFORMATION CONCERNING THE PROJECT.

***************** CARD TYPE 3 - BASIC DESIGN CRITERIA *****************
FORMAT(4F5.2,A1,F5.2)

CL-THE LENGTH OF THE ANALYSIS PERIOD (YEARS).
COLUMNS 3-7

XTTO-THE MINIMUM ALLOWED TIME TO THE FIRST OVERLAY (YEARS).
COLUMNS 8-12

XTBO-THE MINIMUM ALLOWED TIME PERMITTED BETWEEN OVERLAYS (YEARS).
COLUMNS 13-17

P2-THE MINIMUM ALLOWED VALUE OF THE SERVICEABILITY INDEX (POINT AT WHICH AN OVERLAY MUST BE APPLIED).
COLUMNS 18-22

PLEVEL-THE ALPHABETIC CHARACTER TO DETERMINE CLEVEL WHICH IS THE 'PERCENTILE VALUE OF THE NORMAL DISTRIBUTION.'
COLUMN 23

PCTRAT-THE INTEREST RATE OR TIME VALUE OF MONEY, IN PERCENT.
COLUMNS 24-28

************ CARD TYPE 4 - PROGRAM CONTROLS AND CONSTRAINTS ************
FORMAT(2I2,3F5.2)

IPTYPE-THE CODE NUMBER TO DETERMINE THE TYPE OF PROBLEM TO BE RUN --
IPTYPE=1, FLEXIBLE PAVEMENT DESIGN MODE.
IPTYPE=2, ACP OVERLAY DESIGN MODE.
COLUMNS 3-4

NMB-THE NUMBER OF OUTPUT PAGES FOR THE SUMMARY TABLE(8 DESIGNS/PAGE).
COLUMNS 5-6

INPUT DATA FOR FPS-11 (CONTINUED)

CMAX-THE MAXIMUM COST PER SQUARE YARD THAT IS TO BE ALLOWED FOR INITIAL CONSTRUCTION.
COLUMNS 7-11

TMAXIN-THE MAXIMUM ALLOWABLE TOTAL THICKNESS OF INITIAL CONSTRUCTION (INCHES).
COLUMNS 12-16

OMAXIN-THE MAXIMUM ALLOWABLE TOTAL THICKNESS OF ALL OVERLAYS (INCHES).
COLUMNS 17-21

********************** CARD TYPE 5 - TRAFFIC DATA **********************

FORMAT(3F10.2,5F5.2)

RB-THE AVERAGE DAILY TRAFFIC AT THE BEGINNING OF THE ANALYSIS PERIOD.
COLUMNS 3-12

RE-THE AVERAGE DAILY TRAFFIC AT THE END OF THE ANALYSIS PERIOD.
COLUMNS 13-22

XN20-THE 20 YEAR ACCUMULATED 18-KSA EQUIVALENCES.
COLUMNS 23-32

AAS-THE AVERAGE APPROACH SPEED TO THE OVERLAY AREA. ASSUMED TO BE THE SAME FOR BOTH DIRECTIONS.
COLUMNS 33-37

ASO-THE AVERAGE SPEED THROUGH THE OVERLAY AREA, IN THE OVERLAY DIRECTION.
COLUMNS 38-42

ASN-THE AVERAGE SPEED THROUGH THE OVERLAY AREA, IN THE NON-OVERLAY DIRECTION.
COLUMNS 43-47

PROPCT-PERCENT OF ADT WHICH WILL PASS THROUGH THE OVERLAY ZONE DURING EACH HOUR WHILE OVERLAYING TAKES PLACE (NORMALLY ABOUT 6% FOR RURAL AREAS, 5.5% FOR URBAN AREAS, AND ABOUT 4.2% IF TRAFFIC IS EVENLY DISTRIBUTED DURING THE 24 HOURS).
COLUMNS 48-52

PTRUCK-THE PERCENT OF TRUCKS IN THE AVERAGE DAILY TRAFFIC.
COLUMNS 53-57

INPUT DATA FOR FPS-11 (CONTINUED)

**************** CARD TYPE 6 - ENVIRONMENT AND SUBGRADE ****************

FORMAT(5F5.2)

ALPHA-THE DISTRICT OR REGIONAL TEMPERATURE CONSTANT.
COLUMNS 3-7

PROBSW-THE PROBABILITY OF SWELLING IN A PARTICULAR AREA.
COLUMNS 8-12

PVR-THE POTENTIAL VERTICAL RISE DUE TO SWELLING CLAY (INPUT IN INCHES SWELLING CLAY CONSTANT).
COLUMNS 13-17

SWRATE-THE RATE OF SWELLING IN A PARTICULAR AREA (SWELLING CLAY CONSTANT).
COLUMNS 18-22

SCOS-THE STIFFNESS COEFFICIENT OF THE SUBGRADE.
COLUMNS 23-27

*********** CARD TYPE 7 - CONSTRUCTION AND MAINTENANCE DATA ************

FORMAT(7F5.2,2F6.2)

PSI-THE SERVICEABILITY INDEX OF THE INITIAL STRUCTURE.
COLUMNS 3-7

P1-THE BEGINNING SERVICEABILITY INDEX OF THE PAVEMENT AFTER AN OVERLAY.
COLUMNS 6-12

OMININ-THE MINIMUM OVERLAY THICKNESS (INCHES).
COLUMNS 13-17

HPD-THE NUMBER OF HOURS PER DAY THAT OVERLAY CONSTRUCTION TAKES PLACE. THE PRODUCT OF PROPCT TIMES HPD SHOULD NOT BE GREATER THAN 100.0 PERCENT. HOWEVER, IF THE STRIP IS UNDER CONSTRUCTION TWENTY FOUR HOURS A DAY, THE PRODUCT WILL EQUAL 100.0 PERCENT.
COLUMNS 18-22

ACCD-THE ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/COMPACTED C.Y.).
COLUMNS 23-27

ACPR-THE ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR).
COLUMNS 28-32

XLW-THE WIDTH OF EACH LANE (FEET).
COLUMNS 33-37

CM1-ANNUAL ROUTINE MAINTENANCE COST PER LANE MILE FOR THE FIRST YEAR AFTER CONSTRUCTION OR AN OVERLAY.
COLUMNS 38-43

INPUT DATA FOR FPS-11 (CONTINUED)

CM2-ANNUAL INCREMENTAL INCREASE IN ROUTINE MAINTENANCE COST PER LANE MILE.
COLUMNS 44-49

*************** CARD TYPE 8 - DETOUR DESIGN FOR OVERLAYS ***************

FORMAT(4I2,3F5.2,4F5.3)

MODEL-THE MODEL NUMBER WHICH DESCRIBES THE TRAFFIC SITUATION.
COLUMNS 3-4

NLANES-THE TOTAL NUMBER OF LANES OF THE FACILITY, BOTH DIRECTIONS. (THIS VARIABLE IS NOT BEING USED AT THE PRESENT TIME).
COLUMNS 5-6

NLRO-THE NUMBER OF LANES OPEN IN THE OVERLAY DIRECTION.
COLUMNS 7-8

NLRN-THE NUMBER OF LANES OPEN IN THE NON-OVERLAY DIRECTION.
COLUMNS 9-10

XLSC-THE DISTANCE, MEASURED ALONG THE CENTER LINE, OVER WHICH TRAFFIC IS SLOWED IN THE OVERLAY DIRECTION (MILES).
COLUMNS 11-15

XLSN-THE DISTANCE, MEASURED ALONG THE CENTER LINE, OVER WHICH TRAFFIC IS SLOWED IN THE NON-OVERLAY DIRECTION (MILES).
COLUMNS 16-20

XLSD-THE DISTANCE, MEASURED ALONG THE DETOUR, AROUND THE OVERLAY ZONE (MILES).
COLUMNS 21-25

PO2-PERCENT OF VEHICLES THAT WILL BE STOPPED IN THE OVERLAY DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMEN. THIS VARIABLE IS NOT BEING USED AT THE PRESENT TIME.
COLUMNS 25-29

PN2-PERCENT OF VEHICLES THAT WILL BE STOPPED IN THE NON-OVERLAY DIRECTION BECAUSE OF PERSONNEL OR EQUIPMENT. THIS VARIABLE IS NOT BEING USED AT THE PRESENT TIME.
COLUMNS 30-34

DO2-THE AVERAGE DELAY PER VEHICLE STOPPED IN THE OVERLAY DIRECTION BECAUSE OF MOVEMENT OF OVERLAY PERSONNEL AND EQUIPMENT IN THE RESTRICTED ZONE. THIS VARIABLE IS NOT BEING USED AT THE PRESENT TIME.
COLUMNS 35-39

INPUT DATA FOR FPS-11 (CONTINUED)

DN2-THE AVERAGE DELAY PER VEHICLE STOPPED IN THE NON-OVERLAY DIRECTION BECAUSE OF MOVEMENT OF PERSONNEL OR EQUIPMENT. THIS VARIABLE IS NOT BEING USED AT THE PRESENT TIME.
COLUMNS 40-44

*********** CARD TYPE 9 - EXISTING PAVEMENT AND PROPOSED ACP ***********

FORMAT(2F5.3,2F5.2,F6.2,F5.2,F6.2,F5.2)

SCIB1-THE AVERAGE SURFACE CURVATURE INDEX (SCI) OF THE EXISTING PAVEMENT.
COLUMNS 3-7

SIGMB1-THE STANDARD DEVIATION OF THE SCI.
COLUMNS 8-12

DIP-THE COMPOSITE THICKNESS OF THE EXISTING PAVEMENT (INCHES).
COLUMNS 13-17

COST1-THE IN-PLACE COST PER COMPACTED C.Y. OF THE PROPOSED ACP.
COLUMNS 18-22

PSVGE1-THE PROPOSED ACP SALVAGE VALUE AS PERCENT OF THE ORIGINAL COST AT THE END OF THE ANALYSIS PERIOD.
COLUMNS 23-26

COST2-THE IN-PLACE PRESENT VALUE OF THE EXISTING STRUCTURE ($/C.Y.).
COLUMNS 29-33

PSVGE2-THE PROPOSED SALVAGE VALUE OF THE EXISTING STRUCTURE AT THE END OF THE ANALYSIS PERIOD.
COLUMNS 34-39

FLU-LEVEL UP REQUIRED FOR THE FIRST OVERLAY (INCHES).
COLUMNS 40-44

*NOTE - THIS INPUT CARD MUST BE DELETED WHEN RUNNING A NEW CONSTRUCTION PROBLEM.

************* CARD(S) TYPE 10 - PAVING MATERIAL INFORMATION ************

FORMAT(1X,I1,3X,A1,3X,6A3,F6.2,4F8.2,12X,I1)

THE COLUMNS DESCRIPTIONS ARE AS FOLLOWS--

FIRST FIELD - 1 COLUMN - ILAYER - THE LAYER NUMBER IN WHICH THE MATERIAL MAY BE USED.
COLUMN 4

SECOND FIELD - 1 COLUMN - CODE LETTER OF THE MATERIAL.
COLUMN 8

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

INPUT DATA FOR FPS-11 (CONTINUED)

FOURTH FIELD - 6 COLUMNS - THE IN-PLACE COST PER COMPACTED CUBIC YARD.
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.
COLUMNS 44-51

SEVENTH FIELD - 8 COLUMNS - THE MAXIMUM THICKNESS ALLOWED.
COLUMNS 52-59

EIGTH FIELD - 8 COLUMNS - THE SALVAGE VALUE (PERCENT) OF THE MATERIAL.
COLUMNS 60-67

NINTH FIELD - 1 COLUMN - CHECK - A FLAG TO SIGNAL THE LAST MATERIAL FOR A GIVEN PROBLEM.
COLUMN 80

****

*NOTE - A 1 (ONE) MUST BE CODED IN COLUMN 80 FOR ALL MATERIAL CARDS EXCEPT THE LAST MATERIAL CARD WHICH MUST HAVE A 0 (ZERO). WHEN RUNNING AN ACP OVERLAY PROBLEM THIS CARD(S) MUST BE DELETED.

THE MATERIAL PROPERTY CARDS MUST BE SORTED IN ASCENDING ORDER BY THE FIRST FIELD, IN OTHER WORDS, ALL LAYER 1 CARDS MUST BE FIRST, FOLLOWED BY ALL OF THE LAYER 2 CARDS, ...

LAYER 1 IS THE SURFACE LAYER, ASPHALTIC CONCRETE.

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

SOME VARIABLES HAVE BEEN RENAMED FROM EARLIER VERSIONS OF FPS SO THAT THE VALUES USED INTERNALLY TO THE PROGRAM WILL NOT BE CONFUSED WITH THE INPUT VALUES WHICH MAY BE IN A FORM MORE CONVINIENT TO THE USER.

****

EXTERNAL CROSS-REFERENCE TABLES

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

1. SUBPROGRAM AND MAIN CROSS REFERENCE TABLE.

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

THE FORTRAN LANGUAGE ALSO IMPLIES CERTAIN FUNCTION CALLS. THEIR NAMES MAY DIFFER DEPENDING ON THE COMPUTER SYSTEM. THE NAMES SHOWN ARE THOSE BY THE IBM OS/370 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(S) 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.

TABLE 1. PROGRAM EXTERNAL CROSS-REFERENCES

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

CALLED EXTERNAL NAME	CALLING PROGRAM NAME															
	MAIN	INPUT	HEADNG	OVLAY2	TIME	USER	PWRM	CHECK2	STORE	SUMMY	SOLVE2	CALC	OUTPUT	OVRLAY	CHECK	SUMARY
INPUT	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HEADNG	-	X	-	-	-	-	-	-	-	X	-	-	X	-	-	X
OVLAY2	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TIME	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-
USER	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-
PWRM	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-
CHECK2	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
STORE	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
SUMMY	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOLVE2	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CALC	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
OUTPUT	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OVRLAY	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
CHECK	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
SUMARY	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
************** EXPLICIT FORTRAN AND LIBRARY REFERENCES ***************																
CORE	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EXP	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-
SQRT	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
ALOG10	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
************* I B M IMPLIED FORTRAN LIBRARY REFERENCES **************																
FRXPI	-	-	-	X	-	X	X	-	-	-	-	-	-	X	-	-

TABLE 2. REFERENCES TO COMMON

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	CALC	HEADNG	INPUT	OUTPUT	OVLAY2	OVRLAY	SOLVE2	SUMMY	TIME	UUSER
AAS	---	---	---	SF	---	---	---	---	---	---	F
ACCD	---	---	---	SF	---	---	---	---	---	---	F
ACPR	---	---	---	SF	---	---	---	---	---	---	F
ALPHA	---	---	---	SF	---	---	---	---	---	F	---
ASN	---	---	---	SF	---	---	---	---	---	---	---
ASO	---	---	---	SF	---	---	---	---	---	---	F
B	SF	F	---	---	---	---	---	---	---	---	---
BB	SF	---	---	---	---	---	---	---	---	---	---
CINT	S	F	---	---	---	---	---	---	---	---	---
CL	---	---	---	SF	---	SFA	SFA	---	---	F	---
CLEVEL	---	---	---	S	---	---	---	---	---	F	---
CMAX	---	---	---	SF	---	---	---	---	---	---	---
CONT	---	---	F	S	---	---	---	---	---	---	---
COUNTY	---	---	F	S	---	---	---	---	---	---	---
COST	SFA	---	---	---	---	---	F	F	---	---	---
COST1	---	---	---	SF	---	---	---	---	---	---	---

TABLE 2. REFERENCES TO COMMON (CONTINUED)

VARIABLES IN COMMON	PROGRAM NAME										
	MAIN	CALC	HEADNG	INPUT	OUTPUT	OVLAY2	OVRLAY	SOLVE2	SUMMY	TIMER	USER
COST2	---	---	---	SF	---	F	---	---	---	---	---
CM1	---	---	---	SF	---	---	---	---	---	---	---
CM2	---	---	---	SF	---	---	---	---	---	---	---
C1	---	---	---	S	---	SFA	SFA	---	---	---	---
C2	---	---	---	S	---	SFA	SFA	---	---	---	---
D	S	F	---	---	---	---	---	---	---	---	---
DATA	F	---	---	SF	F	---	---	---	---	---	---
DATE	---	---	F	S	---	---	---	---	---	---	---
DIP	---	---	---	SF	---	F	---	---	---	---	---
DIST	---	---	F	S	---	---	---	---	---	---	---
DN2	---	---	---	S	---	---	---	---	---	---	F
DO2	---	---	---	S	---	---	---	---	---	---	F
DMAX	S	---	---	---	---	---	---	F	---	---	---
DMIN	S	---	---	---	---	---	---	F	---	---	---
DOVER	---	F	---	---	S	---	SF	SF	---	---	---
FLU	---	---	---	SF	---	SFA	---	---	---	---	---
FLU1	---	---	---	S	---	F	---	---	---	---	---
HPD	---	---	---	SF	---	---	---	---	---	---	F
HWY	---	---	F	S	---	---	---	---	---	---	---

TABLE 2. REFERENCES TO COMMON (CONTINUED)

VARIABLES IN COMMON	PROGRAM NAME										
	MAIN	CALC	HEADNG	INPUT	OUTPUT	OVLAY2	OVRLAY	SOLVE2	SUMMY	TIMER	USER
IIIK	---	---	---	---	---	S	---	---	---	---	---
INDEX	SF-	---	---	---	F	---	---	---	---	---	---
IPAGE	---	---	SF	S	---	---	---	---	---	---	---
IPTYPE	---	---	---	S	---	---	---	---	---	---	---
ITYPE	---	---	---	S	---	---	---	---	---	---	F
LAYER	SF	F	---	---	SFA	---	F	F	---	---	---
MATYPE	SF	---	---	---	---	---	---	---	---	---	---
MODEL	---	---	---	SF	---	---	---	---	---	---	F
NLANES	---	---	---	SF	---	---	---	---	---	---	---
NLRN	---	---	---	SF	---	---	---	---	---	---	F
NLRO	---	---	---	SF	---	---	---	---	---	---	F
NM	F	---	---	SF	F	---	---	---	---	---	---
NMB	SFA	---	---	SF	---	---	---	---	---	---	---
OVCOST	S	---	---	---	---	---	F	---	---	---	---
OVINC	---	---	---	S	---	---	F	---	---	---	---
OVMAX	---	---	---	S	---	---	---	---	---	---	---
OVMIN	---	---	---	S	---	F	F	---	---	---	---
OVSALV	S	---	---	---	---	---	F	---	---	---	---
PIE	---	---	F	S	---	---	---	---	---	---	---

TABLE 2. REFERENCES TO COMMON (CONTINUED)

VARIABLES IN COMMON	PROGRAM NAME										
	MAIN	CALC	HEADNG	INPUT	OUTPUT	OVLAY2	OVRLAY	SOLVE2	SUMMY	TIMER	UUSER
PLEVEL	---	---	---	SF	---	---	---	---	F	---	---
PN2	---	---	---	S	---	---	---	---	---	---	F
PO2	---	---	---	S	---	---	---	---	---	---	F
PROP	---	---	---	SF	---	---	---	---	---	---	F
PROBN	---	---	F	S	---	---	---	---	---	---	---
PROBSW	---	---	---	SF	---	---	---	---	---	---	---
PSI	---	---	---	SF	---	---	F	---	---	---	---
PSVGE	SF	---	---	---	---	---	F	---	---	---	---
PSVGE1	---	---	---	SF	---	---	---	---	---	---	---
PSVGE2	---	---	---	SF	---	F	---	---	---	---	---
PVR	---	---	---	SF	---	---	---	---	---	F	---
P1	---	---	---	SF	---	---	F	---	---	---	---
P2	---	---	---	SF	---	---	---	---	---	FA	---
RATE	---	---	---	SF	---	SFA	SFA	---	---	---	F
RC	---	---	---	S	---	F	F	---	---	F	---
RO	---	---	---	SF	---	---	F	---	---	F	---
SCIB	---	---	---	---	---	SF	SF	---	---	---	---
SCIB1	---	---	---	SF	---	---	---	---	F	F	---
SCIL	---	---	---	---	F	SFA	S	---	---	---	---
SECT	---	---	F	S	---	---	---	---	---	---	---
SIGMB1	---	---	---	SF	---	---	---	---	---	F	---

TABLE 2. REFERENCES TO COMMON (CONTINUED)

VARIABLES IN COMMON	PROGRAM NAME										
	MAIN	CALC	HEADNG	INPUT	OUTPUT	OVLAY2	OVRLAY	SOLVE2	SUMMY	TIME	USER
SLOSS	---	---	---	---	---	SFA	S	---	---	---	---
SWRATE	---	---	---	SF	---	---	---	---	---	FA	---
TCKMAX	---	---	---	S	---	---	---	---	---	---	---
TT	---	---	---	---	---	SFA	SF	---	---	---	---
UPLEVL	SFA	---	---	S	F	SF	F	---	---	---	-F
XINC	SF	---	---	---	---	---	---	SF	---	---	---
XLSD	---	---	---	SF	---	---	---	---	---	---	F
XLSN	---	---	---	SF	---	---	---	---	---	---	F
XLSO	---	---	---	SF	---	---	---	---	---	---	F
XLW	---	---	---	SF	---	---	---	---	---	---	---
XNC	---	---	---	S	---	---	---	---	---	F	---
XTBO	---	---	---	SF	---	---	---	---	---	F	---
XTTO	---	---	---	SF	---	---	---	---	---	F	---
Z	---	---	---	---	SFA	---	---	S	---	---	---

NAME DICTIONARY

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, INCHES, ETC., WHICH EACH VARIABLE IS CARRIED IN THE PROGRAM ARE GIVEN.

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	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.
ASN	THE AVERAGE SPEED THROUGH THE OVERLAY AREA IN THE NON-OVERLAY DIRECTION.
ASO	THE AVERAGE SPEED THROUGH THE OVERLAY AREA IN THE OVERLAY DIRECTION.
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.
BPOCCT	PRESENT WORTH OF OVERLAY CONSTRUCTION COST FOR THE BEST OVERLAY POLICY FOR A GIVEN INITIAL DESIGN.
BPRM	THE PRESENT WORTH VALUE OF THE ROUTINE MAINTENANCE FOR THE BEST OVERLAY POLICY (PRESENT VALUE DOLLARS PER SQUARE YARD).
BPTUC	THE PRESENT WORTH VALUE OF TOTAL USER-COSTS FOR THE BEST OVERLAY POLICY. (PRESENT WORTH DOLLARS PER SQUARE YARD).

NAME DICTIONARY (CONTINUED)

BSAL	THE PRESENT WORTH OF THE SALVAGE VALUE TO BE SUBTRACTED FROM OTHER COSTS FOR THE BEST OVERLAY POLICY OF A DESIGN.
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.
CLEVEL	THE 'PERCENTILE VALUE OF THE NORMAL DISTRIBUTION' USED IN SUBROUTINE TIME (SEE PLEVEL).
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 (SEE C1).
CM2	ANNUAL INCREMENTAL INCREASE IN ROUTINE MAINTENANCE COST PER LANE MILE (SEE C2).
CONT	THE HIGHWAY CONTROL NUMBER (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
COUNTY	THE COUNTY NAME (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
COST	THE COST PER UNIT OF THICKNESS OF THE JTH LAYER. COST(J) DETERMINED FROM DATA(,9) USING INDEX AND ILAYER.
COST1	THE IN PLACE COST PER C.Y. OF THE PROPOSED ACP (ACP OVERLAY DESIGN MODE).
COST2	THE IN PLACE PRESENT VALUE OF THE EXISTING STRUCTURE (ACP OVERLAY DESIGN MODE).
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.
D	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'.
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'.

NAME DICTIONARY (CONTINUED)

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.

DATE	THE DATE THE PROBLEM WAS CODED (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
DELD	THE OVERLAY THICKNESS (YARDS, EARLIER VERSIONS INCHES).
DEXT	AN ARRAY OF OVERLAY THICKNESSES WITHIN AN OVERLAY SCHEME.
DIP	THE COMPOSITE THICKNESS OF THE EXISTING PAVEMENT (INCHES).
DIST	THE DISTRICT NUMBER (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
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.
FLU	LEVEL UP REQUIRED FOR THE FIRST OVERLAY (INCHES)
FLU1	SAME AS FLU IN YARDS.
HPD	THE NUMBER OF HOURS PER DAY THAT OVERLAY CONSTRUCTION TAKES PLACE.
HWY	THE HIGHWAY NUMBER (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
I	THE NUMBER OF PERFORMANCE PERIODS AS USED IN 'OVRLAY', 'TIME', AND PORTIONS OF 'OUTPUT'.
IBT	THE NUMBER OF PERFORMANCE PERIODS OF THE BEST OVERLAY POLICY.
ICOST	A FLAG WHICH IS CHANGED FROM ZERO TO ONE IN 'SOLVE2' IF AN INITIAL DESIGN IS MORE EXPENSIVE THAN CMAX (MAXIMUM ALLOWABLE COST FOR INITIAL DESIGN).

NAME DICTIONARY (CONTINUED)

IDUMMY	A TEMPORARY ARRAY USED TO PRINT VALUES FROM THE POLICY ARRAY IN INTEGER FORM.
IIIK	A FLAG THAT IS SET IF THE COST OF THE INITAL OVERLAY, IN AN ACP OVERLAY JOB, IS GREATER THAN THE FUNDS AVAILABLE FOR THE FIRST OVERLAY (WHEN KNOTL=0). USED IN SUBROUTINES OVLAY2 AND SUMMY.
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).
IPTYPE	THE CODE NUMBER TO DETERMINE THE TYPE OF PROBLEM. IPTYPE = 1, FLEXIBLE PAVEMENT DESIGN MODE. IPTYPE = 2, ACP OVERLAY DESIGN MODE.
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.
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 DESIGNATES AN URBAN ROAD
JJ1	A FLAG SET TO 0 (ZERO) IF THE CURRENT DESIGN IS NOT AN ALTERNATE, SET TO 1 (ONE) IF THE CURRENT DESIGN IS AN ALTERNATE. USED IN SUBROUTINES CHECK AND CHECK2.
JJ2	A COUNTER THAT KEEPS TRACK OF THE NUMBER OF 'NON-ALTERATE' DESIGNS. USED IN SUBROUTINES OUTPUT AND SUMARY
JL	IS THE DO LOOP VARIABLE IN SUBROUTINE OUTPUT AND A SUBSCRIPT IN THE Z ARRAY IN SUBROUTINE CHECK CALLED FROM INSIDE THE DO LOOP IN SUBROUTINE OUTPUT. CAUTION SHOULD BE TAKEN BEFORE CHANGING THE SUBSCRIPT IN SUBROUTINE CHECK.
KNTOL	THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED (SOME MAY NOT BE POSSIBLE), INITIALIZED IN 'MAIN', COUNTED IN 'OUTPUT', AND PRINTED IN 'SUMARY'.

NAME DICTIONARY (CONTINUED)

KOUNT	A COUNTER WHICH KEEPS TRACK OF THE NUMBER OF FEASIBLE INITIAL DESIGNS FOR A GIVEN DESIGN TYPE.
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 EQUALS MATYPE.
LLL	A FLAG THAT IS SET IF THE ACCUMULATED THICKNESS OF ALL OVERLAYS IS GREATER THAN THE MAXIMUM ALLOWED FOR THE CURRENT OVERLAY SCHEME (WHEN KNTOL=0). USED IN SUBROUTINES OVLAY2 AND SUMMY.
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.
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 (NMD 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.

NAME DICTIONARY (CONTINUED)

NMP	THE NUMBER OF MATERIALS AVAILABLE, 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.
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.
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 (IN YARDS) VARIES WITH CONFIDENCE LEVEL.
OVMAX	THE ACCUMULATED MAXIMUM THICKNESS OF ALL OVERLAYS (YARDS, EARLIER VERSIONS IN INCHES).
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).
P	INITIAL SERVICEABILITY INDEX, AT A GIVEN TIME EITHER PSI OR P1.
PIE	THE IPE NUMBER FOR THE PROJECT (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
PLEVEL	THE ALPHABETIC CHARACTER TO DETERMINE CLEVEL.
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 BEST DESIGN STRATEGIES 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 BEST DESIGNS.

IN THE FLEXIBLE PAVEMENT DESIGN MODE THE ARRAY IS USED AS FOLLOWS--

POLICY(1,) DESIGN NUMBER (NMDGN).
POLICY(2,) INITIAL CONSTRUCTION COST.
POLICY(3,) OVERLAY CONSTRUCTION COST.
POLICY(4,) USER COST.
POLICY(5,) BLANK. (SEAL COAT COST IN EARLIER VERSIONS OF FPS).
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(I+40,), I FROM 1 TO THE NO. OF SWELLING CLAY LOSSES TO BE PRINTED, SERVICEABILITY LOSS DUE TO SWELLING CLAY.

IN THE ACP OVERLAY DESIGN MODE THE ARRAY IS USED AS FOLLOWS--

POLICY(1,) FUTURE LEVEL-UP (A CONSTANT EQUAL TO ONE INCH).
POLICY(2,) USER COST FOR INITIAL OVERLAY.
POLICY(3,) FUTURE OVERLAYS CONSTRUCTION COST.
POLICY(4,) FUTURE OVERLAYS USER COST.
POLICY(5,) BLANK. (SEAL COAT COST IN EARLIER VERSIONS OF THE OVRLAY PROGRAMS, SEE REFERENCE 2).
POLICY(6,) ROUTINE MAINTENANCE COST.
POLICY(7,) SALVAGE VALUE COST.
POLICY(8,) TOTAL COST.
POLICY(9,) FIRST LEVEL-UP (IN YARDS).
POLICY(10,) INITIAL OVERLAY CONSTRUCTION COST.
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 THE NO. OF OVERLAY THICKNESSES TO BE PRINTED, THE OVERLAY POLICY INCLUDING LEVEL-UP.
POLICY(I+40,), I FROM 1 TO THE NO. OF SWELLING CLAY LOSSES TO BE PRINTED, SERVICEABILITY LOSS DUE TO SWELLING CLAY.

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.
PROBN	THE PROBLEM NUMBER (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
PROBSW	PROBABILITY OF SWELL, PRODUCT OF LOCATIONS VULNERABLE AND SOIL SWELLING CLAY PROBABILITY (SWELLING CLAY CONSTANT)

NAME DICTIONARY (CONTINUED)

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).
PSVGE1	THE PROPOSED ACP SALVAGE VALUE, AS PERCENT OF THE ORIGINAL COST, AT THE END OF THE ANALYSIS PERIOD (ACP OVERLAY DESIGN MODE).
PSVGE2	THE PROPOSED SALVAGE VALUE (PERCENT) OF THE EXISTING STRUCTURE AT THE END OF THE ANALYSIS PERIOD (ACP OVERLAY DESIGN MODE).
PVR	POTENTIAL VERTICAL RISE DUE TO SWELLING CLAY (INPUT IN INCHES), (SWELLING CLAY CONSTANT)
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.
P2	THE MINIMUM ALLOWED VALUE OF THE SERVICEABILITY INDEX (POINT AT WHICH AN OVERLAY MUST BE APPLIED).
RATE	THE INTEREST RATE OR TIME VALUE OF MONEY. INTERNALLY, 5.0 PERCENT IS 0.05 FOR 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.
SCI	THE SURFACE CURVATURE INDEX, A CALCULATED VALUE (VARIABLE SS IN PORTIONS OF THE FPS PROGRAM).
SCIB1	THE AVERAGE SURFACE CURVATURE INDEX OF THE EXISTING PAVEMENT (ACP OVERLAY DESIGN MODE)
SCOST	COST PER SQUARE YARD, CALCULATED IN 'SOLVE2', OF AN INITIAL DESIGN.

NAME DICTIONARY (CONTINUED)

SECT	THE HIGHWAY SECTION NUMBER (FOR IDENTIFICATION PURPOSES) READ IN SUBROUTINE INPUT AND USED IN SUBROUTINE HEADNG.
SIGMB1	THE STANDARD DEVIATION OF SCIB1.
SS	THE SURFACE CURVATURE INDEX, SCI, CALCULATED BY 'CALC'.
SWRATE	SWELLING CLAY CONSTANT FOR THE SWELLING RATE.
T	TIME TO LOSS OF SERVICEABILITY OF A DESIGN, CALCULATED BY 'TIME'.
TCKMAX	THE MAXIMUM ALLOWABLE TOTAL THICKNESS OF INITIAL CONSTRUCTION
TPRIM	TIME FROM INITIAL CONSTRUCTION TO THE PRESENT PERFORMANCE PERIOD OR OVERLAY (YEARS).
TT	AN ARRAY OF T'S, FOR EACH PERFORMANCE PERIOD, THE TIME TO THE NEXT OVERLAY (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-HALF INCH. 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').

NAME DICTIONARY (CONTINUED)

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).
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 (VALIDITY OF ROW SUBSCRIPT VALUES CHECKED IN SOLVE2). Z(,1) SCI, SURFACE CURVATURE INDEX. Z(,2) COST OF INITIAL DESIGN (DOLLARS PER SQUARE YARD). Z(,I+2) THE THICKNESS OF THE I'TH LAYER (YARDS).

CRITICAL DIMENSION STATEMENTS

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.

DATA STATEMENTS AND DIMENSIONS ALLOW A 6 LAYER DESIGN, AND 10 MATERIALS EXCLUDING SUBGRADE.

IF DIMENSIONS OF THE ARRAYS ARE DEFINED AS--

LAYER = MAXIMUM NUMBER OF LAYERS IN A DESIGN, EXCLUDING SUBGRADE.
LP1 = ONE PLUS LAYER (INCLUDES SUBGRADE).
NK = MAXIMUM COUNT OF DESIGN TYPES WITH AN OPTIMAL DESIGN.
NM = NUMBER OF MATERIALS EXCLUDING SUBGRADE.
NPOS = MAXIMUM NUMBER OF DESIGN TYPES WITH NO FEASIBLE COMPLETE DESIGNS.
NUMBER = MAXIMUM NUMBER OF FEASIBLE INITIAL DESIGNS.

THE FOLLOWING ARRAYS SHOULD BE DIMENSIONED AS--

B(LAYER+1)
BB(NM+1)
COST(LAYER)
D(LAYER+1)
DMAX(LAYER)
DMIN(LAYER)
INDEX(LAYER+1)
IPOSS(NK)
NMBMAT(LAYER)
NN(LAYER)
NPOSS(NPOS)
OCOST(NK)
PSVGE(LAYER)
XINC(LAYER)
Z(NUMBER,LAYER+2)

IN FPS-11, LAYER=6, NM=10, NK=100, NPOSS=100, NUMBER=1000.

REFERENCES

1. Schafer, Dale L., "Flexible Pavement Computer Program Documentation," Research Report 123-11, Texas Transportation Institute, Texas A & M University, College Station, Texas, April, 1972.

2. Brown, James L., and Hugo E. Orellana, "An Asphaltic Concrete Overlay Design Subsystem," Research Report 101-1F, Texas Highway Department, Austin, Texas, December, 1970.

3. Scrivner, F. H., W. M. Moore, W. F. McFarland, and Gary R. Carey, "A Systems Approach to the Flexible Pavement Design Problem," Research Report 32-11, Texas Transportation Institute, Texas A & M University, College Station, Texas, October, 1968.

4. Darter, Michael I., B. Frank McCullough, and James L. Brown, "Reliability Concepts Applied to the Texas Flexible Pavement System - FPS," A Paper Prepared for Presentation at the 51st Annual Meeting of the Highway Research Board, January, 1972.

5. "Materials and Tests Division Manual of Testing Procedures," Volume 1, Texas Highway Department, Austin, Texas, April, 1970.

APPENDIX I

DOCUMENTATION OF MATHEMATICAL FORMULAS

APPENDIX I.

Documentation of Mathematical Formulas

The basic equations used in FPS-11 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 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
  - E. Stochastic Variables
- Section 2 - Basic Equations
  - A. Deflection Equations
    - 1. For Initial Construction
    - 2. For ACP Overlays
  - B. Traffic Equation
  - C. Performance Equation
  - D. Stochastic Equations
- Section 3 - Evaluation of Swelling Clay Constants.

Appendix I - Section 1

Variables for Basic Equations

A. Design Variables

D(J)	a_i	= the strength coefficient of the i^{th} layer of a pavement, $i = 1, 2, . . ., n + 1.$
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 applicaton of either Dynaflect load, to the j^{th} sensor.
	r_1^2	= 100. $\quad r_2^2 = 244.$
SCIB1	S	= the average Surface Curvature Index of the existing pavement. (Input for ACP Overlay Mode).

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 <u>millions</u>.
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 under Performance Variables).
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 value of P occurring immediately after initial or overlay construction

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

PROBSW C_1 = the fraction of a roadway length that has expansive clay in locations that are likely to promote volume change.

PVR C_2 = the maximum amount of differential heave in inches that is likely to be noted along a roadway.

SWRATE θ = a constant which determines the rate of heaving of the expansive clay.

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.

$t_o = 0$

ALPHA α = a temperature constant for a given locality.

<u>Stochastic Variables</u>

XN1 N_D = Number of equivalent 18-kip axles in one direction used for thickness design.

SDLOGN $s_{\text{Log } N_k}$ = Standard Deviation of *Log (XN).

CLEVEL K = A standard normal variate which varies with confidence level used as follows:

Confidence Level	K
A	0.0
B	0.8415
C	1.6450
D	2.3267
E	3.0900
F	3.7500

---

*All logarithms are to the base 10 unless otherwise specified.

Appendix I - Section 2

Basic Equations

A 1. Initial Construction 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 Pavment 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, "Some Recent Findings in Flexible Pavement Research." The equation is given below:

$$S = W_1 - W_2$$

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

$$\Delta jk = \frac{C_0}{a_k^{C_1}} \left[\frac{1}{r_j^2 + C_2 (\sum_{i=0}^{k-1} a_i D_i)^2} - \frac{1}{r_j^2 + C_2 (\sum_{i=0}^{k} a_i D_i)^2} \right]$$

$C_0 = 0.891,$

$C_1 = 4.503,$

$C_2 = 6.25,$

$a_0 = D_0 = 0,$

and the other variables are previously defined.

A 2. The ACP Overlay Deflection Equation (Subroutines OVRLAY and OVLAY2).

This is a special case of the above equation. In Research Project 101, "An Asphaltic Concrete Overlay Design Subsystem," this equation was confirmed by field tests (Ref. 2). The equation is given below:

$$S = \frac{C_0}{a_1^{C_1}} \left(\frac{1}{r_1^2} - \frac{1}{r_1^2 + C_2 (a_1 D_1)^2} \right) + \frac{SCIB1}{\frac{1}{r_1^2} - \frac{1}{r_2^2}} \left(\frac{1}{r_1^2 + C_2 (a_1 D_1)^2} \right)$$
$$- \left[\frac{C_0}{a_1^{C_1}} \left(\frac{1}{r_2^2} - \frac{1}{r_2^2 + C_2 (a_1 D_1)^2} \right) + \frac{SCIB1}{\frac{1}{r_1^2} - \frac{1}{r_2^2}} \left(\frac{1}{r_2^2 + C_2 (a_1 D_1)^2} \right) \right]$$

Which is of the form: S = a + b (SCIB1)

where a and b are functions of the thickness D_1 and stiffness a_1 of the overlay only, and SCIB1 is the Average Surface Curvature Index of the existing pavement.

B. The Traffic Equation (Subrountine TIME).

The Traffic Equation development is reported in Research 32-11, "A Systems Approach to the Flexible Pavement Design Problem," (Ref. 3). The equation is given below:

$$N_k = \frac{N_c}{C(r_0 + r_c)} \cdot \left[2 r_0 t_k + \left(\frac{r_c - r_0}{C} \right) t_k^2 \right]$$

where the symbols are 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 C_1, C_2 and θ listed under performance variables and discussed more in Section 3.

$$P = 5 - \left[\sqrt{5 - P_{k-1}} + \frac{53.6\, S_k^2}{\alpha} (N - N_{k-1}) \right]^2 - .335\, C_1 C_2 \left(e^{-\theta t_{k-1}} - e^{-\theta t} \right)$$

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

D. Stochastic Equations (Subroutine TIME)

The equations quantifying uncertainties considered in FPS-11, are covered in this section. The equation development is described in a paper presented at the 51st Annual Meeting of the Highway Research Board. (Ref. 4). The equations used follows:

$$^{*}\text{Log } N_D = \text{Log } N_k + K s_{\text{Log } N_k}$$

Where:

$$s^2_{\text{Log } N_k} = s^2_{\text{Log } Q} + s^2_{\text{Log } \alpha} + s^2_{2 \text{ Log } S} + s^2_{\text{l.o.f.}}$$

and

$$s^2_{\text{Log } Q} = \left[\frac{0.0471}{(\sqrt{5-P_2} - \sqrt{5-P})^2}\right]\left[\frac{0.01P_2^2}{5-P_2} + \frac{0.01P^2}{5-P}\right]$$

$$s^2_{\text{Log } \alpha} = \frac{3.3894}{\alpha^2}$$

$$s^2_{2 \text{ Log } S} = \left(\frac{0.755}{S^2}\right)\left(s^2_R + s^2_E\right)$$

*Log to the base 10 unless otherwise specified.

s = standard deviation.

$s^2_{1.o.f.}$ = 0.0631, variance component due to lack of fit of the performance equation.

s^2_R = variance component in S along the roadway.

$s^2_R = (0.34S)^2$, for Initial Construction Mode.

s^2_R = An input for ACP Overlay Mode.

s^2_E = variance component due to lack of fit error of the deflection equation in predicting S.

$s^2_E = (0.30S)^2$, for initial construction.

$s^2_E = (0.38S)^2$, for ACP overlays.

Appendix I - Section 3

Evaluation of Swelling Clay Constants

FPS-11 uses three constants to calculate the reduction in serviceability loss due to swelling clay and other non-traffic causes of serviceability loss.

Swelling Probability (PROBSW)

Swelling probability is a fraction between 0 and 1 which represents the proportion of the project length which is likely to experience swell. This suggests that swelling clay must be present, and that local conditions must be conducive to swelling. Cuts, grade points, bridge approaches, grass root grade lines, and choppy fills seem to be more of a problem than uniform fills. Local experience must be input for this value until more definite guidelines can be developed.

Potential Vertical Rise (PVR)

The potential vertical rise, PVR, is a measure of how much the surface of the bed of clay can rise if it is supplied with all the moisture it can absorb. PVR can either be estimated in a particular locality from the total amount of differential heave the designer (or maintenance personnel) would expect to observe over a long period of time, or by using Texas Test Method, Tex-124-E (Ref. 5). Extremely bad clay may have a PVR in the order of ten to twenty inches.

For highways that have been in existence for some time, the remaining potential for swelling should be reduced by the amount of swell that has already occurred. How much has occurred will depend on the age of the roadbed and the swell rate constant which is discussed in the next section. Figure 1 provides a multiplier (ratio) to apply to the original PVR if the swell rate constant and age of an existing road are known.

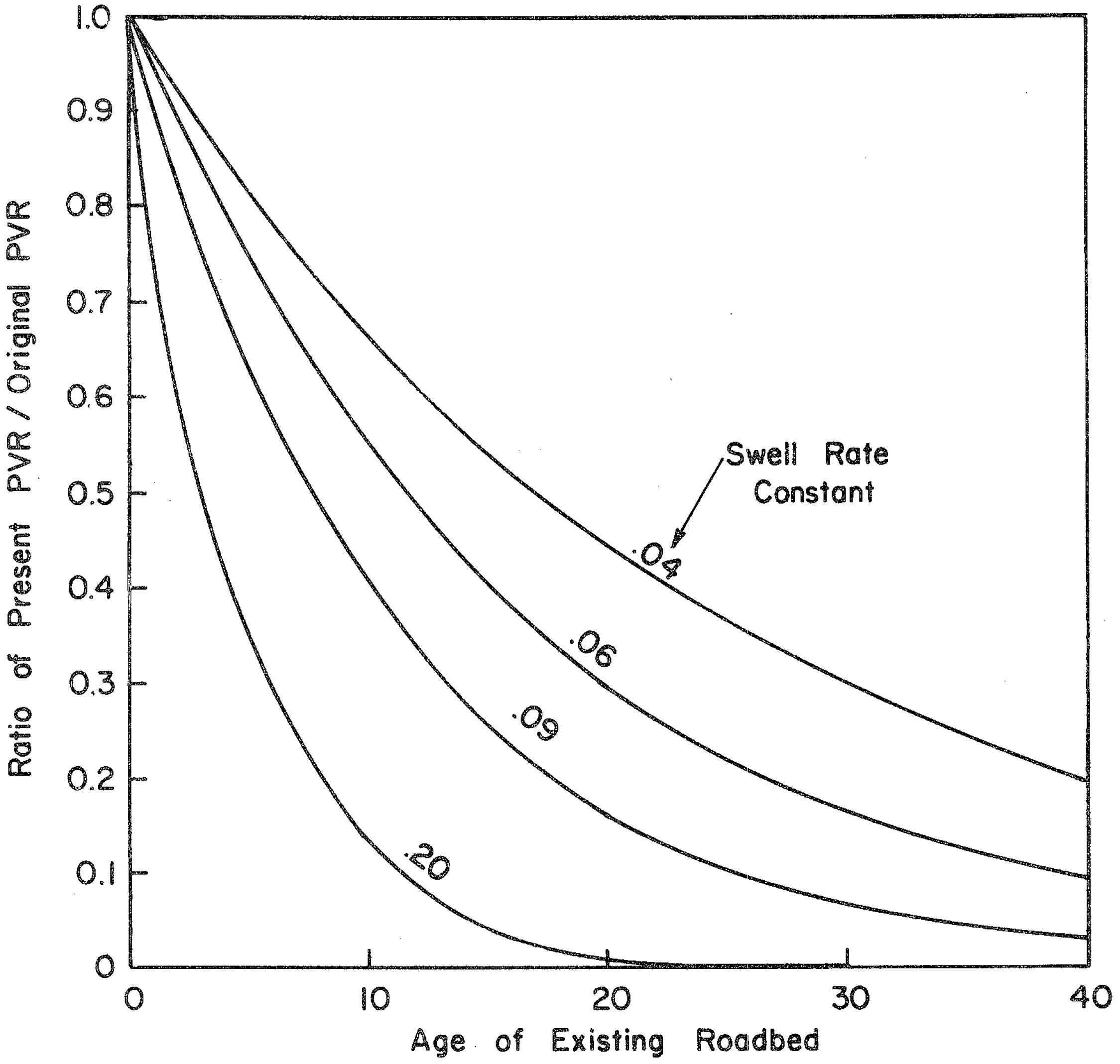

Figure 1: CHART FOR ESTIMATING PVR FOR AN EXISTING ROAD

Swelling Rate (SWRATE)

The swelling rate constant is used to calculate how fast swelling takes place. This constant lies between .04 and 0.20. It is larger when the soil is cracked and open, and when a large moisture supply is available due to poor drainage, high rainfall, underground seeps, or other sources of water. When drainage conditions are good or the soil is tight the swelling rate constant becomes smaller.

The nomograph in Figure 2 gives a method of selecting this constants based upon the judgement of the designer of local soil and moisture conditions. Figure 3 shows the effects (in the absence of traffic) for three values of PVR and two values of the swelling rate constant on the performance curve. For the curves shown the swelling probability used is 1.0. The effect of other values of swelling probability can be evaluated considering that this constant is used solely as a multiplying modifier on PVR in the program. For example, a swelling probability of 0.10 and PVR of 10 inches is exactly equal in the program to a swelling probability of 1.0 and a PVR of one inch.

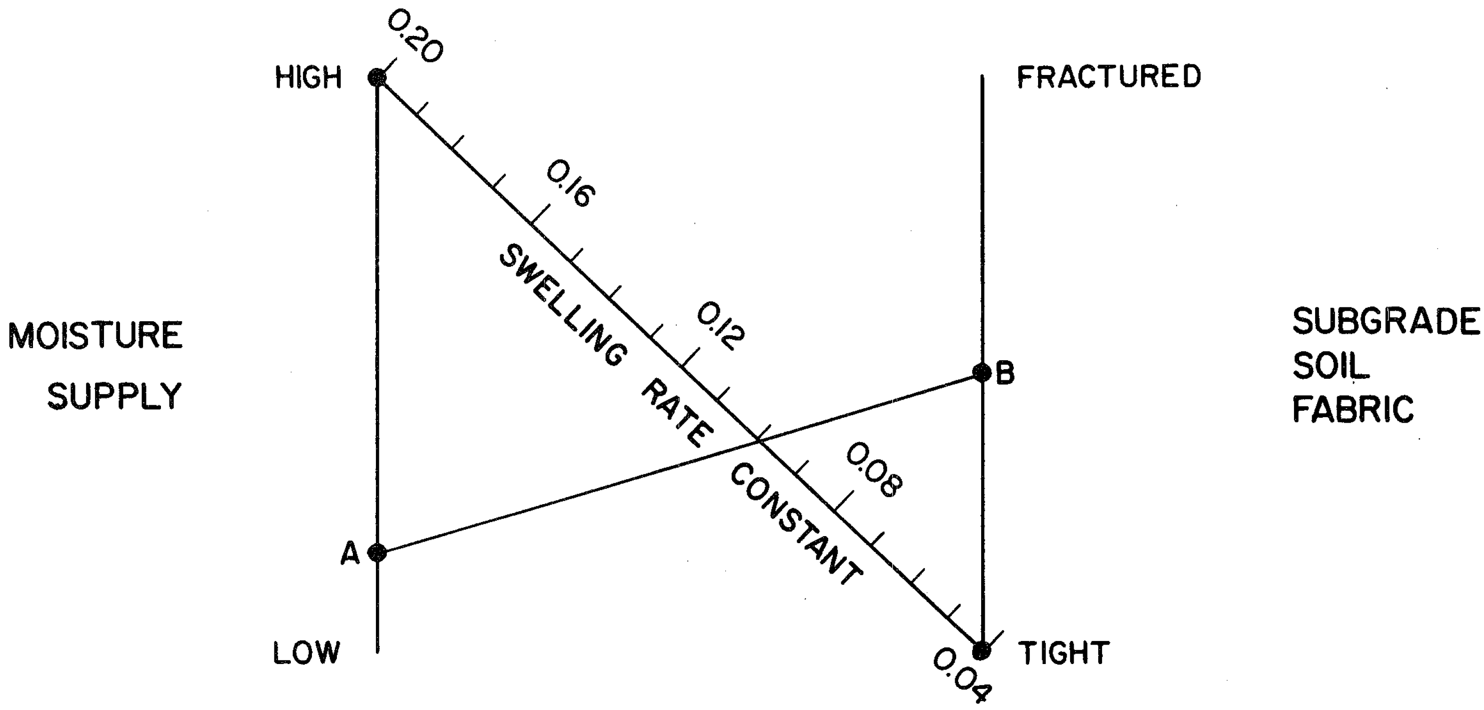

Figure 2: NOMOGRAPH FOR SELECTING SWELLING RATE CONSTANT

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

Low Rainfall
Good drainage

b) HIGH MOISTURE SUPPLY

High Rainfall
Poor drainage
Vicinity of culverts, bridge abutments, inlet leads

c) SOIL FABRIC CONDITIONS

Self explanatory

d) USE OF THE NOMOGRAPH

1) Select the appropriate moisture supply condition which may be somewhere between low and high (such as A).
2) Select the appropriate soil fabric (such as B).
3) Draw a straight line between the selected points (A to B).
4) Read SWRATE from the diagonal axis (read 0.10).

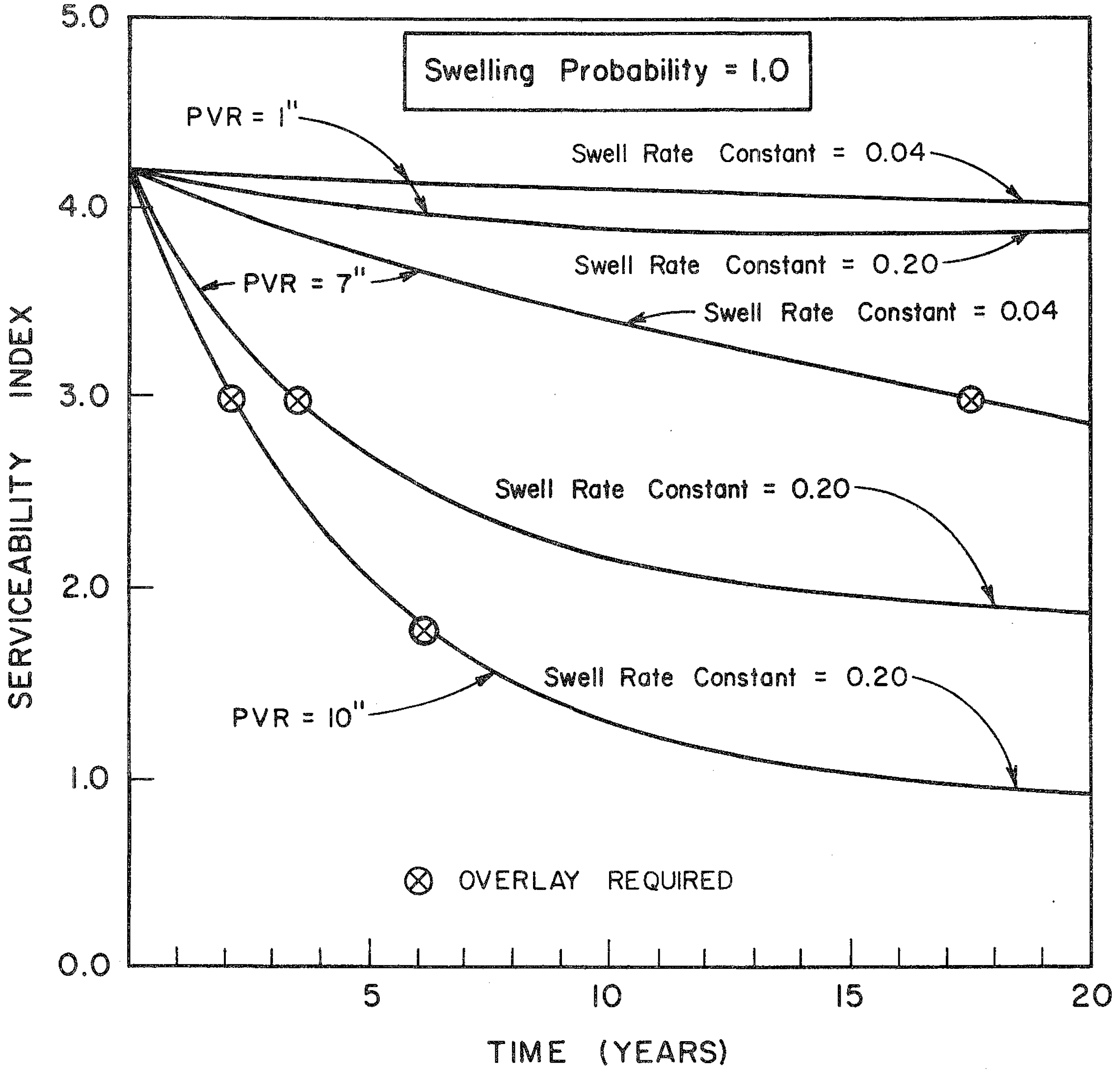

Figure 3: PERFORMANCE CURVES ILLUSTRATING SERVICEABILITY LOSS NOT CAUSED BY TRAFFIC

APPENDIX II.

EXAMPLE CODE SHEETS AND OUTPUT

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PROJECT IDENTIFICATION

1.0 Card type	01	1 2
1.1 Problem number	1B	3 4 5
1.2 District	14	6 7
1.3 County	TRAVIS	8 9 10 11 12 13 14 15 16 17 18 19 20 21
1.4 Control	3136	22 23 24 25
1.5 Section	01	26 27
1.6 Highway	LP 1 M0PAC	28 29 30 31 32 33 34 35 36 37
1.7 Date	05/24/72	38 39 40 41 42 43 44 45
1.8 IPE	238	46 47 48 49

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PROJECT COMMENTS

Card Type

```
02  EXAMPLE PROBLEM FOR FPS-11 DOCUMENTATIO
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    N REPORT USING THE NEW CONSTRUCTION
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

02  MODE.  THIS RUN IS THE SAME AS IN THE F
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    P DESIGN MANUAL EXCEPT FOR THE MINIMUM
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

02  TIME TO THE FIRST OVERLAY AND THE SALVA
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    GE VALUES.  THESE CHANGES REFLECT THE
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

02  RECOMMENDATIONS CONTAINED IN THE TEXT O
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    F THE DESIGNER'S MANUAL.
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

02
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

02
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

02
12  3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
    42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
```

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

BASIC DESIGN CRITERIA

3.0 Card type ____________________ 0 3
1 2

3.1 Length of analysis period (years) ____________________ 2 0
4 5

3.2 Minimum time to first overlay (years) ____________________ 6
9 10

3.3 Minimum time between overlay (years) ____________________ 6
14 15

3.4 Minimum serviceability index ____________________ 3 • 0
19 20 21

3.5 Design confidence level ____________________ E
23

3.6 Interest rate (%) ____________________ 7 • 0
25 26 27

PROGRAM CONTROLS AND CONSTRAINTS

4.0 Card type ____________________ 0 4
1 2

4.1 Problem type: 1 = new pavt. const., 2 = ACP overlay ____________________ 1
4

4.2 Number of summary output pages (8 designs/page) ____________________ 3
6

4.3 Max. funds available per S.Y. for initial const. ($) ____________________ 8 • 0 0
8 9 10 11

4.4 Maximum total thickness of initial construction (inches) ____________________ 3 6 • 0
13 14 15 16

4.5 Maximum total thickness of all overlays (inches) ____________________ 6 • 0
18 19 20 21

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

TRAFFIC DATA

5.0 Card type ________ 0 5
1 2

5.1 ADT at beginning of analysis period (veh./day) ________ 39330.
5 6 7 8 9 10 11

5.2 ADT at end of analysis period (veh./day) ________ 64752.
15 16 17 18 19 20 21

5.3 One-drctn. cumulative 18 KSA during analysis period ________ 6894000.
23 24 25 26 27 28 29 30 31

5.4 Avg. approach speed to the overlay zone (mph) ________ 50
34 35

5.5 Avg. speed through overlay zone (overlay direction) (mph) ________ 20
39 40

5.6 Avg. speed through overlay zone (non-overlay direction) (mph) ________ 50
44 45

5.7 Percent of ADT arriving ea. hr. of construction ________ 5.5
49 50 51

5.8 Percent trucks in ADT ________ 8
54 55

ENVIRONMENT AND SUBGRADE

6.0 Card type ________ 0 6
1 2

6.1 District temperature constant ________ 31
4 5

6.2 Swelling probability ________ 0.85
9 10 11 12

6.3 Potential vertical rise (inches) ________ 5.0
13 14 15 16

6.4 Swelling rate constant ________ 0.08
19 20 21 22

6.5 Subgrade stiffness coefficient ________ 0.26
24 25 26 27

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

CONSTRUCTION AND MAINTENANCE DATA

7.0	Card type	07	1 2
7.1	Initial serviceability index	4.0	4 5 6
7.2	Serviceability index after overlaying	3.9	9 10 11
7.3	Minimum overlay thickness (inches)	0.8	14 15 16
7.4	Overlay construction time (hrs/day)	7	19 20
7.5	Asph. conc. compacted density (tons/C.Y.)	1.26	24 25 26 27
7.6	Asph. conc. production rate (tons/hr)	75	28 29 30
7.7	Width of each lane (feet)	12	34 35
7.8	First year cost of routine maintenance (dollars/lane - mile)	100.00	38 39 40 41 42 43
7.9	Annual incremental increase in maintenance cost (dollars/lane - mile)	10.00	44 45 46 47 48 49

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

DETOUR DESIGN FOR OVERLAYS

8.0 Card type ________ 0 8
1 2

8.1 Detour model used during overlaying ________ 3
4

8.2 Total number of lanes of the facility ________ 6
5 6

8.3 Number of lanes open in the overlay direction ________ 1
8

8.4 Number of lanes open in the non-overlay direction ________ 3
10

8.5 Distance traffic is slowed (overlay direction) (miles) ________ 1 . 0
12 13 14

8.6 Distance traffic is slowed (non-overlay direction) (miles) ________ .
17 18 19

8.7 Detour distance around the overlay zone (miles) ________ .
22 23 24

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PAVING MATERIAL INFORMATION

10.0 Card type	1 0	1 2
10.1 Layer designation number	1	4
10.2 Letter code of material	A	8
10.3 Name of material	LT. WT. ACP	12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
10.4 In-place cost/comp. - C.Y. ($)	21.42	31 32 33 34 35
10.5 Stiffness coefficient	0.96	40 41 42 43
10.6 Min. allowable thickness of initial const. (inches)	1.00	47 48 49 50 51
10.7 Max. allowable thickness of initial const. (inches)	1.00	55 56 57 58 59
10.8 Material's salvage value as % of original cost	30	62 63 64 65
10.9 Check*	1	80

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PAVING MATERIAL INFORMATION

10.0	Card type	10	1 2
10.1	Layer designation number	2	4
10.2	Letter code of material	B	8
10.3	Name of material	ACP	12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
10.4	In-place cost/comp. - C.Y. ($)	15.48	31 32 33 34 35
10.5	Stiffness coefficient	0.96	40 41 42 43
10.6	Min. allowable thickness of initial const. (inches)	1.50	47 48 49 50 51
10.7	Max. allowable thickness of initial const. (inches)	1.50	55 56 57 58 59
10.8	Material's salvage value as % of original cost	30	62 63 64 65
10.9	Check*	1	80

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PAVING MATERIAL INFORMATION

10.0 Card type ________ 1 0
1 2

10.1 Layer designation number ________ 3
4

10.2 Letter code of material ________ C
8

10.3 Name of material ________ BLACK BASE
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

10.4 In-place cost/comp. - C.Y. ($) ________ 13•93
31 32 33 34 35

10.5 Stiffness coefficient ________ 0•96
40 41 42 43

10.6 Min. allowable thickness of initial const. (inches) ________ 2•50
47 48 49 50 51

10.7 Max. allowable thickness of initial const. (inches) ________ 10•00
55 56 57 58 59

10.8 Material's salvage value as % of original cost ________ 40
62 63 64 65

10.9 Check* ________ 1
80

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PAVING MATERIAL INFORMATION

10.0	Card type	10	1 2
10.1	Layer designation number	4	4
10.2	Letter code of material	D	8
10.3	Name of material	CRUSHED STONE	12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
10.4	In-place cost/comp. - C.Y. ($)	4.40	31 32 33 34 35
10.5	Stiffness coefficient	0.60	40 41 42 43
10.6	Min. allowable thickness of initial const. (inches)	10.00	47 48 49 50 51
10.7	Max. allowable thickness of initial const. (inches)	18.00	55 56 57 58 59
10.8	Material's salvage value as % of original cost	75	62 63 64 65
10.9	Check*	1	80

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PAVING MATERIAL INFORMATION

10.0	Card type	10	1 2
10.1	Layer designation number	5	4
10.2	Letter code of material	E	8
10.3	Name of material	LIME TREATED SUBG	12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
10.4	In-place cost/comp. - C.Y. ($)	2.40	31 32 33 34 35
10.5	Stiffness coefficient	0.40	40 41 42 43
10.6	Min. allowable thickness of initial const. (inches)	6.00	47 48 49 50 51
10.7	Max. allowable thickness of initial const. (inches)	6.00	55 56 57 58 59
10.8	Material's salvage value as % of original cost	90	62 63 64 65
10.9	Check*	0	80

```
                              TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

PROB   DIST.        COUNTY       CONT.  SECT.    HIGHWAY      DATE      IPE   PAGE
 1B     14          TRAVIS        3136    01    LP 1 MOPAC  05/24/72   238     1
*******************************************************************************
                            COMMENTS ABOUT THIS PROBLEM

EXAMPLE PROBLEM FOR FPS-11 DOCUMENTATION REPORT USING THE NEW CONSTRUCTION
MODE.  THIS RUN IS THE SAME AS IN THE FP DESIGN MANUAL EXCEPT FOR THE MINIMUM
TIME TO THE FIRST OVERLAY AND THE SALVAGE VALUES.  THESE CHANGES REFLECT THE
RECOMMENDATIONS CONTAINED IN THE TEXT OF THE DESIGNER'S MANUAL.
*******************************************************************************

BASIC DESIGN CRITERIA
*********************

  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                    20.0
  MINIMUM TIME TO FIRST OVERLAY (YEARS)                                     6.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                     6.0
  MINIMUM SERVICEABILITY INDEX P2                                           3.0
  DESIGN CONFIDENCE LEVEL                                                   E
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                            7.0

PROGRAM CONTROLS AND CONSTRAINTS
********************************

  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)                  3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)               8.00
  MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)               36.0
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)       6.0

TRAFFIC DATA
************

  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                     39330.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                              64752.
  ONE-DIRECTION 20.-YEAR ACCUMULATED NO. OF EQUIVALENT 18-KSA          6894000.
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                          50.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION) (MPH)             20.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)         50.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)            5.5
  PERCENT TRUCKS IN ADT                                                     8.0

ENVIRONMENT AND SUBGRADE
************************

  DISTRICT TEMPERATURE CONSTANT                                            31.0
  SWELLING PROBABILITY                                                      0.85
  POTENTIAL VERTICAL RISE (INCHES)                                          5.00
  SWELLING RATE CONSTANT                                                    0.08
  SUBGRADE STIFFNESS COEFFICIENT                                            0.26
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                              TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

PROB   DIST.        COUNTY       CONT.  SECT.    HIGHWAY      DATE      IPE    PAGE
 1B     14          TRAVIS        3136    01    LP 1 MOPAC  05/24/72    238      2

                              INPUT DATA CONTINUED


CONSTRUCTION AND MAINTENANCE DATA
*********************************

  SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                            4.0
  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                 3.9
  MINIMUM OVERLAY THICKNESS (INCHES)                                       0.8
  OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                    7.0
  ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                         1.26
  ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                          75.0
  WIDTH OF EACH LANE (FEET)                                               12.0
  FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)             100.00
  ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)     10.00

DETOUR DESIGN FOR OVERLAYS
**************************

  TRAFFIC MODEL USED DURING OVERLAYING                                     3
  TOTAL NUMBER OF LANES OF THE FACILITY                                    6
  NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)              1
  NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)         3
  DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                   1.00
  DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)               0.0
  DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                          0.0

PAVING MATERIALS INFORMATION
****************************

            MATERIALS              COST     STR.     MIN.     MAX.    SALVAGE,
   LAYER CODE     NAME            PER CY   COEFF.   DEPTH    DEPTH     PCT.
     1    A   LT. WT. ACP          21.42    0.96     1.00     1.00     30.00
     2    B   ACP                  15.48    0.96     1.50     1.50     30.00
     3    C   BLACK BASE           13.93    0.96     2.50    10.00     40.00
     4    D   CRUSHED STONE         4.40    0.60    10.00    18.00     75.00
     5    E   LIME TREATED SUBG     2.40    0.40     6.00     6.00     90.00
```

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                               TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                               FLEXIBLE PAVEMENT DESIGN

 PROB   DIST.      COUNTY       CONT.  SECT.    HIGHWAY      DATE      IPE    PAGE
  18     14        TRAVIS        3136    01   LP 1 MOPAC  05/24/72    238      3
 FOR THE 1 LAYER DESIGN WITH THE FOLLOWING MATERIALS--
        MATERIALS               COST    STR.     MIN.     MAX.   SALVAGE
LAYER CODE        NAME         PER CY  COEFF.   DEPTH    DEPTH    PCT.
  1    A   LT. WT. ACP         21.42    0.96     1.00     1.00   30.00
          SUBGRADE                      0.26

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

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                              TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

  PROB   DIST.      COUNTY      CONT.  SECT.    HIGHWAY     DATE     IPE    PAGE
   1B     14        TRAVIS       3136    01   LP 1 MOPAC  05/24/72   238      4
  FOR THE 2 LAYER DESIGN WITH THE FOLLOWING MATERIALS--
         MATERIALS              COST    STR.    MIN.     MAX.   SALVAGE
 LAYER CODE       NAME         PER CY  COEFF.  DEPTH    DEPTH    PCT.
   1    A   LT. WT. ACP        21.42    0.96    1.00     1.00   30.00
   2    B    ACP               15.48    0.96    1.50     1.50   30.00
          SUBGRADE                      0.26

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

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                              TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

  PROB   DIST.      COUNTY      CONT.  SECT.    HIGHWAY      DATE      1PE    PAGE
   1B     14        TRAVIS       3136    01    LP 1 MOPAC  05/24/72    238      5
  FOR THE 3 LAYER DESIGN WITH THE FOLLOWING MATERIALS--
        MATERIALS               COST    STR.     MIN.     MAX.   SALVAGE
 LAYER CODE       NAME         PER CY  COEFF.   DEPTH    DEPTH     PCT.
   1    A    LT. WT. ACP        21.42    0.96     1.00     1.00    30.00
   2    B    ACP                15.48    0.96     1.50     1.50    30.00
   3    C    BLACK BASE         13.93    0.96     2.50    10.00    40.00
            SUBGRADE                     0.26

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

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                              TEXAS HIGHWAY DEPARTMENT
                                     FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

  PROB   DIST.       COUNTY       CONT.  SECT.     HIGHWAY      DATE      IPE    PAGE
   18     14         TRAVIS       3136    01     LP 1 MOPAC  05/24/72    238      6
  FOR THE 4 LAYER DESIGN WITH THE FOLLOWING MATERIALS--
         MATERIALS               COST     STR.     MIN.      MAX.   SALVAGE
 LAYER CODE        NAME         PER CY  COEFF.   DEPTH     DEPTH     PCT.
   1     A   LT. WT. ACP        21.42    0.96     1.00      1.00    30.00
   2     B   ACP                15.48    0.96     1.50      1.50    30.00
   3     C   BLACK BASE         13.93    0.96     2.50     10.00    40.00
   4     D   CRUSHED STONE       4.40    0.60    10.00     18.00    75.00
          SUBGRADE                       0.26

   4   THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
        FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
              LT. WT. ACP           1.00 INCHES
              ACP                   1.50 INCHES
              BLACK BASE            4.50 INCHES
              CRUSHED STONE        17.50 INCHES
        THE LIFE OF THE INITIAL STRUCTURE =  9.05 YEARS
        THE OVERLAY SCHEDULE IS
              2.30 (INCH(ES) (INCLUDING 0.5 INCH LEVEL-UP) AFTER  9.05 YEARS.

        TOTAL LIFE =  20.92YEARS

        SERVICEABILITY LOSS DUE TO SWELLING CLAY IN EACH PERFORMANCE PERIOD IS
             (1)  0.733
             (2)  0.423

        THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
             INITIAL CONSTRUCTION COST           5.120
             TOTAL ROUTINE MAINTENANCE COST      0.223
             TOTAL OVERLAY CONSTRUCTION COST     0.744
             TOTAL USER COST DURING
                    OVERLAY CONSTRUCTION         0.127
             SALVAGE VALUE                      -0.774
             TOTAL OVERALL COST                  5.441


        NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --       39


          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
```

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                              TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

 PROB   DIST.      COUNTY      CONT.  SECT.    HIGHWAY      DATE      IPE    PAGE
  1B     14        TRAVIS       3136    01    LP 1 MOPAC  05/24/72    238      7
 FOR THE 5 LAYER DESIGN WITH THE FOLLOWING MATERIALS--
          MATERIALS            COST     STR.     MIN.     MAX.   SALVAGE
LAYER CODE       NAME         PER CY   COEFF.   DEPTH    DEPTH     PCT.
  1     A   LT. WT. ACP       21.42     0.96     1.00     1.00    30.00
  2     B   ACP               15.48     0.96     1.50     1.50    30.00
  3     C   BLACK BASE        13.93     0.96     2.50    10.00    40.00
  4     D   CRUSHED STONE      4.40     0.60    10.00    18.00    75.00
  5     E   LIME TREATED SUBG  2.40     0.40     6.00     6.00    90.00
          SUBGRADE                      0.26

  5    THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
        FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
              LT. WT. ACP          1.00 INCHES
              ACP                  1.50 INCHES
              BLACK BASE           4.50 INCHES
              CRUSHED STONE       15.00 INCHES
              LIME TREATED SUBG    6.00 INCHES
        THE LIFE OF THE INITIAL STRUCTURE =  9.39 YEARS
        THE OVERLAY SCHEDULE IS
              1.30 (INCH(ES) (INCLUDING 0.5 INCH LEVEL-UP) AFTER  9.39 YEARS.

        TOTAL LIFE =  20.11YEARS

        SERVICEABILITY LOSS DUE TO SWELLING CLAY IN EACH PERFORMANCE PERIOD IS
             (1)  0.752
             (2)  0.387

        THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
             INITIAL CONSTRUCTION COST           5.215
             TOTAL ROUTINE MAINTENANCE COST      0.223
             TOTAL OVERLAY CONSTRUCTION COST     0.421
             TOTAL USER COST DURING
                    OVERLAY CONSTRUCTION         0.121
             SALVAGE VALUE                      -0.761
             TOTAL OVERALL COST                  5.218


        NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --       40


          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  5
                      6. THE MAXIMUM DEPTH OF LAYER  5
```

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                            TEXAS HIGHWAY DEPARTMENT
                                    FPS - 11
                            FLEXIBLE PAVEMENT DESIGN

PROB   DIST.      COUNTY      CONT.  SECT.    HIGHWAY     DATE       IPE   PAGE
 1B     14        TRAVIS      3136    01    LP 1 MOPAC  05/24/72    238     8
                      SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST

                         1      2      3      4      5      6      7      8
********************************************************************************
MATERIAL ARRANGEMENT    ABCDE  ABCDE  ABCDE  ABCD   ABCD   ABCDE  ABCD   ABCDE
INIT. CONST. COST      5.21   5.30   5.13   5.12   5.20   4.52   4.79   4.83
OVERLAY CONST. COST    0.42   0.42   0.74   0.74   0.74   0.80   1.14   1.14
USER COST              0.12   0.13   0.13   0.13   0.13   0.72   0.19   0.19
ROUTINE MAINT. COST    0.22   0.22   0.22   0.22   0.22   0.20   0.22   0.22
SALVAGE VALUE         -0.76  -0.74  -0.83  -0.77  -0.75  -0.70  -0.79  -0.81
********************************************************************************
TOTAL COST             5.22   5.33   5.40   5.44   5.54   5.54   5.56   5.57
********************************************************************************
NUMBER OF LAYERS        5      5      5      4      4      5      4      5
********************************************************************************
LAYER DEPTH (INCHES)
     D(1)              1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00
     D(2)              1.50   1.50   1.50   1.50   1.50   1.50   1.50   1.50
     D(3)              4.50   5.50   3.50   4.50   5.50   3.50   3.50   3.50
     D(4)             15.00  12.50  17.50  17.50  15.00  12.50  18.00  15.00
     D(5)              6.00   6.00   6.00                 6.00          6.00
********************************************************************************
NO.OF PERF.PERIODS      2      2      2      2      2      3      2      2
********************************************************************************
PERF. TIME (YEARS)
     T(1)              9.4    9.4    9.1    9.0    9.1    6.9    7.9    8.1
     T(2)             20.1   20.3   21.0   20.9   21.0   13.2   20.2   20.6
     T(3)                                                20.1
********************************************************************************
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
     O(1)              1.3    1.3    2.3    2.3    2.3    1.3    3.3    3.3
     O(2)                                                 1.3
********************************************************************************
SWELLING CLAY LOSS
 (SERVICEABILITY)
    SC(1)              0.75   0.76   0.73   0.73   0.73   0.61   0.67   0.68
    SC(2)              0.39   0.39   0.42   0.42   0.42   0.32   0.47   0.47
    SC(3)                                                 0.21
********************************************************************************
```

```
                              TEXAS HIGHWAY DEPARTMENT
                                     FPS - 11
                              FLEXIBLE PAVEMENT DESIGN

PROB   DIST.       COUNTY       CONT.   SECT.     HIGHWAY      DATE      IPE    PAGE
 1B     14         TRAVIS        3136     01    LP 1 MOPAC  05/24/72    238      9
                          SUMMARY OF THE BEST DESIGN STRATEGIES
                            IN ORDER OF INCREASING TOTAL COST

                            9       10       11       12       13       14       15       16
*************************************************************************************************
MATERIAL ARRANGEMENT       ABCD     ABCD    ABCDE    ABCD     ABCD    ABCDE    ABCDE    ABCDE
INIT. CONST. COST          5.51     5.28     4.91     5.59     5.67     5.38     4.99     4.75
OVERLAY CONST. COST        0.39     0.74     1.14     0.39     0.39     0.74     1.14     0.73
USER COST                  0.24     0.13     0.19     0.23     0.20     0.19     0.19     0.88
ROUTINE MAINT. COST        0.22     0.22     0.22     0.22     0.22     0.22     0.22     0.21
SALVAGE VALUE             -0.77    -0.74    -0.79    -0.75    -0.73    -0.77    -0.78    -0.78
*************************************************************************************************
TOTAL COST                 5.59     5.64     5.67     5.69     5.76     5.77     5.77     5.79
*************************************************************************************************
NUMBER OF LAYERS             4        4        5        4        4        5        5        5
*************************************************************************************************
LAYER DEPTH (INCHES)
     D(1)                  1.00     1.00     1.00     1.00     1.00     1.00     1.00     1.00
     D(2)                  1.50     1.50     1.50     1.50     1.50     1.50     1.50     1.50
     D(3)                  5.50     6.50     4.50     6.50     7.50     6.50     5.50     2.50
     D(4)                 17.50    12.50    12.50    15.00    12.50    10.00    10.00    17.50
     D(5)                                   6.00                       6.00     6.00     6.00
*************************************************************************************************
NO.OF PERF.PERIODS           2        2        2        2        2        2        2        3
*************************************************************************************************
PERF. TIME (YEARS)
     T(1)                 10.1      8.9      8.2     10.1      9.9      9.3      8.1      7.6
     T(2)                 22.9     20.3     21.1     22.7     22.0     21.9     20.8     15.0
     T(3)                                                                                23.3
*************************************************************************************************
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
     O(1)                  1.3      2.3      3.3      1.3      1.3      2.3      3.3      1.3
     O(2)                                                                                 1.3
*************************************************************************************************
SWELLING CLAY LOSS
 (SERVICEABILITY)
    SC(1)                  0.79     0.72     0.69     0.79     0.78     0.75     0.68     0.65
    SC(2)                  0.41     0.42     0.48     0.40     0.40     0.43     0.47     0.34
    SC(3)                                                                                0.21
*************************************************************************************************
```

```
                            TEXAS HIGHWAY DEPARTMENT
                                    FPS - 11
                            FLEXIBLE PAVEMENT DESIGN

PROB   DIST.      COUNTY      CONT.  SECT.    HIGHWAY     DATE     IPE   PAGE
 18     14        TRAVIS      3136    01    LP 1 MOPAC  05/24/72   238    10
                      SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST

                         17     18     19     20     21     22     23     24
********************************************************************************
MATERIAL ARRANGEMENT    ABCD   ABCD   ABCD   ABCDE  ABCDE  ABCDE  ABCD   ABCD
INIT. CONST. COST       5.75   4.35   4.73   4.81   4.44   5.76   4.81   4.43
OVERLAY CONST. COST     0.39   1.23   1.49   1.49   1.15   0.39   1.49   1.23
USER COST               0.15   0.76   0.25   0.25   0.85   0.26   0.25   0.82
ROUTINE MAINT. COST     0.22   0.20   0.22   0.22   0.20   0.22   0.22   0.20
SALVAGE VALUE          -0.71  -0.73  -0.83  -0.89  -0.76  -0.76  -0.81  -0.71
********************************************************************************
TOTAL COST              5.80   5.81   5.86   5.87   5.88   5.88   5.97   5.98
********************************************************************************
NUMBER OF LAYERS          4      4      4      5      5      5      4      4
********************************************************************************
LAYER DEPTH (INCHES)
     D(1)               1.00   1.00   1.00   1.00   1.00   1.00   1.00   1.00
     D(2)               1.50   1.50   1.50   1.50   1.50   1.50   1.50   1.50
     D(3)               8.50   2.50   3.50   2.50   2.50   7.50   4.50   3.50
     D(4)              10.00  17.50  17.50  18.00  15.00  10.00  15.00  15.00
     D(5)                                   6.00   6.00   6.00
********************************************************************************
NO.OF PERF.PERIODS        2      3      2      2      3      2      2      3
********************************************************************************
PERF. TIME (YEARS)
     T(1)               9.6    6.3    7.7    7.8    6.7   10.3    7.8    6.5
     T(2)              20.8   13.1   22.8   23.1   14.0   23.5   23.1   13.5
     T(3)                     20.6                 22.3                 21.4
********************************************************************************
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
     O(1)               1.3    2.3    4.3    4.3    2.3    1.3    4.3    2.3
     O(2)                      1.3                  1.3                  1.3
********************************************************************************
SWELLING CLAY LOSS
 (SERVICEABILITY)
    SC(1)               0.76   0.57   0.66   0.66   0.59   0.80   0.66   0.58
    SC(2)               0.39   0.36   0.54   0.54   0.37   0.41   0.54   0.36
    SC(3)                      0.23                 0.23                 0.23
********************************************************************************


        THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS         79
```

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PROJECT IDENTIFICATION

1.0	Card type	01	1 2
1.1	Problem number	130	3 4 5
1.2	District	14	6 7
1.3	County	TRAVIS	8 9 10 11 12 13 14 15 16 17 18 19 20 21
1.4	Control	3136	22 23 24 25
1.5	Section	1	26 27
1.6	Highway	LP 1 MOPAC	28 29 30 31 32 33 34 35 36 37
1.7	Date	05/24/72	38 39 40 41 42 43 44 45
1.8	IPE	238	46 47 48 49

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PROJECT COMMENTS

Card Type

02 EXAMPLE PRØBLEM FØR FPS-11 DØCUMENTATIØ
N REPØRT USING THE ACP ØVERLAY MØDE.

02 THIS RUN SIMULATES THE ANTICIPATED NEED
TØ ØVERLAY MØPAC TEN YEARS HENCE. NO-

02 TE THAT A 'MEASURED' SCI ØF 0.10 IS ASS
UMED. THIS IS LARGER THAN WØULD HAVE

02 BEEN PREDICTED BY FPS-11 IN INITIAL CØN
STRUCTIØN. TRAFFIC HAS BEEN PRØJECTED

02 TØ INCREASE AT ABØUT THE SAME RATE FROM
1992 TØ 2002 AS FRØM 1972 TØ 1992. LP

02 1 IS THEREFØRE PREDICTED TØ APPRØACH HØ
URLY DAYTIME CAPACITY BY 2000. INPUT

02 9.7 IS A WEIGHTED VALUE USING 10 YEAR L
IFE IN TABLE 10.1 ØF 1972 FPD MANUAL.

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

BASIC DESIGN CRITERIA

3.0 Card type 0 3
1 2

3.1 Length of analysis period (years) 2 0
4 5

3.2 Minimum time to first overlay (years)
9 10

3.3 Minimum time between overlay (years) 6
14 15

3.4 Minimum serviceability index 3 • 0
19 20 21

3.5 Design confidence level D
23

3.6 Interest rate (%) 7 • 0
25 26 27

PROGRAM CONTROLS AND CONSTRAINTS

4.0 Card type 0 4
1 2

4.1 Problem type: 1 = new pavt. const., 2 = ACP overlay 2
4

4.2 Number of summary output pages (8 designs/page) 3
6

4.3 Max. funds available per S.Y. for initial const. ($) 5 • 0 0
8 9 10 11

4.4 Maximum total thickness of initial construction (inches) •
13 14 15 16

4.5 Maximum total thickness of all overlays (inches) 1 0 • 0
18 19 20 21

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

TRAFFIC DATA

5.0 Card type ________ 05
1 2

5.1 ADT at beginning of analysis period (veh./day) ________ 52000.
5 6 7 8 9 10 11

5.2 ADT at end of analysis period (veh./day) ________ 104000.
15 16 17 18 19 20 21

5.3 One-drctn. cumulative 18 KSA during analysis period ________ 8272800.
23 24 25 26 27 28 29 30 31

5.4 Avg. approach speed to the overlay zone (mph) ________ 50
34 35

5.5 Avg. speed through overlay zone (overlay direction) (mph) ________ 20
39 40

5.6 Avg. speed through overlay zone (non-overlay direction) (mph) ________ 50
44 45

5.7 Percent of ADT arriving ea. hr. of construction ________ 5.5
49 50 51

5.8 Percent trucks in ADT ________ 8
54 55

ENVIRONMENT AND SUBGRADE

6.0 Card type ________ 06
1 2

6.1 District temperature constant ________ 31
4 5

6.2 Swelling probability ________ 0.85
9 10 11 12

6.3 Potential vertical rise (inches) ________ 2.3
13 14 15 16

6.4 Swelling rate constant ________ 0.08
19 20 21 22

6.5 Subgrade stiffness coefficient ________ .
24 25 26 27

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

CONSTRUCTION AND MAINTENANCE DATA

7.0 Card type ____ 07
1 2

7.1 Initial serviceability index ____ .
4 5 6

7.2 Serviceability index after overlaying ____ 3.9
9 10 11

7.3 Minimum overlay thickness (inches) ____ 0.5
14 15 16

7.4 Overlay construction time (hrs/day) ____ 7
19 20

7.5 Asph. conc. compacted density (tons/C.Y.) ____ 2.00
24 25 26 27

7.6 Asph. conc. production rate (tons/hr) ____ 120
28 29 30

7.7 Width of each lane (feet) ____ 12
34 35

7.8 First year cost of routine maintenance ____ 100.00
(dollars/lane - mile)
38 39 40 41 42 43

7.9 Annual incremental increase in maintenance cost ____ 10.00
(dollars/lane - mile)
44 45 46 47 48 49

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

DETOUR DESIGN FOR OVERLAYS

8.0 Card type ______ 0 8
1 2

8.1 Detour model used during overlaying ______ 3
4

8.2 Total number of lanes of the facility ______ 6
5 6

8.3 Number of lanes open in the overlay direction ______ 1
8

8.4 Number of lanes open in the non-overlay direction ______ 3
10

8.5 Distance traffic is slowed (overlay direction) (miles) ______ 1 • 0
12 13 14

8.6 Distance traffic is slowed (non-overlay direction) (miles) ______ 0 • 0
17 18 19

8.7 Detour distance around the overlay zone (miles) ______ 0 • 0
22 23 24

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

EXISTING PAVEMENT AND PROPOSED ACP

9.0	Card type	09	1 2
9.1	SCI of the existing pavement	0.100	3 4 5 6 7
9.2	The standard deviation of SCI	0.035	8 9 10 11 12
9.3	The composite thickness of the existing pavement (inches)	28.0	13 14 15 16
9.4	In-place cost/comp. - C.Y. of proposed ACP ($)	15.48	18 19 20 21 22
9.5	Proposed ACP's salvage value as % of original cost	10	23 24 25 26
9.6	In-place value of existing pavement/comp. - C.Y. ($)	5.21	29 30 31 32 33
9.7	Existing pavement's salvage value as % of present value	66	34 35 36 37
9.8	Level-up required for the first overlay (inches)	1.0	41 42 43

```
                            TEXAS HIGHWAY DEPARTMENT
                                    FPS - 11
                               ACP OVERLAY DESIGN

PROB   DIST.      COUNTY      CONT.  SECT.    HIGHWAY     DATE     IPE   PAGE
180     14    TRAVIS          3136     1    LP 1 MOPAC  05/24/72   238     1
********************************************************************************
                        COMMENTS ABOUT THIS PROBLEM

EXAMPLE PROBLEM FOR FPS 11 DOCUMENTATION REPORT USING THE ACP OVERLAY MODE.
THIS RUN SIMULATES THE ANTICIPATED NEEDTO OVERLAY MOPAC TEN YEARS HENCE.  NOTE
THAT A 'MEASURED' SCI OF 0.10 IS ASSUMED.  THIS IS LARGER THAN WOULD HAVE BEEN
PREDICTED BY FPS 11 IN INITIAL CONSTRUCTION.  TRAFFIC HAS BEEN PROJECTED TO
INCREASE AT ABOUT THE SAME RATE FROM 1992 TO 2002 AS FROM 1972 TO 1992. LP 1
IS THEREFORE PREDICTED TO APPROACH HOURLY DAYTIME CAPACITY BY 2000. INPUT 9.7
IS A WEIGHTED VALUE USING 10 YEAR LIFE IN TABLE 10.1 OF 1972 FP DESIGN MANUAL.
********************************************************************************

BASIC DESIGN CRITERIA
*********************

  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                    20.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                     6.0
  MINIMUM SERVICEABILITY INDEX P2                                           3.0
  DESIGN CONFIDENCE LEVEL                                                   D
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                            7.0

PROGRAM CONTROLS AND CONSTRAINTS
********************************

  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)                  3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR FIRST OVERLAY (DOLLARS)                5.00
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)      10.0

TRAFFIC DATA
************

  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                    52000.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                            104000.
  ONE-DIRECTION 20.-YEAR ACCUMULATED NO. OF EQUIVALENT 18-KSA         8272800.
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                          50.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION) (MPH)             20.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)         50.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)            5.5
  PERCENT TRUCKS IN ADT                                                     8.0

ENVIRONMENT AND SUBGRADE
************************

  DISTRICT TEMPERATURE CONSTANT                                            31.0
  SWELLING PROBABILITY                                                      0.85
  POTENTIAL VERTICAL RISE (INCHES)                                          2.30
  SWELLING RATE CONSTANT                                                    0.08
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                              TEXAS HIGHWAY DEPARTMENT
                                      FPS - 11
                                 ACP OVERLAY DESIGN

PROB   DIST.       COUNTY          CONT.  SECT.     HIGHWAY      DATE      IPE    PAGE
180     14     TRAVIS              3136     1    LP 1 MOPAC  05/24/72   238      2

                               INPUT DATA CONTINUED


CONSTRUCTION AND MAINTENANCE DATA
*********************************

  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                       3.9
  MINIMUM OVERLAY THICKNESS (INCHES)                                             0.5
  OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                          7.0
  ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                               2.00
  ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                               120.0
  WIDTH OF EACH LANE (FEET)                                                     12.0
  FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)                   100.00
  ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)           10.00

DETOUR DESIGN FOR OVERLAYS
**************************

  TRAFFIC MODEL USED DURING OVERLAYING                                           3
  TOTAL NUMBER OF LANES OF THE FACILITY                                          6
  NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)                    1
  NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)               3
  DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                         1.00
  DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)                     0.0
  DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                                0.0

EXISTING PAVEMENT AND PROPOSED ACP
**********************************

  THE AVERAGE SCI OF THE EXISTING PAVEMENT                                        0.100
  THE STANDARD DEVIATION OF SCI                                                   0.035
  THE COMPOSITE THICKNESS OF THE EXISTING PAVEMENT (INCHES)                     28.0
  THE IN-PLACE COST/COMPACTED C.Y. OF PROPOSED ACP (DOLLARS)                    15.48
  SALVAGE VALUE OF PROPOSED ACP AT END OF ANALYSIS PERIOD (PERCENT)             10.0
  IN-PLACE VALUE OF EXISTING PAVEMENT (DOLLARS/C.Y.)                             5.21
  SALVAGE VALUE OF EXISTING PAVT. AT END OF ANALYSIS PERIOD (PERCENT)           66.0
  LEVEL-UP REQUIRED FOR THE FIRST OVERLAY (INCHES)                               1.00
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                                    TEXAS HIGHWAY DEPARTMENT
                                           FPS - 11
                                       ACP OVERLAY DESIGN

PROB    DIST.       COUNTY          CONT.   SECT.     HIGHWAY      DATE       IPE     PAGE
180      14     TRAVIS               3136     1     LP 1 MOPAC  05/24/72     238       3

          AVERAGE SCI = 0.100                          CCNFIDENCE LEVEL = D

                             SUMMARY OF THE BEST OVERLAY SCHEMES
                              IN ORDER OF INCREASING TOTAL COST

                              1      2      3      4
**************************************************
INITIAL OVERLAY
   CONSTRUCTION COST   3.22   2.36   1.93   1.93
   USER COST           2.38   1.75   1.43   1.43
FUTURE OVERLAY(S)
   CONSTRUCTION COST   0.0    0.19   0.75   0.40
   USER COST           0.0    6.16  12.00  14.14
ROUTINE MAINT. COST    0.28   0.23   0.22   0.21
SALVAGE VALUE         -0.76  -0.75  -0.76  -0.74
**************************************************
**************************************************
TOTAL COST             5.13   9.95  15.58  17.37
**************************************************
**************************************************
NO.OF PERF.PERIODS       1      2      2      3
**************************************************
PERF. TIME (YEARS)
     T(1)             22.9   12.2    8.2    8.2
     T(2)                    24.5   21.7   16.1
     T(3)                                  23.3
**************************************************
1ST LEVEL-UP(INCHES)   1.0    1.0    1.0    1.0
FUTURE LEVEL-UP(S)     0.5    0.5    0.5    0.5
**************************************************
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
     O(1)              7.5    5.5    4.5    4.5
     O(2)                     1.0    3.0    1.0
     O(3)                                   1.0
**************************************************
SWELLING CLAY LOSS
 (SERVICEABILITY)
    SC(1)              0.55   C.41   0.32   0.32
    SC(2)                     0.16   0.22   0.16
    SC(3)                                   0.C8
**************************************************


       THE TOTAL NUMBER OF FEASIBLE OVERLAY SCHEMES CONSIDERED WAS          4
```