A RECOMMENDED TEXAS HIGHWAY DEPARTMENT PAVEMENT DESIGN SYSTEM USER'S MANUAL

by

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A System Analysis of Pavement Design
and Research Implementation

Research Project 1-8-68-123

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PREFACE

This report is not a research report in the sense that it contains any new research results. It does illustrate the type of effort that is necessary to "bridge the gap" between research and operating personnel.

It is expected that the Texas Highway Department will ultimately publish the User's Manual in loose leaf form for easy revision. The basis for this report are the following research reports:

123-1	"A Systems Approach Applied to Pavement Design and Research"
32-11	"A Systems Approach to the Flexible Pavement Design Problem"
32-12	"An Empirical Equation for Predicting Pavement Deflection"
32-13	"Flexible Pavement Performance Related to Deflections, Axle Applications, Temperature and Foundation Movements"
101-1F	"Utilizing Deflection Measurements to Upgrade Pavement Structures"

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ABSTRACT

This manual provides instructions to the Texas Highway Department operating personnel for collecting, developing, and processing data for use in the "THD Flexible Pavement Design System". Detailed coding instructions are given for each of the three computer programs used in the design system.

The first program, "STIFFNESS COEFFICIENT", uses the measurements obtained with the Dynaflect to calculate deflections. Deflections, together with total thickness of the existing pavement, are used to calculate stiffness coefficients for the subgrade and pavement.

The second program, "PROFILE ANALYSIS", makes the necessary calculations to verify statistically the engineer's selection of subgrade design sections.

The third program, "FPS-7", uses the coefficients calculated previously, performance variables, traffic variables, cost variables, and design variables, etc. to calculate the optimum designs.

Examples of the computer program inputs and outputs are also included.

CHAPTER 1. OBJECTIVES

The objective of the "THD Pavement Design System User's Manual" is to provide guidelines for the Texas Highway Department to design flexible pavements by a rational design system.

This manual provides a "Systems Approach" to the Design of Flexible Pavements. The model for the Flexible Pavement System (FPS for short) was developed in Research Project 32 at the Texas Transportation Institute (Reference 1).

This design system takes into account both physical and cost variables, and provides means for making design decisions based on probable overall costs rather than on initial construction costs alone.

The solution of the design equations, and the search for the least-cost design, are made using a computer because of the number of variables involved, and the need to investigate all possible designs meeting selected criteria.

In writing the computer program, FPS-7, (Reference 1), an attempt was made to provide for ease of change, so that as new findings are made in flexible pavement research, they can be incorporated into the program with a minimum effort.

CHAPTER 2. FPS GENERAL JOB FLOW

This manual provides instructions for collecting and processing data for use in the "THD Flexible Pavement Design System".

The "General Flow Diagram", Figure 2.1, shows how work will progress on a flexible pavement design problem. The three blocks enclosed by dashed lines constitute the scope of this manual.

The "FPS Job Flow Diagram", Figure 2.2, shows the flow of work as discussed in this manual. The subject matter in each of the blocks is discussed in detail in Chapter 3. Chapter 4 gives in detail the coding instructions for the three computer programs used in the Flexible Pavement Design System. Examples of the program's inputs and outputs are included in Appendices A, B, and C.

THD FLEXIBLE PAVEMENT DESIGN SYSTEM

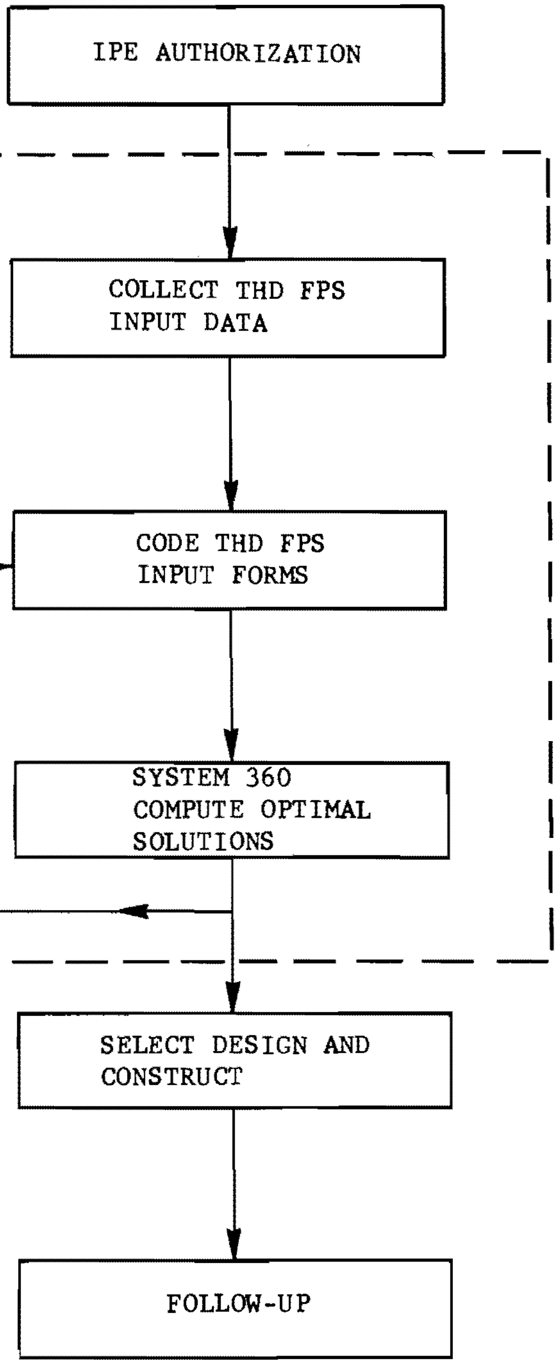
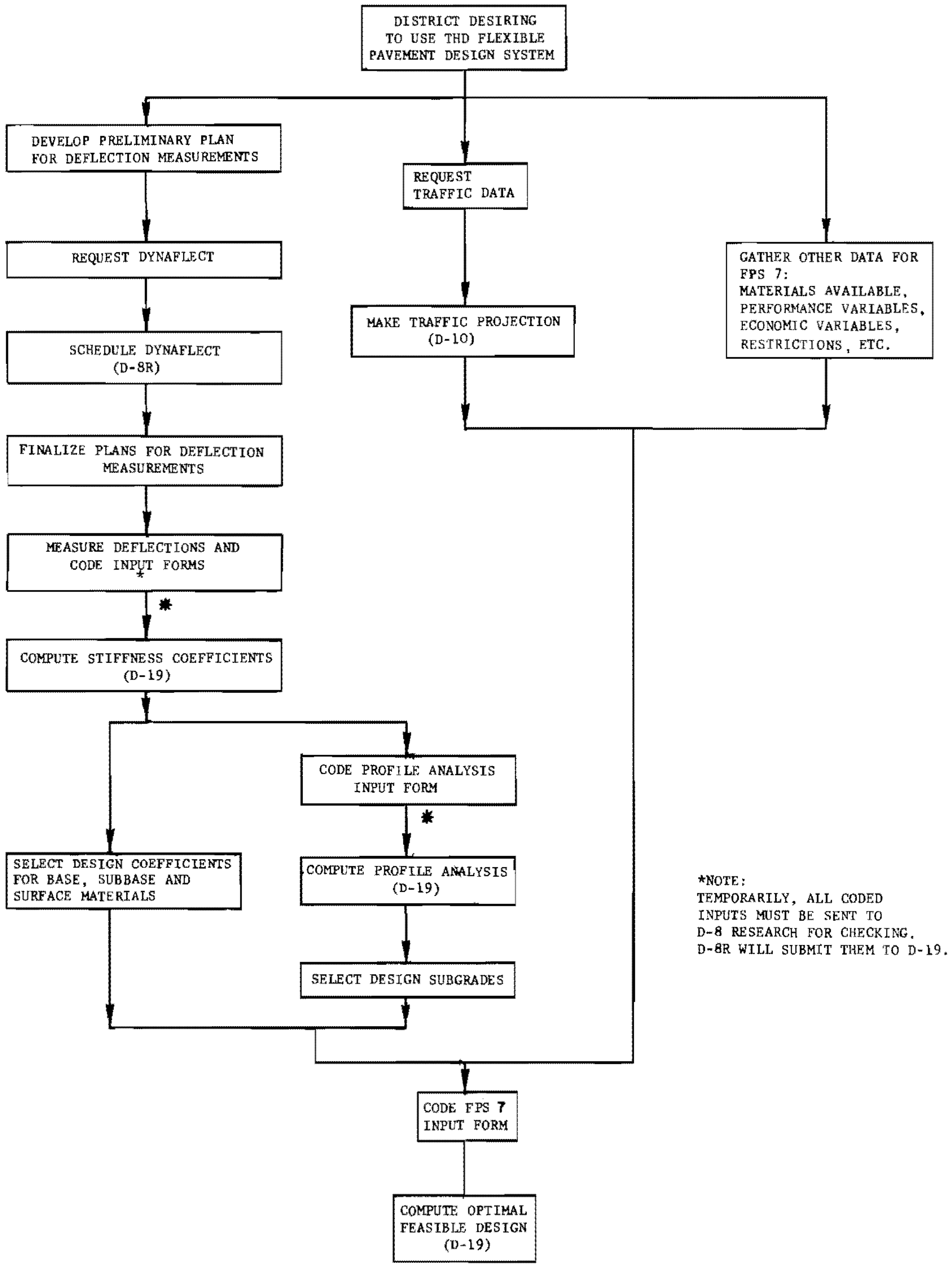


Figure 2.1 GENERAL FLOW DIAGRAM

THD FLEXIBLE PAVEMENT DESIGN SYSTEM



*NOTE:
TEMPORARILY, ALL CODED INPUTS MUST BE SENT TO D-8 RESEARCH FOR CHECKING. D-8R WILL SUBMIT THEM TO D-19.

Figure 2.2 FPS JOB FLOW DIAGRAM

CHAPTER 3. COLLECTING INPUT DATA

This chapter is designed to serve as a guide for the design engineer who is using the THD Flexible Pavement Design System. Emphasis is on developing reasonable inputs to the computer programs. Actual coding for the computer programs is discussed in Chapter 4.

STIFFNESS COEFFICIENTS

With deflections and composite pavement thickness as inputs, stiffness coefficients can be computed from an empirical deflection equation (Reference 2). The computer program "Stiffness Coefficient", which solves these equations is discussed later under the section "STIFFNESS COEFFICIENT PROGRAM".

The Highway Department has two Dynaflects that are availalbe to any District. A Dynaflect should be requested at least 6-weeks in advance (See Appendix D for order form) to insure availability as well as to aid in scheduling for state-wide use. D-8R will furnish one man to operate the Dynaflect vehicle and the District will be required to furnish men to record data and provide traffic protection.

Field Measurements:

The Dynaflect load wheels should be placed in the outside wheel path for measuring deflections to be used in calculating stiffness coefficients.

Base Material Coefficients: To determine coefficients of base materials the designer should choose several existing pavements in the general area of the proposed pavement that have (a) relatively thin surfacing materials, (b) a base material similar to the material proposed for the new pavement, and (c) little or no subbase. To be avoided for use in determining coefficients are base materials which have not reached moisture equilibrium and base materials which are in badly deteriorated pavements. It is recommended that approximately 30 Dynaflect readings be taken on similar base materials.

A practical solution to the sampling procedure might be to take 8 to 10 deflections sampled on each of 3 or 4 different pavements. Steps should be taken to insure that the points to be measured are selected in an unbiased manner. A more desirable sampling procedure would be to take 2 to 3 measurements on each of 10 to 15 different projects. This should give a better measure of possible variation in the material from project to project as well as within projects.

Subbase Material Coefficients: The same procedure discussed previously for base material should be used for determining subbase material coefficients when such materials can be found in existing projects as base materials. For weak subbases such as sand-clays and lime treated subgrades that never appear as the predominant part of a pavement structure, it is necessary to extrapolate stiffness coefficients from those found on subgrade materials. It is felt that such subbases have about the same stiffness as good subgrades (non-rock), and poor base materials.

Subgrade Coefficients: When determining coefficients of subgrade, two types of problems are encountered – (1) "existing pavement" to be reworked and (2) "new location" where a new pavement is to be built. In either case it is important that changes in subgrade be detected.

The problem of an "existing pavement" is an ideal situation for using the Dynaflect. A profile of deflection can be made along the outside wheel-path of both directions of traffic. With the aid of the computer, the stiffness coefficients of the subgrade can be calculated for the entire profile. From studying the stiffness coefficient profile, changes in subgrade can be detected as discussed later under Statistical Analysis of Subgrade.

A "New location" presents a more complicated problem with the first step in solving the problem being similar to current methods of determining subgrade changes. In this step, the designer needs to determine what type subgrades are present and where changes in subgrade occur. This can be done utilizing any of several aids including laboratory testing; geologic, pedologic, and topographic maps; aerial photographs; and engineering experience. After the engineer has isolated different types of subgrade, existing pavements with similar subgrades should be choosen to measure deflections with the Dynaflect and to determine stiffness coefficients. Approximately 30 measurements, selected in an unbiased manner, should be taken for each design subgrade section.

When selecting test sections from an existing pavement, consideration should be given to having that section simulate the proposed section as close as possible. Some features to consider are as follows:

Fill or cut section
Crest or sag of vertical curve
Drainage conditions
Curbed or uncurbed section
Trenched or nontrenched
Paved or unpaved shoulders
Age of pavement

After deflections have been measured, stiffness coefficients can be calculated on the computer.

Computation of Stiffness Coefficients:

The object of the "STIFFNESS COEFFICIENT PROGRAM" is to calculate stiffness coefficients from deflection measurements obtained with the Dynaflect. Field readings obtained with the Dynaflect should be coded as discussed in Chapter 4 under "STIFFNESS COEFFICIENT PROGRAM". The code sheet should be submitted to D-8R for proofing and submitting to the Automation Division. See "Appendix A" for example inputs and outputs from this program. (It is expected that in time D-8R will be eliminated as the "middle agent" in this process).

Statistical Analysis of Subgrade Sections (PROFILE ANALYSIS PROGRAM*)

The object of this program is to make the necessary calculations to statistically verify the engineer's selection of subgrade design sections. One method of selecting the subgrade changes is to plot the stiffness coefficients on graph paper and visually select the apparent changes in subgrade. Figure 3.1 shows an example subgrade coefficient profile with selected subgrade changes labeled as apparent break-points (subgrade changes). The program uses analysis of variance, as discussed in Reference 4, pp 253-4, to check for significant difference between adjacent sections. If any section is found not to be significantly different from an adjacent section; the two sections are combined. To illustrate the mechanics of this program Table 3.1 outlines the manner in which calculations were made on the data in Figure 3.1.

* Developed in Texas Research Project 1-8-66-101, "Utilizing Deflection Measurements to Upgrade Pavement Structures".

TABLE 3.1: STATISTICAL CHECKS BY PROFILE ANALYSIS

Check Number	Analysis of Variance Section No.	Statistical Difference at 95% confidence Level	Intermediate Step Between Checks
1	1 vs 2	Yes	None
2	2 vs 3	Yes	None
3	3 vs 4	No	Combine 3 & 4
4	3 & 4 vs 5	No	Combine 3,4, & 5
5	3,4, & 5 vs 6	Yes	None
6	6 vs 7	Yes	None
7	7 vs 8	Yes	None
8	8 vs 9	Yes	None
9	9 vs 10	No	Combine 9 & 10

After checking the original ten sections it was found that Sections 3,4, and 5 were not statistically different from each other at the 95% confidence level so they were combined into one; as were sections 9 and 10. This procedure eliminated five sections and created two new sections, leaving a total of seven sections. Then, checks were made to determine if the combined sections were significantly different from the preceding section. The results verified that Section No. 2 differed from the combination of Sections No. 3,4, and 5, and Section No. 8 differed from the combination of Sections No. 9 and 10. The remaining seven sections are shown in the output for this program (Appendix B). Figure 3.2 illustrates the remaining statistically different sections with the calculated average line and average line minus one standard deviation.

Coding for the "PROFILE ANALYSIS PROGRAM" is discussed in Chapter 4. Code sheets must be submitted to D-8R for proofing and handling with the Automation Division.

Selecting Design Coefficients:

Ideally, design inputs should be chosen to obtain an answer having a desired confidence level. Because of the complicated design equations and many variables involved in Program FPS-7, a rigorous statistical analysis that will compute confidence levels has not been developed. A sensitivity analysis is now being conducted by the Center for Highway Research, at the University of Texas, and it is hoped that this analysis will help develop recommended design values for Stiffness Coefficients and other inputs. For the present, based on limited experience, it is recommended that average coefficients be used for base and pavement materials. Subgrade coefficients should be chosen for each significantly different section. It is recommended that the design values for subgrade coefficients be the average value minus one standard deviation.

In most cases stiffness coefficients for thin layered surfacing materials cannot be determined from deflection measurements because of boundary conditions imposed in developing the deflection equations. Based on work in Research Project 32, which developed the equation; work in Research Project 101; and experience gained in measuring base material coefficients in the field; it is recommended that a stiffness coefficient of 0.75 be used for asphaltic concrete surfacing.

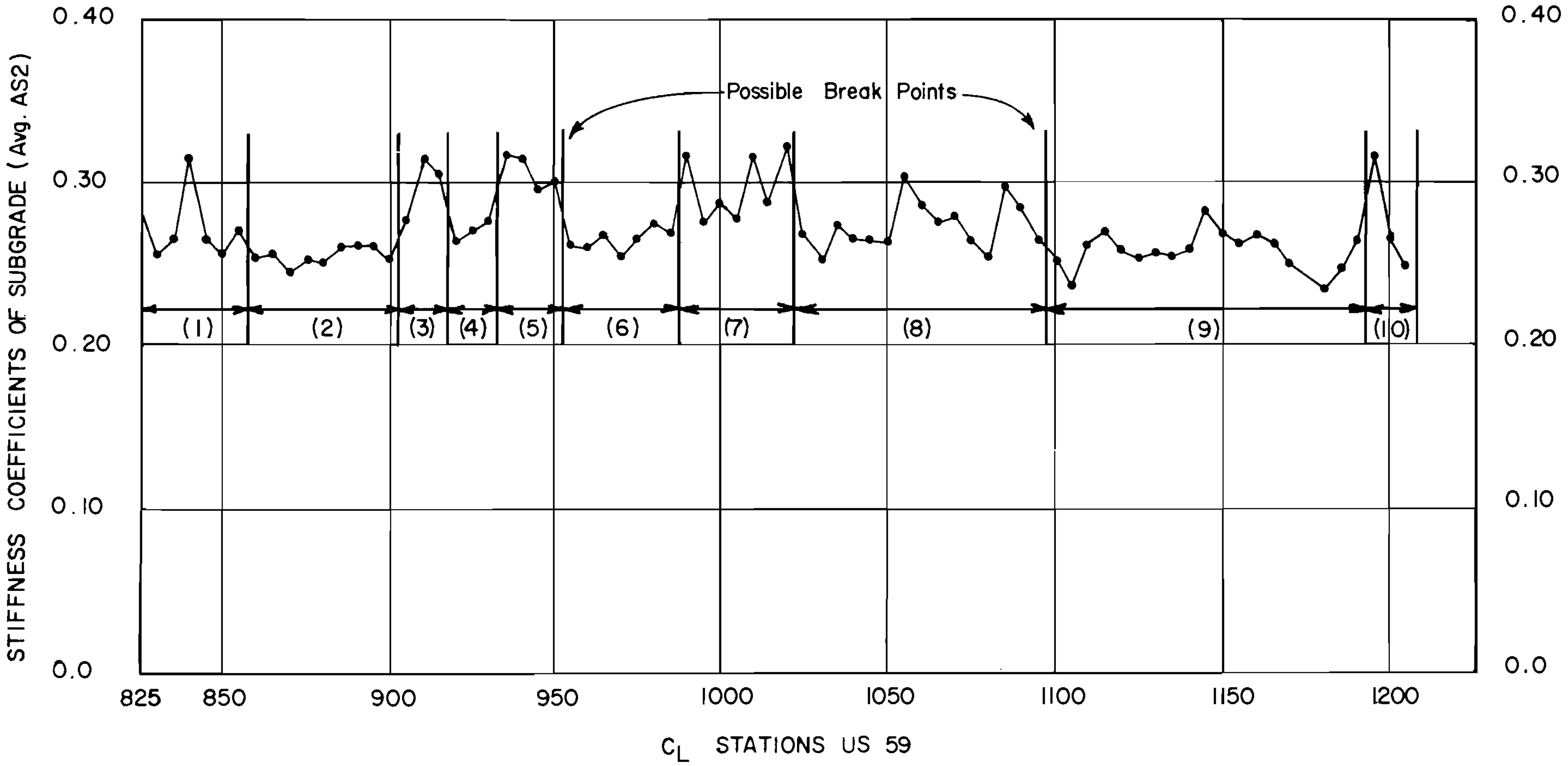


Figure 3.1 ENGINEER FIRST ESTIMATE OF DESIGN SECTION FOR SUBGRADE STIFFNESS COEFFICIENTS

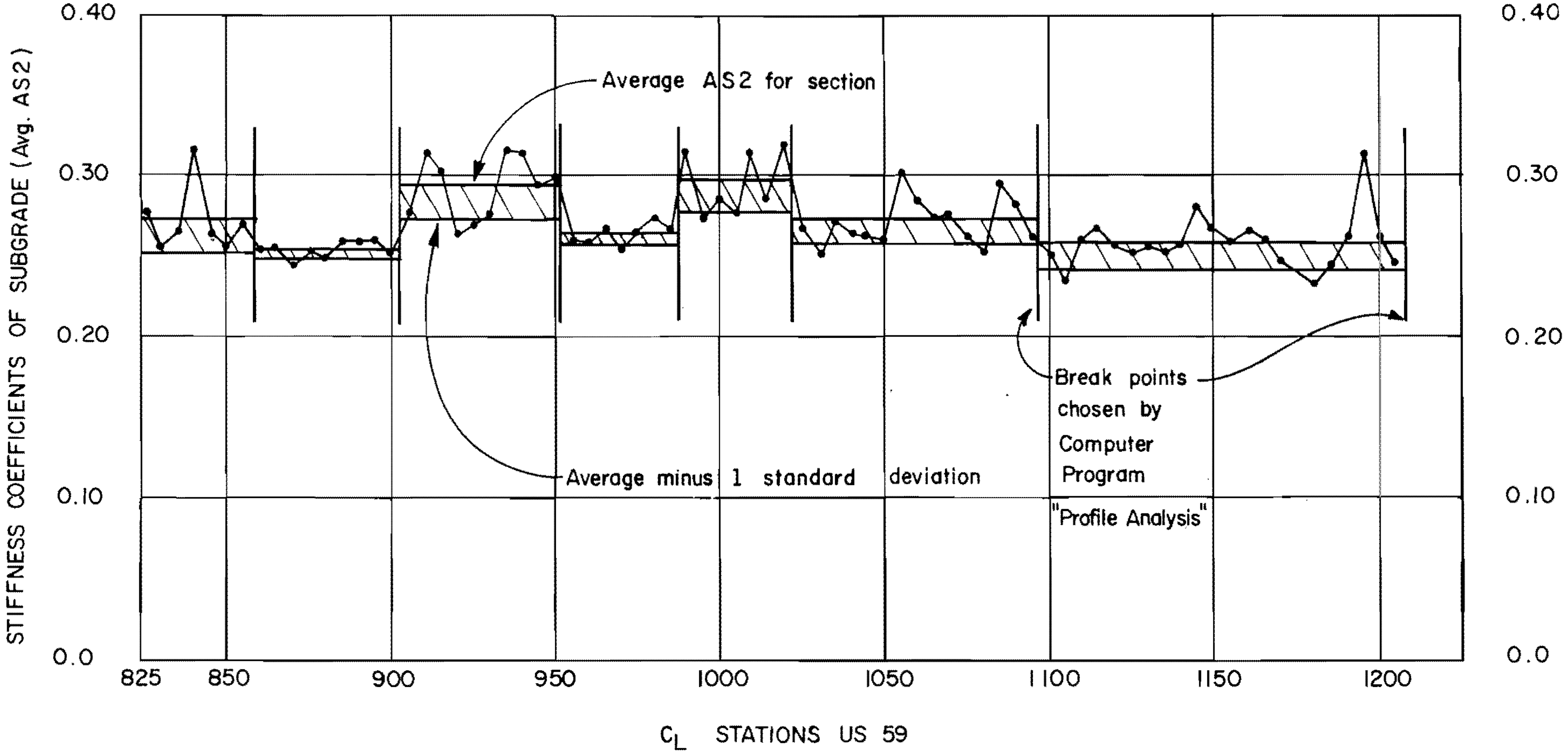


Figure 3.2 DESIGN SECTIONS FOR SUBGRADE STIFFNESS COEFFICIENTS

GENERAL DESCRIPTION FPS-7* PROGRAM

The FPS-7 Program is based on the following general premise: it is the aim of the design engineer to provide from available materials, a pavement that can be maintained above a specified level of serviceability, over a specified period of time, at the minimum over-all cost (Reference 1 & 2).

In order to understand FPS-7, it is necessary to know generally how the data are handled. Figure 3.3 is a Summary Flow Chart of FPS-7, (Reference 5) that may be used as a guide to illustrate the mechanics of the computer program.

The input data are read and printed out. All possible initial designs are computed and each initial design is then individually considered.

Based on the cost per square yard per inch calculated for each material from the input cost per cubic yard, the initial design cost is calculated. If the cost exceeds the maximum funds available for the intitial design, this design is not feasible and consideration goes to the next design.

If the cost restriction is met, the design thickness is compared with the input value for the maximum allowable thickness of the initial construction. If the design thickness is greater, this design is not feasible and consideration goes to the next design.

The expected life of the initial design construction is calculated using the serviceability indices, swelling clay parameters and anticipated traffic. If the design life is less than the specified minimum time to the first overlay, this design is discarded and consideration is passed to the next design.

The optimal overlay policy is selected for designs satisfying the minimum time to the first overlay. If the overlay policy lasts the entire analysis period, this design is a feasible design and the total cost is calculated. The program then considers the next design and continues until all possible designs are either discarded or designated as feasible designs.

The feasible designs are sorted by total costs and a set of optimal designs are printed in order of increasing total cost as shown in the sample output in Appendix C.

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*The FPS-7 computer program input variables have been numbered using the integer number to indentify the card and the decimal number the variable, i.e. (V-5.2) indicates variable 2 of card 5.

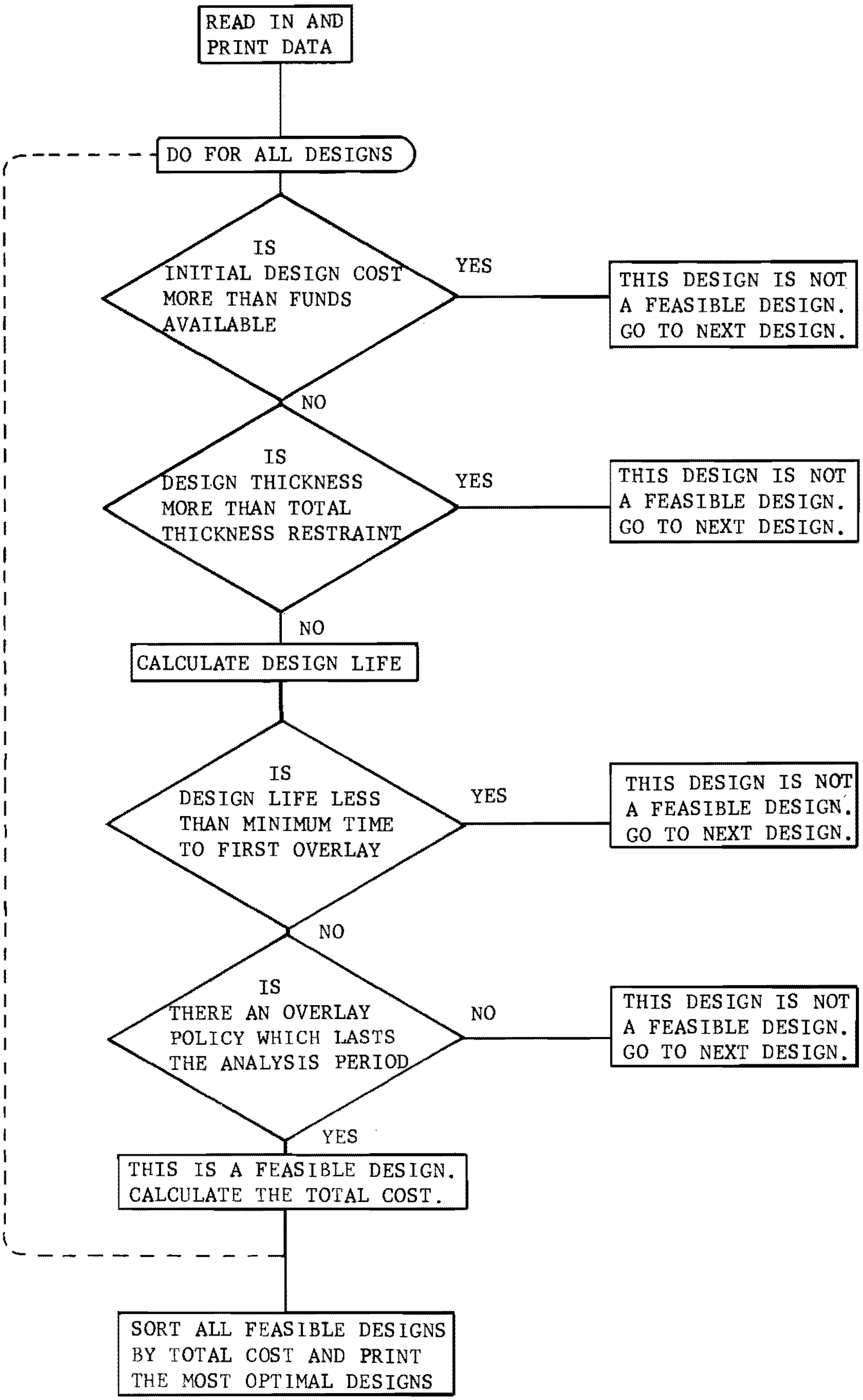

Figure 3.3 SUMMARY FLOW CHART ILLUSTRATING MECHANICS OF THE FPS-7 PROGRAM

PERFORMANCE DATA

Pavement performance is represented by a serviceability index versus time curve. A performance period is the time from the completion of initial or overlay construction to the time when the serviceability index reaches a predetermined minimum value. One performance period or a number of periods may occur during the Design Analysis Period. Figure 3.4 shows an example Design for an Analysis Period of 20 years where two overlays were required.

The sections below include a discussion of the boundary conditions of a performance period. Additionally, the clay swell constant which characterizes expected non-traffic associated loss of serviceability is discussed.

Initial Serviceability

The initial serviceability index has a state-wide average of 4.2. A surface treatment might have an index as low as 3.8 and a very smooth ACP or CRCP might be as high as 4.8. It is recommended that for design values an initial serviceability index of no less than 4.2 be used for all ACP surfacings (V-3.2). Surface treatments usually have a lower serviceability index than ACP surfacings.

Minimum Serviceability

The minimum serviceability index should be the Engineer's estimate of how the pavement would be rated just before an overlay will be required. The value may range from 2.5 on F.M. Roads to 3.5 on Freeways. F.M. Roads, being subject to low volume and slower traffic can tolerate lower serviceabilities than high-speed, large-volume Freeways. The state-wide average index, just before overlaying, is approximately 3.0, and in most cases it is believed that 3.0 should be used as the design value (V-3.4).

Overlay Serviceability

In general the serviceability index after an overlay is about the same as that of initial construction. In this design system it can be specified by the Engineer. It is recommended that this value be maintained within the range 3.8 to 4.8 (V-3.3).

Clay Swell

At the present, the clay swell constant b_1, must be chosen by the Engineer based on experience in the particular locality. Figure 3.5 illustrates performance curves for minor swell, moderate swell, and heavy swell, assuming no serviceability index losses due to traffic. The b_1 constant is used to allow for all non-traffic causes of serviceability loss including swell, consolidation, frost heave, etc., until experience and/or research develops better estimates. For the constant, b_1, it is recommended that one of the three following values listed in Table 3.2 be used (V-3.6).

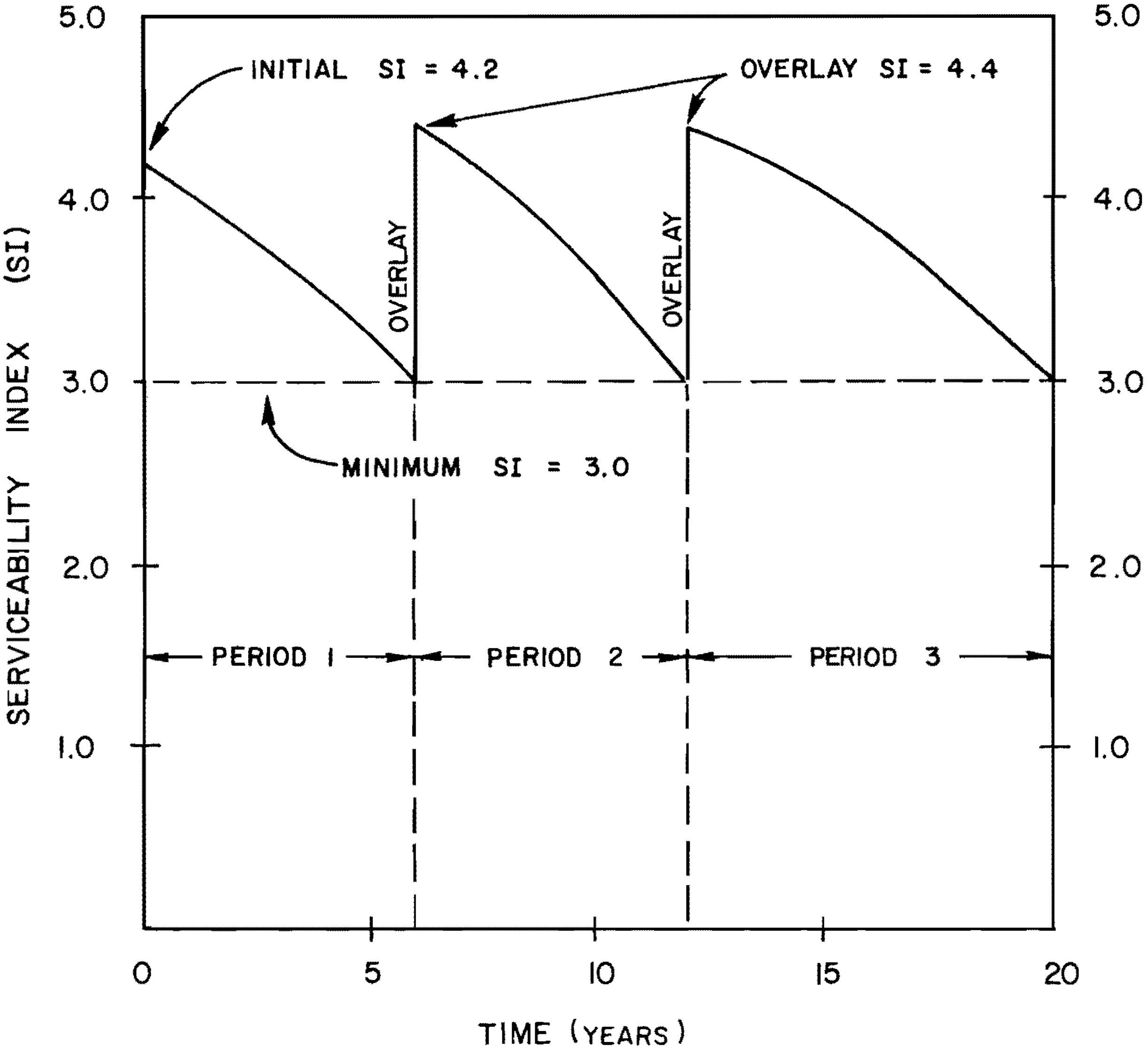

Figure 3.4 PERFORMANCE CURVES

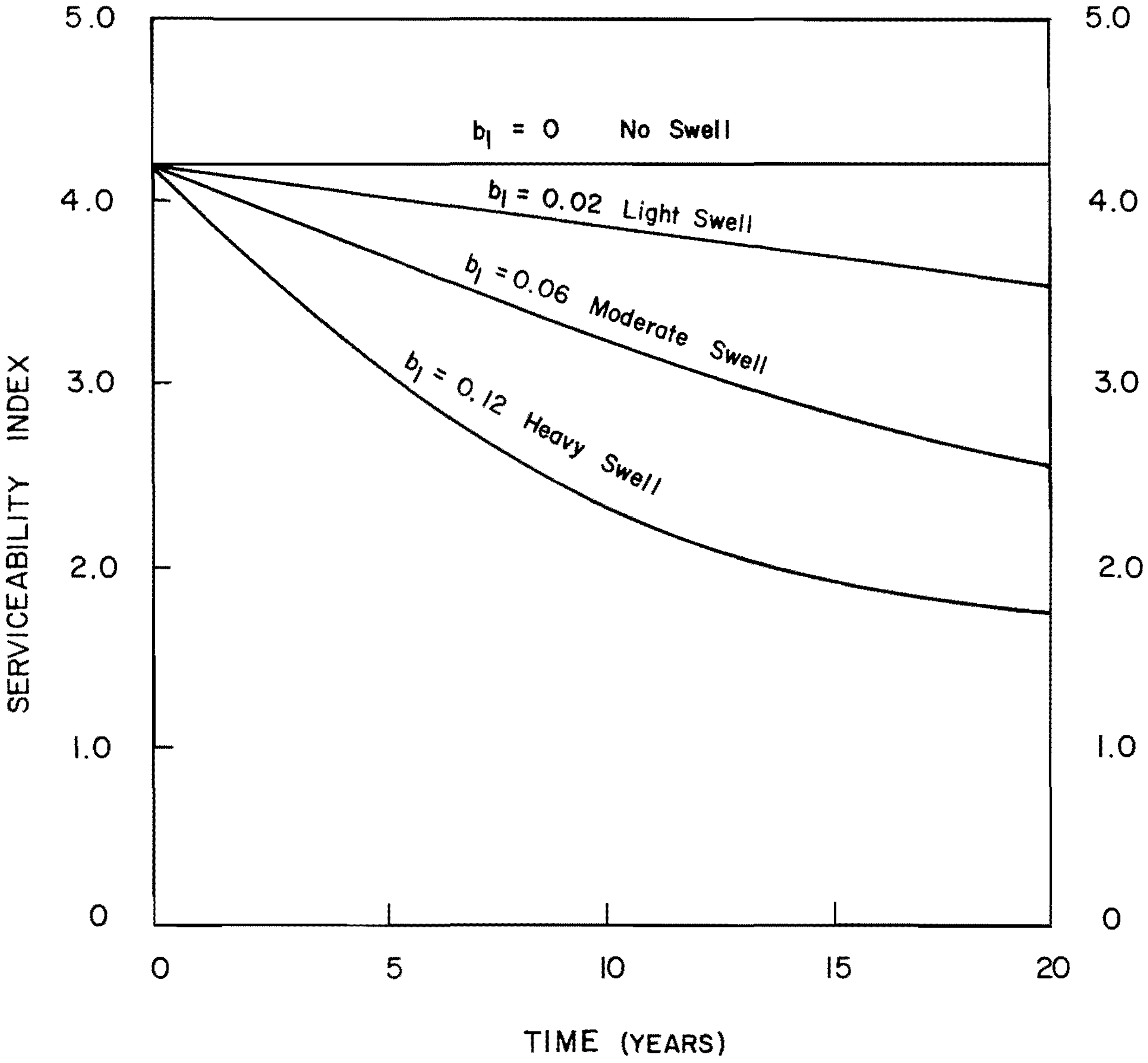

Figure 3.5 PERFORMANCE CURVES ILLUSTRATING SERVICEABILITY LOSS NOT CAUSED BY TRAFFIC

TABLE 3.2 CLAY SWELL CONSTANTS

Expected Non-traffic associated loss of serviceability	b_1	Overlays Required
Light	0.02	None in 20 years
Moderate	0.06	One between 10 & 20 years
Heavy	0.12	At least one before 10 years

District Temperature Constant

This constant is based on temperature-performance data from the AASHO Road Test (Reference 6) and is used in the performance equation. Constants for the particular District involved are listed in Table 3.3, (V-3.1).

TABLE 3.3 DISTRICT TEMPERATURE CONSTANTS

Dist.	Temp. Const.	Dist.	Temp. Const.	Dist.	Temp. Const.	Dist.	Temp. Const.	Dist.	Temp. Const.
1	21	6	23	11	28	16	36	21	38
2	22	7	26	12	33	17	30	22	31
3	22	8	26	13	33	18	26	23	25
4	9	9	28	14	31	19	25	24	24
5	16	10	24	15	31	20	32	25	19

TRAFFIC DATA FROM D-10

The inputs in this section should be obtained from Planning Survey Division (D-10). For services available from D-10 the reader is referred to the Planning Survey Division Manual, Chapter IV (Reference 7).

Average Daily Traffic (ADT)

One direction Average Daily Traffic (ADT) for both the beginning and ending of the analysis period is used in two places in the program -- first, in calculating user cost during overlay construction and second, in determining the distribution of equivalent 18 Kip single axle loads (18 KSA) as a function of time. ADT is assumed to increase uniformly from the beginning of the analysis period to the end (V-4.1 & 4.2).

One Direction Accumulated Equivalent 18 Kip Single Axle Loads

The "One Direction Accumulated Number of Equivalent 18 Kip Single Axle Loads" for the design analysis period as furnished by D-10 is assumed to accumulate proportionally to the rate of accumulation of total traffic. The traffic equation, as modeled in the program, is shown in Reference No. 1, pp. 26. When ADT is increasing with time, as is the general case, the 18 KSA accumulation curve is parabolic curving upward (more 18 KSA occur during the last half of the analysis period than the first). If the ADT is decreasing, the opposite is true (V-4.3).

Percent ADT Arrival Each Hour of Overlay

The average percent of ADT which arrives each hour of overlay construction is used in calculating user cost during overlay construction. In order to predict this value D-10 will have to be furnished the time of day that construction will occur (V-4.4).

An excellent reference showing how traffic varies hourly is D-10's Annual Report, "Permanent Automation Traffic Recorders" (Reference 8).

RESTRICTIONS

This section discusses the restrictive variables. It is these restrictions which force the program to yield solutions that are physically and economically realistic. These variables also serve as controls in the program to tell it when to stop calculating.

It is recommended that all the restrictive variables be coded in the first run of the program as non-restrictive as possible in order to reduce their tendency to make the total cost larger than the true optimum design cost. There are physical limits for each of these variables which limit the designer's or programmer's ability to make them completely non-restrictive. These limitations will be discussed for each of the variables below.

Length of Analysis Period

The length in years of the analysis period for new construction should be 20 years according to current practice. Exception to this could be made in designing detours or temporary routes (V-2.3).

Minimum Time to First Overlay

The program should first be run with a "Minimum Time to First Overlay" of one or two years. This will remove the restriction caused by this variable and allow scheduling of any early overlay which might be included in the most economical design. If the calculated time to overlay is shorter than desired, because of limited funds for future overlays or because of possible public disfavor of overlaying too soon, it may be necessary to rerun the program specifying a longer time to the first overlay. The cost of increasing the time to the first overlay can be obtained from the two computer runs. Then, it can be decided if the desired delay of overlaying is worth the increase in cost.

Because of non-traffic parameters alone, as shown in Figure No. 3.5, moderately swelling subgrade soils must be overlayed in about 12 years and heavy swelling in about 6 years. Based on this alone, an absolute maximum time for the variable "Minimum Time to First Overlay" would be 12 and 6 years, respectively, for these types of subgrade soils. It is recommended that the absolute maximum time not be specified or prohibitive initial construction costs will be created (V-5.1).

Minimum Time Between Overlays

It is recommended that this variable, the minimum time in years between overlays, not be smaller than two years because the program is dimensioned to handle a total of ten overlays only (V-5.2). Otherwise, it should be handled like V-5.1 above.

Time to First Seal Coat

The time in years to the first seal coat after initial or overlay construction should be selected on the basis of the District's experience. This variable is in the program primarily to allow the designer to restore the coefficient of friction to a pavement surface without affecting its serviceability index (V-5.3).

Time Between Seal Coats

The time in years between seal coats should be selected on the basis of the District's experience, however, this variable must not be smaller than two years because the program is dimensioned for a total of ten seal coats (V-5.4).

Maximum Funds Available

This variable is placed for the designer to specify the funds available (V-5.5).

Minimum and Maximum Allowable Thickness of Each Layer

These variables can be very restrictive if used improperly. If the range between these variables is too large, computer time becomes excessive in calculating costs for all the possible designs. If practical ranges of thickness for each layer are input in the program, no problems should be encountered because of these two variables (V-9.6 & 9.7).

Maximum Total Inches Initial Construction

This variable should be no greater than the total of the maximum thickness for the individual layers (V-5.6).

Minimum Overlay Thickness

The minimum overlay thickness will usually be determined by the type of construction and aggregate gradation specified for future overlays. The program automatically adds a one-inch level up to this thickness when determining overlay costs. The level up is added to restore serviceability and is not considered a part of the structure when strength is calculated. When overlay depths are greater than the minimum thickness required the program increases the thickness in half-inch increments (V-5.7).

Maximum Total Thickness of All Overlays

The maximum overlay thickness is usually determined by geometrics of the cross section. At the present, the code sheet has been designed to limit this value to less than ten inches. The level up depth is not included in the calculation of overlay thickness (V-5.8).

USER COSTS OF OVERLAY

The purpose of this section is to describe the input data which is necessary for calculating traffic users' increase in cost due to overlaying operations. A detailed discussion on how the program calculates the user cost is in Reference 1, pp. 46-71.

ACP Production Rate

The anticipated asphaltic concrete production rate must be furnished in tons per hour. The designer must estimate the input considering the capacity of the contractor who will place future overlays. This production rate determines the time required to place the overlay which in turn affects the user cost (V-6.1). The expected density of the asphaltic concrete should be given in tons per compacted cubic yard (V-6.2).

Detour Model Data

Five types of detours for handling traffic during overlay construction have been modeled in the program. See Figures 3.6 to 3.10 for sketches of these models (V-7.8). To calculate user cost the program uses one of the detour models, traffic data from D-10, and the following variables:

(1) The number of open lanes in the restricted zone in the overlay direction (V-6.7).

(2) The number of open lanes in the restricted zone in the non-overlay direction (V-6.8).

(3) The distance in miles along the center line over which traffic is slowed in the overlay direction (V-6.3), and non-overlay direction (V-6.4) (See Figures 3.6 to 3.10).

(4) The detoured distance around the overlay zone (V-6.5) is used for Detour Model 5 only (See Figure 3.10).

(5) The average number of hours per day that overlay construction takes place. (V-6.6).

(6) Urban or Rural location (V-4.5). (When the traffic has greater than 10% trucks the location should be called Rural, which has higher user costs).

(7) The percent of vehicles stopped by contractor's equipment in the overlay direction (V-7.1). Usually it is expected that the overlay operation will be conducted in such a way that the number of vehicles stopped due to movement of overlay personnel and equipment will be small. In the absence of other information it is recommended that this variable be estimated to be near or equal to zero.

(8) The percent of vehicles stopped by contractors equipment in the non-overlay direction (V-7.2). As in (7) above it is recommended that this variable be estimated to be near or equal to zero.

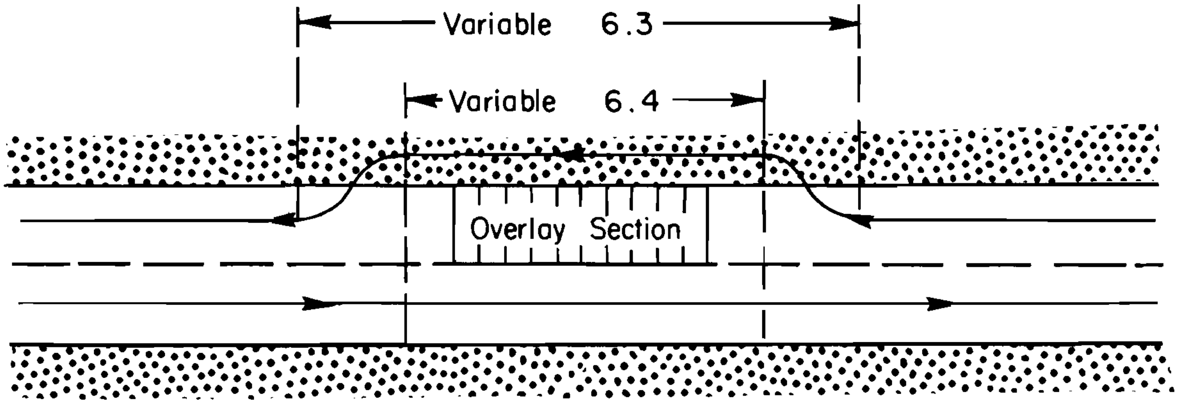

Figure 3.6 DETOUR MODEL NO.1

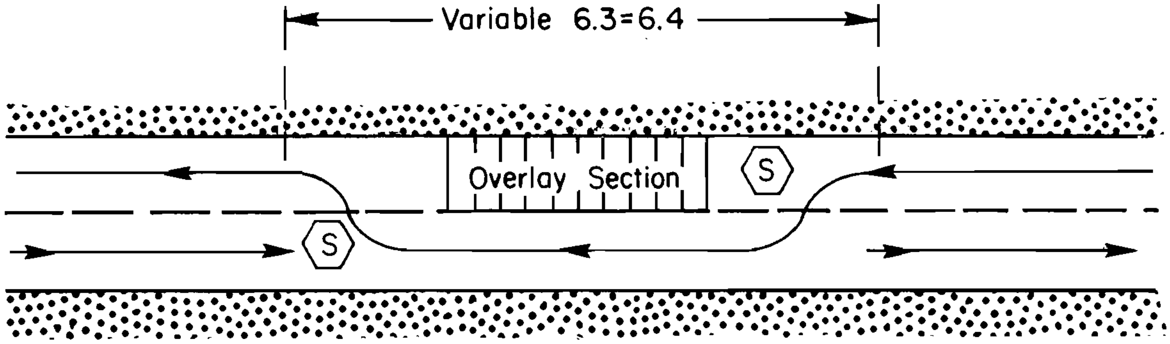

Figure 3.7 DETOUR MODEL NO.2

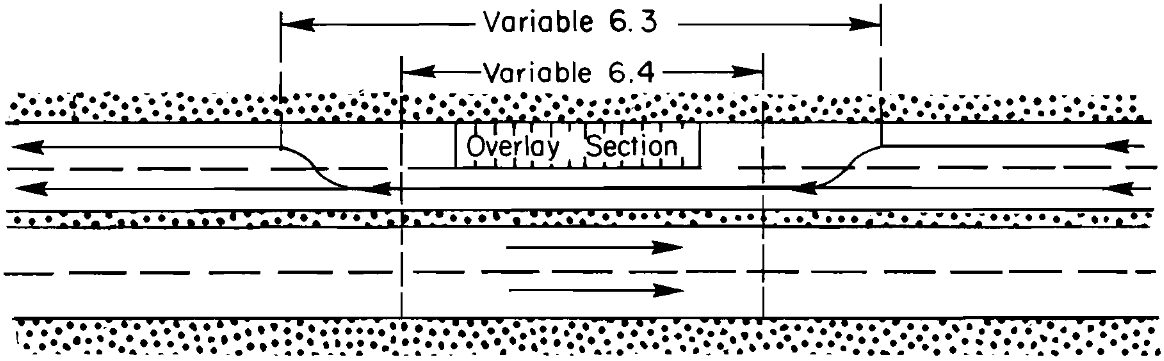

Figure 3.8 DETOUR MODEL NO.3

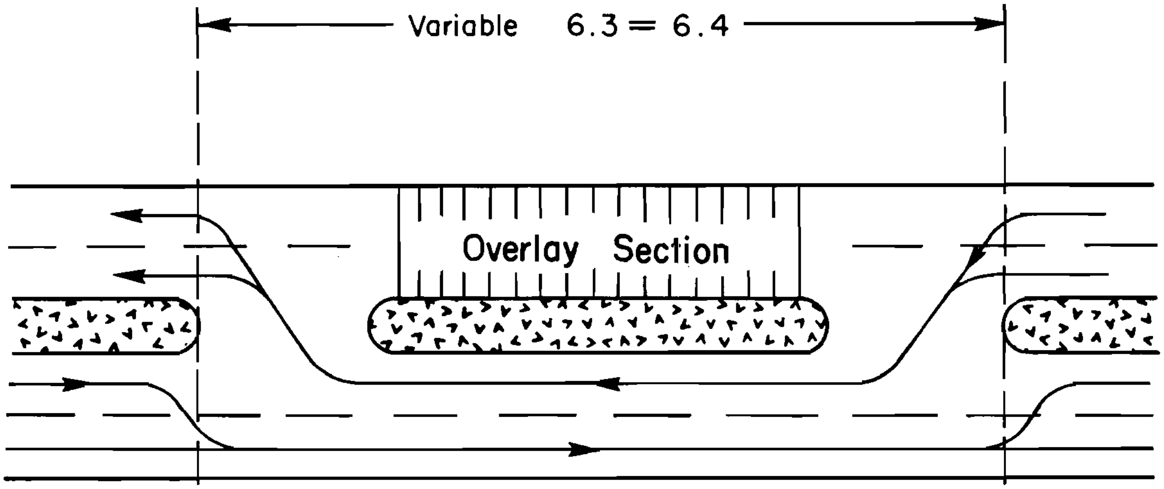

Figure 3.9 DETOUR MODEL NO.4

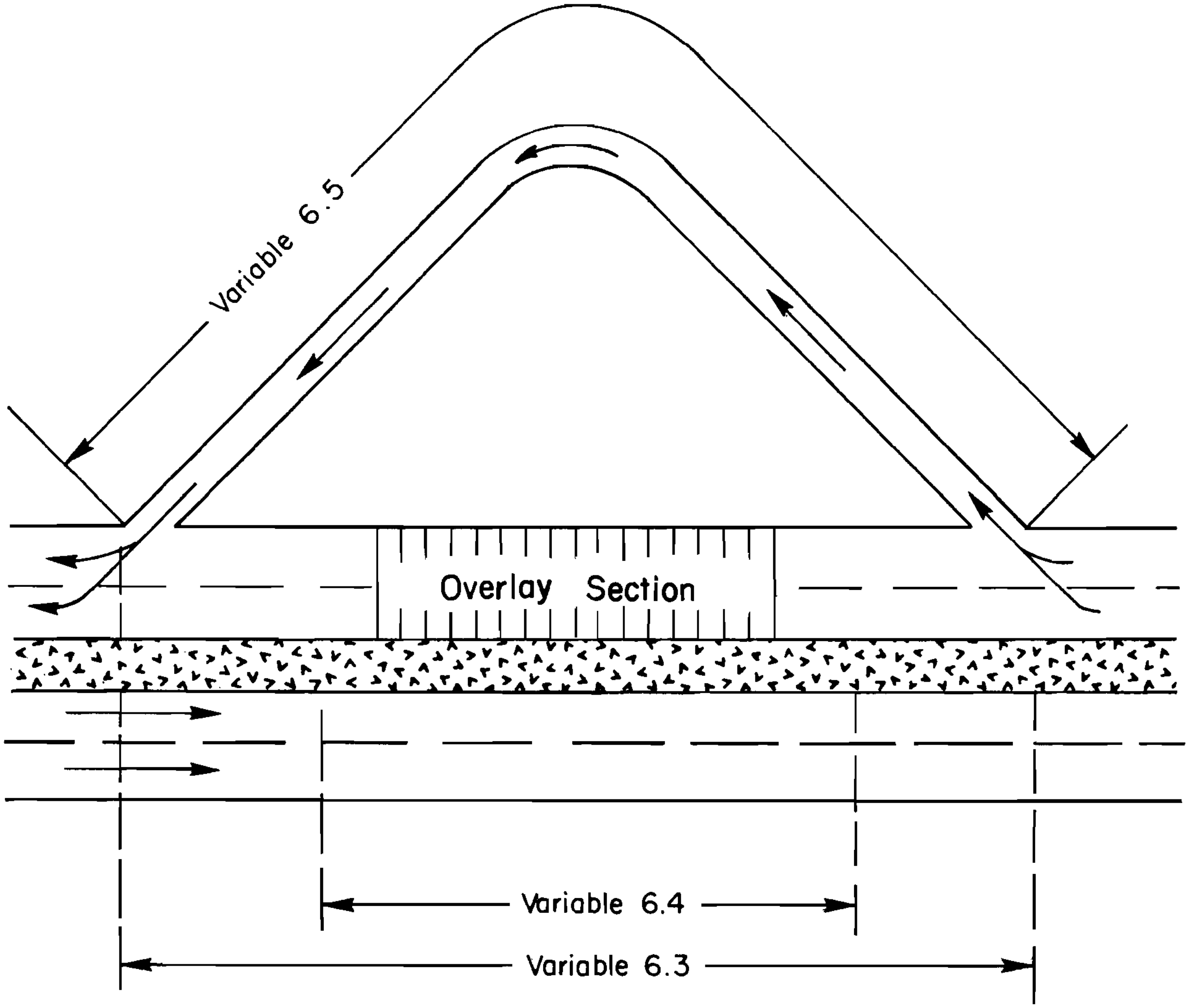

Figure 3.10 DETOUR MODEL NO.5

(9) The average delay per vehicle stopped by contractor's equipment in the overlay direction in hours (V-7.3).

(10) The average delay per vehicle stopped by contractor's equipment in the non-overlay direction in hours (V-7.4).

(11) The average approach speed to the overlay zone (MPH), (V-7.5).

(12) The average speed in miles per hour through the overlay zone in the overlay direction (V-7.6).

(13) The average speed in miles per hour through the overlay zone in the non-overlay direction (V-7.7).

Numerical values for the above variables for the most part are either self evident or require engineering judgement. For the variables requiring judgement it is suggested that more effort be used in obtaining accurate input when the ADT is approaching capacity.

When the one direction VPH (Vehicles Per Hour) in any detour lane exceeds 1350 in rural areas and 1400 in urban areas, the detour model will reach capacity and stop each car that goes through the detour in that direction. The stopping will cause long queueing of traffic and a large user cost.

COST INPUTS

Costs are the basic outputs of Program FPS-7 and they are highly dependent on the cost inputs. Careful consideration should be given to developing each cost input.

Interest Rate

In the computer program, pavement designs are compared on the basis of present value of all costs occuring during the analysis period. Such costs as maintenance, seal coats, overlays, salvage values, and user costs are all discounted to present value.

An interest rate of 5 to 10 percent appears to be about the range of today's value of money. At the Area III, Research Advisory Committee "Pavement Structure Design and Evaluation", meeting on January 7, 1969, a poll was taken asking: "What interest rate should be used when discounting future costs". The average answer of the 10 committee members was 7% (Reference 9). It is recommended that 7% interest be used in this program.

Construction Materials Cost

Estimating construction materials cost should be one of the most important things to consider in making the engineer's estimate. The costs should be converted into dollars per compacted cubic yard (V-9.4).

For salvage purposes the engineer should also estimate the value of each material at the end of the analysis period and convert this value to a percent of its original construction value. For example, a treated subgrade may retain nearly 100% of its originally invested value, while only 30% of the value of asphaltic concrete may be usable at the end of the analysis period. The present worth of the salvaged materials is used in comparing total costs of alternate designs. It should be remembered that this value is discounted for the entire length of the analysis period. It may be a negative value (V-9.8).

Seal Coat Costs

The estimate for seal coat cost should be in dollars per lane mile (V-8.2). Seal Coats are placed as scheduled by the programmer. This schedule is input in the form of "Time to the First Seal Coat", and "Time Between Seal Coats". These two inputs were discussed in detail under the subsection "Restrictions". This schedule is initiated after initial construction and after each overlay. The program also assumes that seal coats do not affect the serviceability index of the pavement.

A detailed discussion of how the program mathematically handles the above cost is in Reference No. 1, pp. 44, 45.

Routine Maintenance

The average cost for the first year after construction usually varies between $25 and $50. The annual incremental increase in cost is between $10 and $30. These costs are per lane mile. It is recommended that an initial cost of $50 per lane mile and an incremental increase of $20 per lane mile be used in this program unless maintenance records have been analyzed and results obtained are significantly different from these values (V-8.1 & 8.2), (Reference 10). (The initial cost does not affect the program's choice of optimum design but is necessary to calculate a realistic overall cost).

PROGRAM CONTROLS

This section discusses the means by which the designer or programmer can control the number of pages or designs in the output summary list. Additionally, a detailed discussion is given on how the program selects various material combinations.

Number of Output Pages

After the complete analysis has been performed, the computer program lists a summary of the best overall design strategies. Eight designs are contained on each summary page and the programmer should indicate the number of these pages that he desires (V-2.1). The current maximum number of pages is three.

Layer Designation Number and Letter Code of Material

It is important that the engineer should provide information about all materials available for the program to consider and calculate the optimum solution.

Each construction material that is input to the computer program must be accompanied by a layer designation number (V-9.1) which indicates the layer in which the material may be used. Each material should also be assigned a letter code (V-9.2) by which the material can be identified in the output summary table. The numbering is done in sequence from top to bottom. Surfacing materials will be 1, base materials will be 2, etc. The subgrade is not numbered. This scheme allows alternative materials to be used in each layer of the design. For example, the engineer may want to consider two or more base materials. The surface material would be designated the number "1", each base material would be designated the number "2", etc. The program is written so that all combinations of materials will be analyzed with the stipulation that no two materials with the same designation number will be used in the same design, and no higher numbered layer will be used on top of a low numbered layer.

Example:			Designs Considered:		
1A = Surfacing	1A	1A	1A	1A	1A
2B = Base	Subg.	2B	2B	2C	2C
2C = Base		Subg.	3D	Subg.	3D
3D = Subbase			Subg.		Subg.

Number of Available Materials

The total number of available materials would be the total number in the above discussion and should not include the subgrade layer (V-2.2).

CHAPTER 4. GENERAL USER CODING INSTRUCTIONS

The input forms for "The Texas Highway Department Flexible Pavement System" can be divided into three major parts as follows:

1. Input form for the "STIFFNESS COEFFICIENT PROGRAM". Deflection measurements are the primary inputs for this program.
2. Input form for the "PROFILE ANALYSIS PROGRAM". Stiffness coefficient values are the primary inputs for this program.
3. Input form for the "FPS-7 PROGRAM". Selected stiffness coefficient values, costs, traffic, performance, materials, and other variables and parameters make up the inputs for this program.

The user should include Form 1305 (see Appendix D) with each submission of coded input sheets.

Characters which May be Used on The Input Forms

The inputs on these forms includes both alphalbetic (hereafter termed letters) and numeric characters. There are three data format types used within these programs. Of these three formats two (F and I formats) require the use of numerical data (only numbers can be used). In the third format type (A format), numbers, letters and other special characters may be used as follows:

1. Capital letters (only)
2. Numerals
3. Blank spaces
4. Special characters + - / = . (* ,) ' &.

To avoid any errors in key punching, the following characters should be entered as:

Alphabetic (capital letters)	Numerals
Ø	Zero 0
I	One 1
Ƶ	Two 2

A term mentioned quite often throughout the explanation of the coding instructions is "right justified". It can be defined as follows: for any integer variable using a given field (columns) in a code sheet, the last digit should be located so that it falls in the right most column.

STIFFNESS COEFFICIENT PROGRAM

This program uses the measurements obtained with the Dynaflect to calculate deflections. These, together with the total thickness of the existing pavement are used to calculate the stiffness coefficients of the subgrade (AS2) and the existing pavement (AP2).

The inputs for this program are coded on two types of code sheets labeled "STIFFNESS COEFFICIENT PROGRAM".

The first sheet is for the first three cards. Card #1, makes provision for district and project identification as well as the date and other remarks appropriate for the section under consideration. Cards #2 and #3 are optional. They make provisions for materials description of the different layers in an existing pavement. The second sheet is basically a data sheet to record the deflection measurements. This code sheet makes provision for 25 deflection measurements. If the section requires more than 25 measurements the second code sheet may be repeated as many times as necessary.

A glossary of terms for the output listing of this program is given in Appendix A "STIFFNESS COEFFICIENT PROGRAM".

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 1 - PROJECT IDENTIFICATION

(Columns 1-3 of Card #1)

Card No.

1	0	0
1	2	3

An identification number for the type of card being processed has been printed in these columns.

(Columns 4-5 of Card #1)

The District number is inserted in the columns to the right side (right justified). Only numbers are to be used.

Dist.

1	9
4	5

Example: The deflection measurements were taken in District 19.

(Columns 6-19 of Card #1)

County

				B	0	W	I	E					
6	7	8	9	10	11	12	13	14	15	16	17	18	19

The County name in which the deflection tests were obtained is inserted in these columns. The letters may be placed in any column. Letters, numerals, blank spaces and special characters may be used.

Example: The deflection measurements were taken in BOWIE County.

(Columns 20-23 of Card #1)

Control

	2	1	8
20	21	22	23

The control number of the roadway that was measured is inserted in the columns to the right side (right justified). Only numbers are to be used.

Example: The control number where the testing was performed is 218.

(Columns 24-25 of Card #1)

Section

	1
24	25

The section number for the roadway that is being tested is inserted in the columns to the right side (right justified). Only numbers are to be used.

Example: The Section number where tests were performed is 1.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

(Columns 26-27 of Card #1)

Job

26	27

The job number is inserted in these columns to the right side (right justified). Only numbers are to be used.

If not available leave blank.

(Columns 28-34 of Card #1)

Highway

	U	S		5	9	
28	29	30	31	32	33	34

The highway number on which deflections were obtained is printed in these columns. Letters, numerals, blank spaces and special characters may be written in any of these columns:

Example: The deflection measurements were taken on highway US 59.

(Columns 35-37 of Card #1)

Lane

S	B	L
35	36	37

The lane and traffic direction on which deflections were taken is printed (use Capital Letters) in these columns.

Example: The lane in which the measurements were taken was the SBL (South Bound Lane).

(Columns 38-42 of Card #1)

Total Pav. Depth

1	3	.	0	0
38	39	40	41	42

The total pavement depth is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The total pavement thickness was 13.00 inches.

(Columns 43-44 of Card #1)

Month

0	4
43	44

The month of the year in which the test was taken is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The month in which the test was performed was 4 (April).

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

(Columns 45-46 of Card #1)

Day

0	7
45	46

The day of the month in which the test was performed is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The tests were performed on the 7th.

(Columns 47-48 of Card #1)

Year

7	0
47	48

The year in which the test is performed is to be inserted in these columns. Only numbers are to be used.

Example: The year that the tests were performed is 1970.

(Columns 49-50 of Card #1)

Dynaflect

2	9
49	50

The Dynaflect number with which measurements were taken is to be inserted in these columns to the right side (right justified). Only numbers are to be used. The last two digits of the equipment number stenciled on the Dynaflect are to be used.

Example: The equipment number for the Dynaflect was 29.

(Columns 51-78 of Card #1)

0	8		F	T	•		L	T	•		Ø	F		C	E	N	T	E	R		L	I	N	E			
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

Provision has been made to add any comments or remarks related to the project. Capital letters, numerals, special characters or blanks may be used in these columns.

Example: The tests were taken at: 08 FT. LT. OF CENTER LINE.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 2 - EXISTING PAVEMENT

(Columns 1-3 of Card #2)

Card No.

2	0	0
1	2	3

An identification number for the type of card being processed has been printed in these columns.

*(Columns 4-23 of Card #2)

Type of Material

A	S	P	H	A	L	T	I	C		C	0	N	C	R	E	T	E		
4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

The type of material used in the top layer is inserted in these columns. Capital letters, blank spaces, numerals and special characters may be used in any of these columns.

Example: The type of material used for the top layer is ASPHALTIC CONCRETE.

*(Columns 24-27 of Card #2)

Layer Thick (in)

	1	.0	0
24	25	26	27

The thickness of the top layer is to be inserted in these columns. Provision has been made to write up to two decimal places.

Example: The thickness of the top layer is 1.00 in.

*(Columns 28-47 of Card #2)

Type of Material

I	R	0	N		0	R	E		B	A	S	E							
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47

The type of material used in the second layer (beginning from the top) is inserted in these columns. Capital letters, blank spaces, numerals and special characters may be used in any of these columns.

Example: The material used in the second layer is IRON ORE BASE.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

*(Columns 48-51 of Card #2)

Layer Thick (in.)

1	2	.0	0
48	49	50	51

The thickness of the second layer is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The thickness of the IRON ORE BASE IS 12.00 in.

*(Columns 52-71 of Card #2)

Type of Material

S	U	B	G	R	A	D	E												
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71

If the pavement is composed of more than two layers, the type material for the next layer is inserted in these columns. If the pavement is composed of two layers then the type of subgrade soil should be inserted in these columns.

Example: Since there is no other layer in this pavement structure SUBGRADE is written in these columns.

*(Columns 72-75 of Card #2)

Layer Thick (in.)

		.	
72	73	74	75

The thickness of the third layer is to be inserted in these columns. If there is not a third layer and subgrade material was written in the previous columns, these columns should be blank.

Example: Since there is no third layer Columns 72-75 have been left blank.

*This is optional data depending on user's desires. If the data is not to be used leave columns blank.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 3 - EXISTING PAVEMENT (CONTINUED)

(Columns 1-3 of Card #3)

Card No.

3	0	0
1	2	3

An identification number for the type of card being processed has been printed in these columns.

*(Columns 4-23 of Card #3)

Type of Material

4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

If the pavement is composed of more than three layers the type material for the next layer is inserted in these columns. If the pavement is composed of three layers then the type of subgrade soil should be inserted in these columns. Capital letters, blank spaces, numerals and special characters may be used in any of these columns.

*(Columns 24-27 of Card #3)

Layer Thick (in.)

24	25	26	27

The thickness of the fourth layer is to be inserted in these columns. If there is not a fourth layer and subgrade material was written in the previous columns, these columns should be blank.

*(Columns 28-47 of Card #3)

Type of Material

28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47

If the pavement is composed of more than four layers the type material for the next layer is inserted in these columns. If the pavement is composed of four layers then the type of subgrade soil should be inserted in these columns. Capital letters, blank spaces, numerals and special characters may be used in any of these columns.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

*(Columns 48-51 of Card #3)

Layer Thick (in.)

48	49	50	51

The thickness of the fifth layer is to be inserted in these columns. If there is not a fifth layer and subgrade material was written in the previous columns, these columns should be blank.

*(Columns 52-71 of Card #3)

Type of Material

52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71

If the pavement under consideration has up to five layers the subgrade soil is to be written in these columns. Capital letters, blank spaces, numerals and special characters may be used in any of these columns.

*(Columns 72-75 of Card #3)

Layer Thick (in.)

72	73	74	75

If subgrade material was written in the previous columns these columns should be blank.

*This is optional data depending on user's desires. If the data is not available or not to be used leave columns blank.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 4 - DATA CARDS

(Columns 1-3 of Card #4)

CARD NO.

4	0	0
1	2	3

Columns 1-3 of Card 4 - are for identification of the type of data card being processed.

(Columns 4-7 of Card #4)

CONT.

	2	1	8
4	5	6	7

The control number for the roadway under consideration is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The project control number where the test was performed is 218.

(Columns 8-9 of Card #4)

SECT.

	1
8	9

The section number for the roadway under consideration is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The project section number where the test was performed is 1.

(Columns 10-11 of Card #4)

MONTH

0	4
10	11

The month of the year in which the test was performed is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The month in which the test was performed is 4 (April).

(Columns 12-13 of Card #4)

DAY

0	7
12	13

The day of the month in which the test was performed is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The test was taken on the 7 day of April.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

(Columns 14-15 of Card #4)

YEAR	
7	0
14	15

The year in which the test was performed is to be inserted in these columns. To the right side (right justified). Only numbers are to be used.

Example: The year that the test was performed is 70.

(Columns 16-22 of Card #4)

Station						
16	17	18	19	20	21	22
1	0	8	0	+	0	0

The Station number where the test is being taken should be written in these columns. Only numbers are to be used.

Example: The site at which the test was taken was at STATION 1080 + 00 of US 59 SBL.

(Columns 23-24 of Card #4)

℄	
23	24
0	8

The distance in feet from the center line to the point where the test is being taken is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The test was taken at 08 feet from the center line.

(Column 25 of Card #4)

L/R
25
L

If the previous measured distance is to the right of the center line an R should be inserted in this column and an L if the measured distance is to the left of the center line.

Example: The test was performed to the left (L) of the center line.

(Column 26-27 of Card #4)

SC	
26	27
4.	2

The Dyanflect box reading corresponding to Geophone 1 is to be inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The Geophone 1 (SC) reading for this test is 4.2.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

(Column 28-30 of Card #4)

1		
28	29	30
0.	3	0

The Dynaflect box reading corresponding to the multiplier for Geophone 1 is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The multiplier (1) reading for this test is 0.30.

(Columns 31-32 of Card #4)

SC	
31	32
3.	0

The Dynaflect box reading corresponding to Geophone 2 is to be inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The Geophone 2 (SC) reading for this test is 3.0.

(Columns 33-35 of Card #4)

2		
33	34	35
0.	3	0

The Dynaflect box reading corresponding to the multiplier for Geophone 2 is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The multiplier (2) reading for this test is 0.30.

(Columns 36-37 of Card #4)

SC	
36	37
6.	0

The Dynaflect box reading corresponding to Geophone 3 is to be inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The Geophone 3 (SC) reading for this test is 6.0.

(Columns 38-40 of Card #4)

3		
38	39	40
0.	1	0

The Dynaflect box reading corresponding to the multiplier for Geophone 3 is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The multiplier (3) reading for this test is 0.10.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

(Columns 41-42 of Card #4)

SC	
41	42
4	.5

The Dynaflect box reading corresponding to Geophone 4 is to be inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The Geophone 4 (SC) reading for this test is 4.5.

(Columns 43-45 of Card #4)

4		
43	44	45
0	.1	0

The Dynaflect box reading corresponding to the multiplier for Geophone 4 is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The multiplier (4) reading for this test is 0.10.

(Columns 46-47 of Card #4)

SC	
46	47
3	.7

The Dynaflect box reading corresponding to Geophone 5 is to be inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The Geophone 5 (SC) reading for this test is 3.7.

(Columns 48-50 of Card #4)

5		
48	49	50
0	.1	0

The Dynaflect box reading corresponding to the multiplier for Geophone 5 is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The multiplier (5) reading for this test is 0.10.

(Columns 51-53 of Card #4)

TEMP.		
51	52	53

The temperature (°F) at the time of testing may be inserted in these columns to the right side (right justified). The user may at his discretion omit (leave columns blank) the temperature.

STIFFNESS COEFFICIENT PROGRAM
(EXPLANATION OF DATA CODING)

(Columns 54-58 of Card #4)

Time				
54	55	56	57	58
	1	1	2	9

The time at which the testing was done may be inserted in these columns. Only numbers are to be used and the numbers must be right justified.

Example: The time at which the test was performed was 11:29.

This is optional data depending on user's desires. If the data is not to be used leave columns blank.

(Columns 59-74 of Card #4)

Remarks															
59	60	61	62	63	64	65	66	67	68	69	70	7	72	73	74

Any pertinent remarks may be inserted in these columns. Numerals, capital letters and special characters may be used.

(Columns 75-76 of Card #4)

ICK	
75	76
	1

When the last measured deflection for a given section has been taken a number should be placed in these columns to indicate the end of the section. Only numbers are to be used.

Example: To indicate that the last measurement has been taken for the section under consideration a 1 is written in column 76 of the last card.

PROFILE ANALYSIS PROGRAM

Using the stiffness coefficients of the subgrade this program makes the necessary calculations to statistically verify the engineer's selection of subgrade design sections.

The input for this program is coded on a code sheet labeled "PROFILE ANALYSIS PROGRAM". Basically this code sheet has three types of cards. Card No. 1 makes provision for district and project identification as well as other remarks appropriate for the section under consideration. Card No. 2 makes provisions for recording the numbers where apparent break points or changes in the subgrade occur. Card No. 3 of the Profile Analysis Program code sheet has four headings. The first heading "REF. POINT" is to record in sequence the number of measurements. The "STATION" heading makes provision to record the station number at which the measurement was taken. Under the heading "STIFF COEF. VALUES" (AS2), provisions have been made to record up to tour readings for the same station. Under the "AVG. AS2" heading the average of preceeding "STIFF COEF. VALUES" is to be recorded. Card No. 3 may be repeated as many times as necessary.

PROFILE ANALYSIS PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 1 - PROJECT IDENTIFICATION

(Columns 4-5 of Card #1)

DIST.

1	9
4	5

The District number of the user district is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The user is District 19.

(Columns 6-19 of Card #1)

COUNTY

					B	0	W	I	E				
6	7	8	9	10	11	12	13	14	15	16	17	18	19

The county name in which the highway being studied is located is printed (use capital letters) in these columns.

The letters may be placed in any column (letters, numerals, blank spaces and special characters may be used).

Example: The roadway is located in BOWIE County.

(Columns 20-23 of Card #1)

CONTROL

	2	1	8
20	21	22	23

The control number for the highway under consideration is inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The project control number for this Highway is 218.

(Columns 24-25 of Card #1)

SECTION

	1
24	25

The section number for the highway under consideration is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The section number is 1.

PROFILE ANALYSIS PROGRAM
(EXPLANATION OF DATA CODING)

(Columns 26-27 of Card #1)

JOB

26	27

The job number associated with control and section number for project identification purposes is to be inserted in these columns to the right side (right justified). Only numbers are to be used. If not available leave blank.

(Columns 28-34 of Card #1)

HIGHWAY

U	S		5	9		
28	29	30	31	32	33	34

The highway number is inserted in these columns. Letters, numerals, blank spaces and special characters may be written in any of these columns.

Example: The study is being done on US 59.

(Columns 35-42 of Card #1)

DATE

0	4	/	0	7	/	7	0
35	36	37	38	39	40	41	42

The date in which the tests were taken is to be inserted in these columns, (month, day, year),

Example: The date is 04/07/70.

(Columns 43-44 of Card #1)

NO. OF SECTIONS

1	0
43	44

The number of sections is to be inserted in these columns to the right (right justified). Only numbers are to be used.

The number of sections is determined by counting the number of blocks that had been coded in Card #2.

Example: The number of sections is 10.

PROFILE ANALYSIS PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 2 - LAST REF. POINT AT EACH SECTION

(Columns 1-60 of Card #2)

		7		1	6		1	9		2	2		2	6		3	3		4	0		5	5		7	3		7	6
1	2	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

This card consists of 20 three-column blocks (columns 1-60). It makes provisions to record up to 20 break points or changes in subgrade, one per block. Only numbers are to be used.

Example: The break points or changes in subgrade occurred following "LAST REF. POINT AT EACH SECTION": 7, 16, 19, 22, 26, 33, 40, 55, 73, 76.

PROFILE ANALYSIS PROGRAM
(EXPLANATION OF DATA CODING)

CARD NO. 3 - DATA CARDS*

(Columns 1-7 of Card #3)

STATION

1	2	3	4	5	6	7
	8	2	5	+	0	0

The station number is to be recorded in these columns.

Example: The data for the first point corresponds to Sta. 825 + 00.

(Columns 8-12 of Card #3)

AVG.
AS2

8	9	10	11	12
0	.	2	7	8

The average stiffness coefficient value (AVG AS2) is to be recorded in these columns to the right (right justified). Provision has been made to record these values with up to three decimal places. Only numbers are to be used.

Example: The stiffness coefficient at Sta. 825 + 00 is 0.278.

*This card should be repeated as many times as necessary.

FPS-7 PROGRAM

The input for this program is accomplished with the aid of five code sheets. These five code sheets have a total of 9 different type cards. Card 1 makes provision for project identification and any comments appropriate to the project. Card 2 has data concerning the different parameters for program control (Card 1 and 2 are on Code Sheet 1).

Card 3 has the performance variables. The input of the traffic variables is accomplished with Card 4 (Card 3 and 4 are in Code Sheet 2).

Card 5 has the restrictive variables for overlays and seal coats. Card 6 has the overlay parameters associated with overlay and road geometrics (Card 5 and 6 are in Code Sheet 4).

Card 7 has data concerning traffic speeds and delays associated with overlay operations. Card 8 has data related to cost considerations (Card 7 and 8 are in Code Sheet 4).

Card 9 makes provision for the name of the material and the different parameters associated with it. This card is repeated as many times as necessary, depending on how many materials are used for the proposed design; including subgrade. (Card 9 is on Code Sheet 5).

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

PROJECT IDENTIFICATION-CARD NO. 1

(Columns 1-8 of Card #1)

1.1 DATE

0	3	/	2	6	/	7	0
1	2	3	4	5	6	7	8

The date on which the work is being performed is inserted in these columns (month, day, year).

Example: Date 03/26/70 (March 26, 1970)

(Columns 9-10 of Card #1)

1.2 DISTRICT

1	9
9	10

The district number is inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: District 19.

(Columns 11-21 of Card #1)

1.3 HIGHWAY

U	S		5	9		N	–	S	B	L
11	12	13	14	15	16	17	18	19	20	21

For identification purposes, the highway number and direction of traffic to which the study is related should be inserted in these columns. Letters, numerals, blanks and special characters may be written in any of these columns.

Example: Highway US 59 N-SBL. (North and South Bound Lanes)

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

PROJECT IDENTIFICATION-CARD NO. 1

(Columns 22-25 of Card #1)

1.4 CONTROL

	2	1	8
22	23	24	25

The control number of the project for which the study is being performed is inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: Control 218.

(Columns 26-27 of Card #1)

1.5 SECTION

	1
26	27

The section number associated with the control number for project identification is inserted in these columns to the right (right justified). Only numbers are to be used.

Example: Section 1.

(Columns 28-31 of Card #1)

1.6 IPE

28	29	30	31

The IPE number authorizing the project should be inserted in these columns to the right (right justified). Only numbers are to be used.

Example: IPE not available.

(Columns 32-55 of Card #1)

1.7 COMMENTS

S	E	C	T	.	N	0		1		S	T	A	.		8	2	5	-	8	5	5		
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55

Any comments or remarks appropriate to the problem under consideration are inserted in these columns. Letters, numerals, blanks, and special characters may be used in these columns.

Example Comments: SECT. N01 STA. 825-855.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

PROGRAM CONTROLS-CARD NO. 2

(Column 10 of Card #2)

2.1 NUMBER OF SUMMARY OUTPUT PAGES

3
10

The number of pages desired is inserted in this column. Eight designs are contained in each summary page and the designer or programmer should indicate the number of these pages that he desires. The current maximum number of pages is three. Only numbers are to be used.

Example: The specified number of pages is 3.

(Column 20 of Card #2)

2.2 NUMBER OF MATERIALS

4
20

The number of materials available for the design under consideration is inserted in this column.

Example: The number of materials considered was 4.

(Columns 27-28 of Card #2)

2.3 LENGTH OF ANALYSIS PERIOD (YEARS)

2	0
27	28

The length of the analysis period for the project under consideration is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: Length of analysis period 20 years.

(Columns 37-38 of Card #2)

2.4 WIDTH OF EACH LANE (FEET)

1	2
37	38

The width of each lane is recorded in this column to the right side (right justified). Only numbers are to be used.

Example: The width of each lane is 12 feet.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

PERFORMANCE VARIABLES-CARD NO. 3

(Columns 7-8 of Card #3)

3.1 DISTRICT TEMPERATURE CONSTANT

2	5
7	8

The District temperature constant is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The temperature constant for District 19 is 25.

(Columns 17-19 of Card #3)

3.2 INITIAL SERVICEABILITY INDEX

4	•	2
17	18	19

The initial serviceability index for initial construction is to be inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The initial serviceability index is 4.2.

(Columns 27-29 of Card #3)

3.3 SERVICEABILITY INDEX AFTER AN OVERLAY

4	•	4
27	28	29

The desired serviceability index after an overlay is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The desired serviceability index after an overlay is 4.4

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

PERFORMANCE VARIABLES-CARD NO. 3

(Columns 37-39 of Card #3)

3.4 MIN. SERVICEABILITY INDEX

3	•	0
37	38	39

The minimum serviceability index that will be allowed before an overlay takes place is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The minimum serviceability index for this project is 3.0.

(Columns 55-60 of Card #3)

3.6 SWELLING CLAY PARAMETER, b_1

0	•	0	2	0	0
55	56	57	58	59	60

The swelling clay parameter for the project under consideration is inserted in these columns. Provision has been made to write up to four decimal places.

Example: The swelling clay parameter considered for this project was 0.0200.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

TRAFFIC VARIABLES-CARD NO. 4

(Columns 4-10 of Card #4)

4.1 ONE DRCTN ADT AT BEGINNING OF ANALYSIS PERIOD__________

		6	3	5	0	•
4	5	6	7	8	9	10

The one direction average daily traffic at the beginning of the design period is inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The one direction ADT at the beginning of the analysis period is 6350.

(Columns 14-20 of Card #4)

4.2 ONE-DRCTN ADT AT END OF ANALYSIS PERIOD__________

	1	1	8	0	0	•
14	15	16	17	18	19	20

The projected one direction average daily traffic at the end of the analysis period is inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The projected one-direction ADT at the end of analysis period is 11800.

(Columns 22-30 of Card #4)

4.3 ONE-DRCTN CUMULATIVE 18 KSA AFTER 20 YEARS__________

	2	0	9	8	0	0	0	•
22	23	24	25	26	27	28	29	30

The predicted one direction cumulative equivalent 18 Kip Single Axle loads at the end of the analysis period (20 years) are inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: For this project the projected cumulative 18 KSA after 20 years is 2098000 applications.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

TRAFFIC VARIABLES-CARD NO.4

(Columns 37-39 of Card #4)

4.4 PROPORTION OF ADT ARRIVING EA. HR. OF CONST. (%)

7	•	0
37	38	39

The proportion of ADT arriving at the overlay zone each hour of construction is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The proportion of ADT arriving is 7.0%.

(Column 50 of Card #4)

1
50

4.5 TYPE OF RD: 1 = RURAL, 2 = URBAN

Insert code number 1 if the road is in a rural area. Insert 2 if in an urban area.

Example: For the project under consideration the code number is 1, the road is in a rural area.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

RESTRICTIONS-CARD NO. 5

(Columns 8-9 of Card #5)

5.1 MIN. TIME TO FIRST OVERLAY (YEARS)____________________

	2
8	9

The minimum time (years) to the first overlay for the proposed design is inserted in these columns to the right (right Justified). Only numbers may be used.

Example: For the design under consideration the minimum time to the first overlay is 2 years.

(Columns 18-19 of Card #5)

5.2 MIN. TIME BETWEEN OVERLAYS (YEARS)____________________

	3
18	19

The minimum time (years) required between overlays for the proposed design is inserted in these columns to the right (right justified). Only numbers may be used.

Example: For the proposed design the minimum time between overlays is 3 years.

(Columns 28-29 of Card #5)

5.3 TIME TO FIRST SEAL COAT (YEARS)____________________

	5
28	29

The time (years) to the first seal coat for the proposed design is inserted in these columns to the right (right justified). Only numbers may be used.

Example: For the design under consideration the minimum time to the first seal coat is 5 years.

(Columns 38-39 of Card #5)

5.4 TIME BETWEEN SEAL COATS (YEARS) ____________________

	3
38	39

The time (years) between seal coats for the proposed design is inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: For the proposed design the minimum time between seal coats is 3 years.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

RESTRICTIONS-CARD NO. 5

(Columns 47-50 of Card #5)

5	•	0	0
47	48	49	50

5.5 MAXIMUM FUNDS AVAILABLE PER S.Y. FOR INTL. CONST. ($)

The maximum number of dollars available per square yard for initial construction is inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: Maximum number of dollars available per square yard for initial construction is 5.00.

(Columns 56-60 of Card #5)

3	0	•	0	0
56	57	58	59	60

5.6 MAX. TOTAL THICK. OF INITIAL CONSTRUCTION (INCHES)

The maximum allowable thickness (inches) for initial construction is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The maximum allowable thickness is 30 inches.

(Columns 67-70 Card #5)

5.7 MINIMUM OVERLAY THICKNESS (INCHES)

0	•	5	0
67	68	69	70

The desired minimum overlay thickness should be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The minimum overlay thickness is 0.50 inches.

(Columns 77-80 of Card #5)

5	•	0	0
77	78	79	80

5.8 MAXIMUM TOTAL THICKNESS OF ALL OVERLAYS (INCHES).

The desired maximum total thickness of all overlays is to be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The desired maximum total thickness of all overlays is 5.00 inches.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

OVERLAY PARAMETERS-CARD NO. 6

(Columns 6-8 of Card #6)

6.1 ASPH. CONC. PRODUCTION RATE (TONS/HR)

	7	5
6	7	8

The number of tons per hour at which asphaltic concrete is produced for the project under consideration is to be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: Asphaltic Concrete production rate 75 Tons/Hr.

(Columns 17-20 of Card #6)

6.2 ASPH. CONC. COMPACTED DENSITY (TONS/C.Y.)

1	●	9	8
17	18	19	20

The number of tons per cubic yard of asphaltic concrete to be used in the project should be inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: It is estimated that 1.98 Tons/C.Y. will be used.

(Columns 27-29 for Card #6)

6.3 ℄ DISTANCE OVER WHICH TRAF. IS SLOWED IN THE O.D. (MI) *

1	●	0
27	28	29

The distance in miles along the center line in the overlay direction over which traffic is slowed is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The distance over which traffic is slowed is 1.0 mile.

---

* O.D. = OVERLAY DIRECTION

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

OVERLAY PARAMETERS-CARD NO. 6

(Columns 37-39 of Card #6)

6.4 ℄ DISTANCE OVER WHICH TRAF. IS SLOWED IN THE N.O.D. (MI) **

1	●	0
37	38	39

The distance in miles along the center line in the non-overlay direction over which traffic is slowed is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The distance over which traffic is slowed is 1.0 mile.

(Columns 47-49 of Card #6)

6.5 DETOUR DIST. AROUND THE OVERLAY ZONE (MI) ***

	●	
47	48	49

The detoured distance in miles around the overlay zone is inserted in these columns only when detour model FIVE is used. For detour models 1 to 4 these columns should be left blank. Provision has been made to write up to one decimal place.

Example: Detour model 3 is used in this project therefore columns 47-49 have been left blank.

(Columns 57-58 of Card #6)

6.6 OVERLAY CONSTRUCTION TIME (HOURS/DAY)

1	1
57	58

The average number of hours per day that overlay takes place is inserted in these columns to the right side (right justified). Only numbers may be used.

Example: For this project the average is 11 hours/day.

** N.O.D. = NON-OVERLAY DIRECTION
*** Input zeros for Detour Models 1-4

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

OVERLAY PARAMETERS-CARD NO. 6

(Column 70 of Card #6)

6.7 NO. OF OPEN LANES IN RESTRICTED ZONE IN O.D. ______ 1 (70)

The number of lanes open to traffic during overlay operations in the overlay direction is inserted in this column. Only numbers are to be used.

Example: The number of lanes open to traffic in the overlay direction is 1.

(Column 80 of Card #6)

6.8 NO. OF OPEN LANES IN RESTRICTED ZONE N.O.D. ______ 2 (80)

The number of lanes open to traffic during overlay operations in the non-overlay direction is inserted in this column. Only numbers are to be used.

Example: The number of lanes open to traffic in the non-overlay direction is 2.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

OVERLAY PARAMETERS (CONTINUED) - CARD NO. 7

(Columns 6-10 of Card #7)

7.1 PROPORTION OF VEH. STOPPED BY ROAD EQUIP. IN O.D. (%)

	0	●	0	1
6	7	8	9	10

The percent of vehicles stopped in the overlay direction due to movement of men and equipment is inserted in these columns. This percentage is based on total traffic. Provision has been made to record up to two decimal places. Only numbers are to be used.

Example: The percent of vehicles stopped is 0.01.

(Columns 16-20 of Card #7)

7.2 PROPORTION OF VEH. STOPPED BY ROAD EQUIP. IN N.O.D. (%)

	0	●	0	1
16	17	18	19	20

The percent of total traffic of vehicles stopped in the non-overlay direction due to movement of men and equipment is inserted in these columns. This percentage is based on total traffic. Provision has been made to record up to two decimal places. Only numbers are to be used.

Example: The percent of vehicles stopped in the non-overlay direction is 0.01.

(Columns 25-30 of Card #7)

7.3 AVG. TIME A VEH. IS STOPPED BY ROAD EQUIP. O.D. (HRS)

0	●	0	0	4	0
25	26	27	28	29	30

The average time (hours) a vehicle is stopped in the overlay zone (overlay direction) is recorded in these columns. Provision has been made to record up to four decimal places. Only numbers are to be used.

Example: For the project under consideration the average delay per vehicle is estimated at 0.0040 hrs.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

OVERLAY PARAMETERS (CONTINUED) - CARD NO. 7

(Columns 35-40 of Card #7)

7.4 AVG. TIME A VEH. IS STOPPED BY ROAD EQUIP. N.O.D. (HRS)__________

0	•	0	0	4	0
35	36	37	38	39	40

The average time (hours) a vehicle is stopped in the overlay zone (non-overlay direction) is inserted in these columns. Provision has been made to record up to four decimal places. Only numbers are to be used.

Example: For the project under consideration the average delay per vehicle is estimated at 0.0040 hrs.

(Columns 47-48 of Card #7)

7.5 AVG. APPROACH SPEED TO THE OVERLAY ZONE (MPH)__________

6	0
47	48

The average approach speed to the overlay zone is inserted in these columns to the right (right justified). Only numbers are to be used.

Example: The average approach speed is 60 mph.

(Columns 57-58 of Card #7)

7.6 AVG. SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)__________

3	0
57	58

The average thru speed in the overlay direction is recorded in these columns to the right side (right justified). Only numbers are to be used.

Example: The average thru speed in the overlay direction is 30 mph.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

OVERLAY PARAMETERS (CONTINUED) - CARD NO. 7

(Columns 67-68 of Card #7)

7.7 AVG. SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)

5	0
67	68

The average thru speed in the non-overlay direction is recorded in these columns to the right side (right justified). Only numbers are to be used.

Example: The average thru speed in the non-overlay direction is 50 mph.

(Column 80 of Card #7)

7.8 TRAF. MODEL USED IN THE ANALYSIS

3
80

The code number for the model describing the traffic situation is inserted in this column.

Example: The traffic model is 3.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

COST VARIABLES - CARD NO. 8

(Columns 5-10 of Card #8)

8.1 FIRST YEAR COST OF ROUTINE MAINT. (DOLLARS/LANE-MI)

	5	0	•	0	0
5	6	7	8	9	10

The cost per lane mile for routine maintenance during the first year after initial or overlay construction has taken place is inserted in these columns. Provision has been made to record up to two decimal places. Only numbers are to be used.

Example: The cost per lane mile is 50.00 dollars.

(Columns 15-20 of Card #8)

8.2 INCREMENTAL INCREASE IN MAINT. COST/YEAR (DOLLARS/LANE-MI)

	2	0	•	0	0
15	16	17	18	19	20

The annual incremental increase in cost per lane mile for routine maintenance is inserted in these columns. Provision has been made to record up to two decimal places. Only numbers are to be used.

Example: The annual incremental cost is 20.00 dollars.

(Columns 24-30 of Card #8)

8.3 COST OF A SEAL COAT (DOLLARS/LANE-MILE)

1	0	0	0	•	0	0
24	25	26	27	28	29	30

The cost per lane mile of a seal coat is recorded in these columns. Provision has been made to record up to two decimal places.

Example: The cost per lane mile of a seal coat is 1000.00 dollars.

(Columns 36-39 of Card #8)

8.4 INTEREST RATE OR TIME VALUE OF MONEY (%)

	7	•	0
36	37	38	39

The interest rate (%) at which money has been discounted for this project is inserted in these columns. Provision has been made to write up to one decimal place. Only numbers are to be used.

Example: The interest rate specified is 7.0%.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

MATERIAL PARAMETERS - CARD NO.*

(Column 4 of Card #)

9.1 LAYER DESIGNATION NUMBER ________

1
4

The layer number in which the material is to be used is recorded in this column. Only numbers are to be used.

Example: The layer in which the material under consideration is used is 1 (top layer).

(Column 8 of Card #)

9.2 LETTER CODE OF MATERIAL ________

A
8

The letter assigned to identified this material should be inserted in this column. Use capital letters only.

Example: The letter A has been assigned to this material.

(Columns 12-29 of Card #)

9.3 NAME OF THE TYPE OF MATERIAL ________

A	C	P															
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

The name of the material is recorded in these columns. Letters, numerals, blank spaces and special characters may be written.

Example: The material name is ACP.

(Columns 31-35 of Card #)

9.4 IN PLACE COST/COMP.–C.Y. ________

2	6	•	0	0
31	32	33	34	35

The in place cost per compacted cubic yard is inserted in these columns. Provision has been made to record up to two decimal places. Only numbers are to be used.

Example: The in place cost per compacted C.Y. for ACP is 26.00 dollars.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

MATERIAL PARAMETERS - CARD NO.*

(Columns 40-43 of Card #)

9.5 STIFFNESS COEFFICIENT

0	•	7	5
40	41	42	43

The stiffness coefficient of the material is inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The stiffness coefficient for this material is 0.75.

(Columns 47-51 of Card #)

9.6 MIN. ALLOWABLE THICK IN INITIAL CONST. (IN)

	1	•	5	0
47	48	49	50	51

The minimum allowable thickness (inches) in initial construction for the material under consideration is inserted in these columns. Provision has been made to write up to two decimal places. Only numbers are to be used.

Example: The minimum thickness for this material is 1.50 inches.

(Columns 55-59 of Card #)

9.7 MAX ALLOWABLE THICK IN INITIAL CONST. (IN)

	6	•	0	0
55	56	57	58	59

The maximum allowable thickness (inches) in initial construction for the material under consideration is inserted in these columns. Provisions has been made to write up to two decimal places. Only numbers are to be used.

Example: The maximum thickness for this material if 6.00 inches.

FPS-7 PROGRAM
(EXPLANATION OF DATA CODING)

MATERIAL PARAMETERS - CARD NO.*

(Columns 63-65 of Card #)

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORIGINAL COST ________________

	1	0
63	64	65

The estimated salvage value of the material (at the end of the analysis period), as a % of the original cost should be inserted in these columns to the right side (right justified). Only numbers are to be used.

Example: The estimated salvage value is 10% of the original cost.

*This card should be repeated as many times as the number of materials available, including subgrade.

For the subgrade card only variables 9.3 and 9.5 have to be filled in; the others are left blank.

REFERENCES

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2. Scrivner, F. H.; and Moore, W. M., "An Emperical Equation for Predicting Pavement Deflections", Research Report 32-12, Texas Transportation Institute, Texas A & M University, College Station, 1968.

3. Brown, James L., "Utilizing Deflection Measurements to Upgrade Pavement Structures", Research Report 101F, Texas Highway Department - to be published in late 1970.

4. Alder, Henry L.; and Roessler, Edward B., Introduction to Probability and Statistics, University of California, W. H. Freeman and Company, San Francisco, 1964.

5. Hudson, W. Ronald; McCullough, B. Frank; Scrivner, F. H.; and Brown, James L., "A Systems Approach Applied to Pavement Design and Research", Research Report 123-1; Highway Design Division Research Section, Texas Highway Department; Texas Transportation Institute, Texas A & M University; Center for Highway Research, The University of Texas at Austin, Austin, 1969.

6. Scrivner, F. H.; and Michalak, Chester H., "Flexible Pavement Performance Related to Deflections, Axle Applications, Temperature and Foundation Movements", Research Report 32-13, Texas Transportation Institute, Texas A & M University, College Station, 1969.

7. "Planning Survey Division Manual", Texas Highway Department, Austin, 1969.

8. "Permanent Traffic Recorder Data", Annual Report 1968, Planning Survey Division, Texas Highway Department, Austin, 1968.

9. "Area III, Research Advisory Committee Meeting Minutes" (Pavement Structure Design and Evaluation), Texas Highway Department, January 7, 1969.

10. McFarland, Frank, "Routine Maintenance Cost for Computer Program for Project 32", Technical Memorandum to: James L. Brown, October 11, 1968, Texas Highway Department Files, Highway Design Division, Austin.

APPENDIX A

“STIFFNESS COEFFICIENT PROGRAM”
Input Code Sheets and Output Listing

TEXAS HIGHWAY DEPARTMENT

FLEXIBLE PAVEMENT-DESIGN SYSTEM

STIFFNESS COEFFICIENT

CARD NO. 1 - PROJECT IDENTIFICATION

Card No.	Dist.	County	Control	Section	Job	Highway	Lane	Total Pav. Depth
1 0 0	19	BOWIE	218	1		US 59	SBL	13.00
1 2 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

Month	Day	Year	Dynaflect	Comments
04	07	70	29	08 FT. LT. OF CENTER LINE
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

CARD NO. 2 - EXISTING PAVEMENT

Card No.	Type of Material		* Layer Thick (in.)	
2 0 0 1 2 3	ASPHALTIC CONCRETE	4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	1.00	24 25 26 27
	IRON ORE BASE	28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	12.00	48 49 50 51
	SUBGRADE	52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	0.00	72 73 74 75

CARD NO. 3 - EXISTING PAVEMENT (CONTINUED)

3 0 0 1 2 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

* The last layer should be the subgrade.

Sheet 1 of 5

FLEXIBLE PAVEMENT DESIGN SYSTEM
STIFFNESS COEFFICIENT
CARD NO. 4 – DATA CARDS

CARD NO.	CONT.	SECT	MONTH	DAY	YEAR
400	218	1	04	07	70

Station	℄	L/R	Sc	1	Sc	2	Sc	3	Sc	4	Sc	5	Temp Pvt.	Time	Remarks	ICK
1205+00	8	L	42	30	30	30	60	10	45	10	37	10		1129		
1200+00	8	L	40	30	26	30	47	10	33	10	28	10		1130		
1195+00	8	L	30	30	45	10	27	10	54	03	43	03				
1190+00	8	L	40	30	25	30	44	10	31	10	26	10				
1185+00	8	L	54	30	37	30	28	30	58	10	48	10				
1180+00	8	L	61	30	42	30	26	30	46	10	37	10				
1175+00	8	L	84	10	76	10	69	10	59	10	54	10		1140		
1170+00	8	L	42	30	29	30	55	10	38	10	31	10				
1165+00	8	L	40	30	28	30	51	10	34	10	28	10				
1160+00	8	L	35	30	24	30	40	10	27	10	68	03				
1155+00	8	L	32	30	23	30	40	10	28	10	71	03				
1150+00	8	L	39	30	25	30	47	10	34	10	28	10		1149		
1145+00	8	L	36	30	22	30	39	10	27	10	22	10				
1140+00	8	L	35	30	25	30	51	10	38	10	31	10				
1135+00	8	L	36	30	26	30	48	10	36	10	31	10				
1130+00	8	L	41	30	28	30	50	10	39	10	30	10				
1125+00	8	L	46	30	31	30	56	10	38	10	32	10		1258		
1120+00	8	L	46	30	30	30	52	10	38	10	29	10				
1115+00	8	L	39	30	25	30	43	10	32	10	25	10				
1110+00	8	L	36	30	25	30	44	10	32	10	26	10				
1105+00	8	L	48	30	35	30	26	30	55	10	46	10			PATCH	
1100+00	8	L	39	30	28	30	46	10	30	10	22	10		1304	PATCH	
1095+00	8	L	38	30	26	30	47	10	35	10	28	10			PATCH	
1090+00	8	L	30	30	58	10	37	10	27	10	23	10			PATCH	
1085+00	8	L	48	10	45	10	42	10	36	10	31	10		1308	CONC	

Sheet 2 of 5

FLEXIBLE PAVEMENT DESIGN SYSTEM
STIFFNESS COEFFICIENT
CARD NO. 4 — DATA CARDS

CARD NO. 1 2 3	CONT. 4 5 6 7	SECT 8 9	MONTH 10 11	DAY 12 13	YEAR 14 15
400	218	1	04	07	70

Station	CL	L/R	DYNAFLECT READING										Temp Pvt.	Time	Remarks	ICK
			Sc	1	Sc	2	Sc	3	Sc	4	Sc	5				
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
1080+00	8	L	5.0	.10	4.8	.10	4.5	.10	3.7	.10	3.3	.10		1310	CONC	
1075+00	8	L	6.9	.10	6.5	.10	5.8	.10	5.0	.10	4.2	.10			CONC	
1070+00	8	L	5.0	.10	4.8	.10	4.4	.10	3.8	.10	3.2	.10			CONC	
1065+00	8	L	6.3	.10	6.0	.10	5.4	.10	4.5	.10	4.2	.10			CONC	
1060+00	8	L	4.4	.10	4.2	.10	3.8	.10	3.1	.10	2.6	.10		1320	CONC	
1055+00	8	L	6.8	.10	4.6	.10	3.1	.10	2.2	.10	5.2	.03				
1050+00	8	L	6.0	.30	3.4	.30	2.2	.30	4.2	.10	3.4	.10				
1045+00	8	L	5.6	.30	3.2	.30	5.2	.10	3.6	.10	2.9	.10				
1040+00	8	L	4.0	.30	2.6	.30	4.2	.10	2.9	.10	2.3	.10				
1035+00	8	L	4.1	.30	2.5	.30	4.3	.10	3.0	.10	2.5	.10		1330		
1030+00	8	L	4.2	.30	2.9	.30	5.1	.10	3.6	.10	2.9	.10			PATCH	
1025+00	8	L	4.7	.30	2.8	.30	4.2	.10	2.7	.10	6.0	.03			PATCH	
1020+00	8	L	3.6	.30	5.1	.10	2.5	.10	4.6	.03	3.4	.03				
1015+00	8	L	3.7	.30	2.2	.30	3.1	.10	6.3	.03	4.5	.03				
1010+00	8	L	3.1	.30	4.7	.10	2.8	.10	5.8	.03	4.5	.03		1336		
1005+00	8	L	4.2	.30	2.5	.30	3.3	.10	5.7	.03	4.3	.03				
1000+00	8	L	3.3	.30	2.0	.30	3.2	.10	2.2	.10	5.0	.03				
995+00	8	L	3.4	.30	2.2	.30	3.4	.10	2.5	.10	6.1	.03				
990+00	8	L	3.1	.30	4.8	.10	3.0	.10	2.2	.10	4.8	.03				
985+00	8	L	4.2	.30	2.6	.30	4.7	.10	3.3	.10	2.6	.03		1342		
980+00	8	L	4.1	.30	2.5	.30	4.1	.10	3.1	.10	2.7	.10				
975+00	8	L	4.0	.30	2.6	.30	5.0	.10	3.8	.10	3.2	.10				
970+00	8	L	4.0	.30	2.8	.30	5.5	.10	4.2	.10	3.5	.10				
965+00	8	L	3.9	.30	2.5	.30	4.5	.10	3.4	.10	2.8	.10				
960+00	8	L	3.4	.30	2.4	.30	4.3	.10	3.2	.10	2.6	.10		1347		

Sheet 3 of 5

FLEXIBLE PAVEMENT DESIGN SYSTEM
STIFFNESS COEFFICIENT
CARD NO. 4 – DATA CARDS

CARD NO.	CONT.	SECT.	MONTH	DAY	YEAR
400	218	1	04	07	70

Station	℄	L/R	DYNAFLECT READING Sc	1	Sc	2	Sc	3	Sc	4	Sc	5	Temp Pvt	Time	Remarks	ICK
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
955+00	8	L	3.6	.30	2.5	.30	4.5	.10	3.2	.10	2.6	.10		1352		
950+00	8	L	3.0	.30	5.2	.10	3.5	.10	2.7	.10	6.8	.03		1354		
945+00	8	L	3.1	.30	5.2	.10	3.2	.10	2.3	.03	4.7	.03				
940+00	8	L	7.0	.10	4.1	.10	2.7	.10	5.6	.03	4.2	.03				
935+00	8	L	3.0	.30	4.7	.10	2.7	.10	5.2	.10	3.8	.03				
930+00	8	L	5.0	.30	2.7	.30	4.5	.10	3.3	.10	2.8	.10				
925+00	8	L	4.0	.30	2.5	.30	4.1	.10	3.0	.10	2.3	.10		1400		
920+00	8	L	3.9	.30	2.6	.30	4.6	.10	3.4	.10	2.8	.10				
915+00	8	L	3.4	.30	5.4	.10	3.6	.10	2.8	.10	2.3	.10				
910+00	8	L	8.0	.10	4.4	.10	2.8	.10	2.1	.10	5.0	.03				
905+00	8	L	4.7	.10	2.6	.30	3.6	.10	2.4	.10	5.6	.03				
900+00	8	L	4.8	.30	3.2	.30	2.0	.30	3.3	.10	2.5	.10		1407	PATCH	
895+00	8	L	4.8	.30	3.1	.30	5.0	.10	3.2	.10	2.5	.10				
890+00	8	L	5.0	.30	3.3	.30	2.2	.30	3.9	.10	3.0	.10				
885+00	8	L	3.6	.30	3.4	.30	3.0	.30	2.6	.30	2.4	.30			CONC	
880+00	8	L	3.5	.30	3.4	.30	3.0	.30	2.6	.30	2.2	.30			CONC APP TO CUL	
875+00	8	L	4.0	.30	3.8	.30	3.2	.30	2.7	.30	2.2	.30		1415	CONC	
870+00	8	L	3.4	.30	3.2	.30	3.0	.30	2.7	.30	2.4	.30			CONC	
865+00	8	L	3.7	.30	3.5	.30	3.3	.30	2.9	.10	2.7	.30			CONC	
860+00	8	L	4.4	.30	2.9	.30	5.1	.10	3.6	.10	2.9	.10			CONC	
855+00	8	L	3.4	.30	2.2	.30	3.4	.10	2.5	.10	6.4	.03			CONC	
850+00	8	L	5.1	.30	3.2	.30	2.2	.30	4.3	.10	3.5	.10		1423		
845+00	8	L	4.6	.10	4.5	.10	4.2	.10	3.7	.10	3.2	.10			CONC	
840+00	8	L	3.9	.30	2.2	.30	3.1	.10	5.6	.03	4.5	.03				
835+00	8	L	5.2	.30	3.0	.30	4.4	.10	3.0	.10	2.3	.10		1432	PATCH	

Sheet 4 of 5

FLEXIBLE PAVEMENT DESIGN SYSTEM
STIFFNESS COEFFICIENT
CARD NO. 4 — DATA CARDS

CARD NO.	CONT.	SECT.	MONTH	DAY	YEAR
400	218	1	04	07	70
1 2 3	4 5 6 7	8 9	10 11	12 13	14 15

Station	℄	L/R	DYNAFLECT READING										Temp Pvt.	Time	Remarks	ICK
			Sc	1	Sc	2	Sc	3	Sc	4	Sc	5				
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
830+00	8	L	6.4	.10	6.2	.10	5.8	.10	5.0	.10	4.4	.10		1435	CONC	
835+00	8	L	4.3	.30	2.6	.30	3.8	.10	2.6	.10	2.0	.10		1438	PATCH	1
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Sheet 5 of 5

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                        TEXAS HIGHWAY DEPARTMENT

                      DISTRICT 19 - DESIGN SECTION

         DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

                    THIS PROGRAM WAS RUN - 04-09-70

DIST.        COUNTY        CONT.    SECT.   JOB    HIGHWAY       DATE      DYNAFLECT
 19          BOWIE          218      1       0   US 59  SBL    4- 7-70        29

     08 FT. LT. OF CENTER LANE      PAV. THICK. = 13.00 INCHES

ASPHALTIC CONCRETE    1.00  IRON ORE BASE        12.00  SUBGRADE                0.0

    STATION.    W1       W2       W3       W4       W5      SCI      AS2      AP2

    1205+00    1.260    0.900    0.600    0.450    0.370    0.360    0.247    0.546
    1200+00    1.200    0.780    0.470    0.330    0.280    0.420    0.265    0.478
    1195+00    0.900    0.450    0.270    0.162    0.129    0.450    0.323    0.395
    1190+00    1.200    0.750    0.440    0.310    0.260    0.450    0.271    0.456
    1185+00    1.620    1.110    0.840    0.580    0.480    0.510    0.241    0.499
    1180+00    1.830    1.260    0.780    0.460    0.370    0.570    0.234    0.498
    1175+00    0.840    0.760    0.690    0.590    0.540    0.080    0.206    1.061
    1170+00    1.260    0.870    0.550    0.380    0.310    0.390    0.252    0.517
    1165+00    1.200    0.840    0.510    0.340    0.280    0.360    0.253    0.531
    1160+00    1.050    0.720    0.400    0.270    0.204    0.330    0.263    0.522
    1155+00    0.960    0.690    0.400    0.280    0.213    0.270    0.260    0.565
    1150+00    1.170    0.750    0.470    0.340    0.280    0.420    0.268    0.471
    1145+00    1.080    0.660    0.390    0.270    0.220    0.420    0.280    0.451
    1140+00    1.050    0.750    0.510    0.380    0.310    0.300    0.256    0.555
    1135+00    1.080    0.780    0.480    0.360    0.310    0.300    0.253    0.564
    1130+00    1.230    0.840    0.500    0.390    0.300    0.390    0.255    0.510
    1125+00    1.380    0.930    0.560    0.380    0.320    0.450    0.252    0.494
    1120+00    1.380    0.900    0.520    0.380    0.290    0.480    0.257    0.472
    1115+00    1.170    0.750    0.430    0.320    0.250    0.420    0.268    0.471
    1110+00    1.080    0.750    0.440    0.320    0.260    0.330    0.260    0.530
    1105+00    1.440    1.050    0.780    0.550    0.460    0.390    0.236    0.561
    1100+00    1.170    0.840    0.460    0.300    0.220    0.330    0.250    0.554
    1095+00    1.140    0.780    0.470    0.350    0.280    0.360    0.259    0.515
    1090+00    0.900    0.580    0.370    0.270    0.230    0.320    0.282    0.490
    1085+00    0.480    0.450    0.420    0.360    0.310    0.030    0.213    1.320
    1080+00    0.500    0.480    0.450    0.370    0.330    0.020    0.194    1.607
    1075+00    0.690    0.650    0.580    0.500    0.420    0.040    0.194    1.357
    1070+00    0.500    0.480    0.440    0.380    0.320    0.020    0.194    1.607
    1065+00    0.630    0.600    0.540    0.460    0.420    0.030    0.191    1.485
    1060+00    0.440    0.420    0.380    0.310    0.260    0.020    0.204    1.524
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DIST.	COUNTY	CONT.	SECT.	JOB	HIGHWAY	DATE	DYNAFLECT
19	BOWIE	218	1	0	US 59 SBL	4- 7-70	29

STATION.	W1	W2	W3	W4	W5	SCI	AS2	AP2
1055+00	0.680	0.460	0.310	0.220	0.155	0.220	0.290	0.539
1050+00	1.800	1.020	0.660	0.420	0.340	0.780	0.262	0.387
1045+00	1.680	0.960	0.520	0.360	0.290	0.720	0.265	0.395
1040+00	1.200	0.780	0.420	0.290	0.230	0.420	0.265	0.478
1035+00	1.230	0.750	0.430	0.300	0.250	0.480	0.273	0.442
1030+00	1.260	0.870	0.510	0.360	0.290	0.390	0.252	0.517
1025+00	1.410	0.840	0.420	0.270	0.180	0.570	0.269	0.423
1020+00	1.080	0.510	0.250	0.138	0.102	0.570	0.320	0.368
1015+00	1.110	0.660	0.310	0.189	0.135	0.450	0.283	0.437
1010+00	0.930	0.470	0.230	0.174	0.135	0.460	0.319	0.395
1005+00	1.260	0.750	0.330	0.171	0.129	0.510	0.275	0.429
1000+00	0.990	0.600	0.320	0.220	0.150	0.390	0.286	0.453
995+00	1.020	0.660	0.340	0.250	0.183	0.360	0.274	0.485
990+00	0.930	0.480	0.300	0.220	0.144	0.450	0.316	0.400
985+00	1.260	0.780	0.470	0.330	0.078	0.480	0.269	0.448
980+00	1.230	0.750	0.410	0.310	0.270	0.480	0.273	0.442
975+00	1.200	0.780	0.500	0.380	0.320	0.420	0.265	0.478
970+00	1.200	0.840	0.550	0.420	0.350	0.360	0.253	0.531
965+00	1.170	0.750	0.450	0.340	0.280	0.420	0.263	0.471
960+00	1.020	0.720	0.430	0.320	0.260	0.300	0.260	0.546
955+00	1.080	0.750	0.450	0.320	0.260	0.330	0.260	0.530
950+00	0.900	0.520	0.350	0.270	0.204	0.380	0.300	0.439
945+00	0.930	0.520	0.320	0.069	0.141	0.410	0.303	0.425
940+00	0.700	0.410	0.270	0.168	0.126	0.290	0.313	0.463
935+00	0.900	0.470	0.270	0.520	0.114	0.430	0.316	0.406
930+00	1.500	0.810	0.450	0.330	0.280	0.690	0.279	0.381
925+00	1.200	0.750	0.410	0.300	0.230	0.450	0.271	0.456
920+00	1.170	0.780	0.460	0.340	0.280	0.390	0.262	0.496
915+00	1.020	0.540	0.360	0.280	0.230	0.480	0.306	0.401
910+00	0.800	0.440	0.280	0.210	0.150	0.360	0.315	0.431

DIST.	COUNTY	CONT.	SECT.	JOB	HIGHWAY	DATE	DYNAFLECT
19	BOWIE	218	1	0	US 59 SBL	4- 7-70	29

STATION.	W1	W2	W3	W4	W5	SCI	AS2	AP2
905+00	1.410	0.780	0.360	0.240	0.168	0.630	0.279	0.393
900+00	1.440	0.960	0.600	0.330	0.250	0.480	0.251	0.485
895+00	1.440	0.930	0.500	0.320	0.250	0.510	0.256	0.464
890+00	1.500	0.990	0.660	0.390	0.300	0.510	0.250	0.476
885+00	1.080	1.020	0.900	0.780	0.720	0.060	0.175	1.377
880+00	1.050	1.020	0.900	0.780	0.660	0.030	0.156	1.833
875+00	1.200	1.140	0.960	0.810	0.660	0.060	0.167	1.445
870+00	1.020	0.960	0.900	0.810	0.720	0.060	0.179	1.342
865+00	1.110	1.050	0.990	0.870	0.810	0.060	0.173	1.395
860+00	1.320	0.870	0.510	0.360	0.290	0.450	0.257	0.481
855+00	1.020	0.660	0.340	0.250	0.192	0.360	0.274	0.485
850+00	1.530	0.960	0.660	0.430	0.350	0.570	0.257	0.444
845+00	0.460	0.450	0.420	0.370	0.320	0.010	0.178	2.040
840+00	1.170	0.660	0.310	0.168	0.135	0.510	0.287	0.412
835+00	1.560	0.900	0.440	0.300	0.230	0.660	0.268	0.403
830+00	0.640	0.620	0.580	0.500	0.440	0.020	0.176	1.774
825+00	1.290	0.780	0.380	0.260	0.200	0.510	0.272	0.435
AVERAGES	1.116	0.750	0.485	0.358	0.288	0.366	0.256	0.659
STANDARD DEVIATION						0.184	0.039	0.420

W1	Deflection at Geophone 1
W2	Deflection at Geophone 2
W3	Deflection at Geophone 3
W4	Deflection at Geophone 4
W5	Deflection at Geophone 5
SCI	Surface Curvature Index (W1 minus W2)
AS2	Stiffness Coefficient of the Subgrade
AP2	Stiffness Coefficient of the Pavement

APPENDIX B

“PROFILE ANALYSIS PROGRAM”
Input Code Sheets and Output Listing

TEXAS HIGHWAY DEPARTMENT

FLEXIBLE PAVEMENT-DESIGN SYSTEM

PROFILE ANALYSIS

CARD NO. 1 - PROJECT IDENTIFICATION

DIST.	COUNTY	CONTROL	SECTION	JOB	HIGHWAY
19	BOWIE	218	1		US 59
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

DATE	NO. OF SECTIONS
04/07/70	10
35 36 37 38 39 40 41 42	43 44

CARD NO. 2 - LAST REF. POINT AT EACH SECTION

7	16	19	22	26	33	40	55	73	76
1 2 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

CARD NO. 3 - DATA CARDS

REF. POINT	STATION	STIFF. COEF. VALUES (AS2)				AVG AS2
	1 2 3 4 5 6 7	NBL	SBL			8 9 10 11 12
1	825+00	.285	.272			0.278
2	830+00	.256				0.256
3	835+00	.264	.268			0.266
4	840+00	.345	.287			0.316
5	845+00	.266				0.266
6	850+00	.257	.257			0.257
7	855+00	.265	.274			0.270
8	860+00	.249	.257			0.253
9	865+00	.256				0.256
10	870+00	.246				0.246
11	875+00	.252				0.252
12	880+00	.250				0.250

CARD NO. 3 - DATA CARDS

REF. POINT	STATION	STIFF. COEF. VALUES (AS2)				AVG. AS2
	1 2 3 4 5 6 7	NBL	SBL	Additional NBL		8 9 10 11 12
13	885+00	.260				0.260
14	890+00	.272	.250			0.261
15	895+00	.266	.256			0.261
16	900+00	.252	.251			0.252
17	905+00		.279			0.279
18	910+00		.315			0.315
19	915+00		.306			0.306
20	920+00		.262			0.262
21	925+00		.271			0.271
22	930+00	.274	.279			0.276
23	935+00	.319	.316			0.318
24	940+00	.320	.313			0.317
25	945+00	.289	.303			0.296
26	950+00		.300			0.300
27	955+00		.260			0.260
28	960+00		.260			0.260
29	965+00		.268			0.268
30	970+00		.253			0.253
31	975+00		.265			0.265
32	980+00		.273			0.273
33	985+00		.269			0.269
34	990+00		.316			0.316
35	995+00		.274			0.274
36	1000+00		.286			0.286
37	1005+00	.280	.275			0.278
38	1010+00	.309	.319			0.314
39	1015+00	.290	.283			0.286
40	1020+00		.320			0.320
41	1025+00		.269			0.269
42	1030+00		.252			0.252
43	1035+00		.273			0.273
44	1040+00		.265			0.265
45	1045+00	.261	.265			0.263
46	1050+00	.262	.262			0.262
47	1055+00	.306	.290	.306		0.301

CARD NO. 3 - DATA CARDS

REF. POINT	STATION 1 2 3 4 5 6 7	STIFF. COEF. VALUES (AS2) NBL	SBL	Additional NBL		AVG. AS2 8 9 10 11 12
48	1060+00	.283		.289		0.286
49	1065+00	.274				0.274
50	1070+00	.277				0.277
51	1075+00	.263				0.263
52	1080+00	.253				0.253
53	1085+00	.295				0.295
54	1090+00	.282	.282			0.282
55	1095+00	.267	.259			0.263
56	1100+00		.250			0.250
57	1105+00		.236			0.236
58	1110+00		.260			0.260
59	1115+00		.268			0.268
60	1120+00		.257			0.257
61	1125+00		.252			0.252
62	1130+00		.255			0.255
63	1135+00		.253			0.253
64	1140+00		.256			0.256
65	1145+00		.280			0.280
66	1150+00		.268			0.268
67	1155+00		.260			0.260
68	1160+00	.270	.263			0.267
69	1165+00	.266	.253			0.260
70	1170+00	.246	.252			0.249
71	1180+00	.235	.234			0.234
72	1185+00	.249	.241			0.245
73	1190+00	.252	.271			0.262
74	1195+00	.306	.323			0.314
75	1200+00	.260	.265			0.262
76	1205+00	.248	.247			0.248
	+					.
	+					.
	+					.
	+					.
	+					.
	+					.

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                              TEXAS HIGHWAY DEPARTMENT

                            DISTRICT 19 - DESIGN SECTION

                           THIS PROGRAM WAS RUN - 05-04-70

                            PROFILE ANALYSIS FOR    US 59

DIST.         COUNTY         CONT.   SECT.   JOB  HIGHWAY    DATE    NO. OF SECT.
 19            BOWIE          218      1      0   US 59    04/07/70       10

                            REFERENCE        STA.         INPUT
                             POINTS                       DATA

                                 1         825+00         0.278
                                 2         830+00         0.256
                                 3         835+00         0.266
                                 4         840+00         0.316
                                 5         845+00         0.266
                                 6         850+00         0.257
                                 7         855+00         0.270
                                 8         860+00         0.253
                                 9         865+00         0.256
                                10         870+00         0.246
                                11         875+00         0.252
                                12         880+00         0.250
                                13         885+00         0.260
                                14         890+00         0.261
                                15         895+00         0.261
                                16         900+00         0.252
                                17         905+00         0.279
                                18         910+00         0.315
                                19         915+00         0.306
                                20         920+00         0.262
                                21         925+00         0.271
                                22         930+00         0.276
                                23         935+00         0.318
                                24         940+00         0.317
                                25         945+00         0.296
                                26         950+00         0.300
                                27         955+00         0.260
                                28         960+00         0.260
                                29         965+00         0.268
                                30         970+00         0.253
                                31         975+00         0.265
                                32         980+00         0.273
                                33         985+00         0.269
                                34         990+00         0.316
                                35         995+00         0.274
                                36        1000+00         0.286
                                37        1005+00         0.278
                                38        1010+00         0.314
                                39        1015+00         0.286
                                40        1020+00         0.320
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                        DISTRICT 19 - DESIGN SECTION

                        PROFILE ANALYSIS FOR    US 59

                        REFERENCE       STA.        INPUT
                         POINTS                     DATA

                            41        1025+00        0.269
                            42        1030+00        0.252
                            43        1035+00        0.273
                            44        1040+00        0.265
                            45        1045+00        0.263
                            46        1050+00        0.262
                            47        1055+00        0.301
                            48        1060+00        0.286
                            49        1065+00        0.274
                            50        1070+00        0.277
                            51        1075+00        0.263
                            52        1080+00        0.253
                            53        1085+00        0.295
                            54        1090+00        0.282
                            55        1095+00        0.263
                            56        1100+00        0.250
                            57        1105+00        0.236
                            58        1110+00        0.260
                            59        1115+00        0.268
                            60        1120+00        0.257
                            61        1125+00        0.252
                            62        1130+00        0.255
                            63        1135+00        0.253
                            64        1140+00        0.256
                            65        1145+00        0.280
                            66        1150+00        0.268
                            67        1155+00        0.260
                            68        1160+00        0.267
                            69        1165+00        0.260
                            70        1170+00        0.249
                            71        1180+00        0.234
                            72        1185+00        0.245
                            73        1190+00        0.262
                            74        1195+00        0.314
                            75        1200+00        0.262
                            76        1205+00        0.248

INPUT BREAK PTS. AT     1    7   16   19   22   25   33   40   55   73   76
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                              TEXAS HIGHWAY DEPARTMENT

                            DISTRICT 19 - DESIGN SECTION

                            PROFILE ANALYSIS FOR    US 59

                           THIS PROGRAM WAS RUN - 05-04-70

DIST.        COUNTY        CONT.   SECT.   JOB  HIGHWAY     DATE   NO. OF SECT.
 19           BOWIE         218      1      0   US 59     04/07/70        7


                AVERAGE AND STANDARD DEVIATION FOR DATA DIVIDED
                 INTO GROUPS OF SIGNIFICANT DIFFERENCE


 BREAK POINTS AT      1    7  16  26  33  40  55  76
       REF. POINTS          AVERAGE          STANDARD         F               F
        LIMITS                OF             DEVIATION      CALC.           TABLE
       OF SECTIONS         SECTIONS          OF SECTIONS                    VALUE

         1  TO   7          0.273                0.021       6.612          4.600
         8  TO  16          0.255                0.005      30.876          4.450
        17  TO  26          0.294                0.021      13.528          4.540
        27  TO  33          0.264                0.007      16.935          4.750
        34  TO  40          0.296                0.020      11.017          4.350
        41  TO  55          0.272                0.014       6.039          4.134
        56  TO  76          0.259                0.017       0.0            0.0
```

APPENDIX C

"FPS-7 PROGRAM"
Input Code Sheets and Output Listing

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS-7

PROJECT IDENTIFICATION - CARD NO. 1

1.1 DATE

0	3	/	2	6	/	7	0
1	2	3	4	5	6	7	8

1.2 DISTRICT

1	9
9	10

1.3 HIGHWAY

U	S		5	9		N	-	S	B	L
11	12	13	14	15	16	17	18	19	20	21

1.4 CONTROL

	2	1	8
22	23	24	25

1.5 SECTION

0	1
26	27

1.6 IPE

28	29	30	31

1.7 COMMENTS

S	E	C	T	.		N	O	.	1		S	T	A	.	8	2	5	-	8	5	5		
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55

PROGRAM CONTROLS - CARD NO. 2

2.1 NUMBER OF SUMMARY OUTPUT PAGES

3
10

2.2 NUMBER OF MATERIALS

4
20

2.3 LENGTH OF ANALYSIS PERIOD (YEARS)

2	0
27	28

2.4 WIDTH OF EACH LANE (FEET)

1	2
37	38

Code Sheet 1 of 7

FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS-7

PERFORMANCE VARIABLES - CARD NO. 3

3.1 DISTRICT TEMPERATURE CONSTANT

2	5
7	8

3.2 INITIAL SERVICEABILITY INDEX

4	●	2
17	18	19

3.3 SERVICEABILITY INDEX AFTER AN OVERLAY

4	●	4
27	28	29

3.4 MINIMUM SERVICEABILITY INDEX

3	●	0
37	38	39

3.5 SWELLING CLAY PARAMETER, P_2' (DOES NOT CHANGE)

1	●	5	0
47	48	49	50

3.6 SWELLING CLAY PARAMETER, b_1

0	●	0	2	0	0
55	56	57	58	59	60

TRAFFIC VARIABLES - CARD NO. 4

4.1 ONE-DRCTN ADT AT BEGINNING OF ANALYSIS PERIOD (VEH./DAY)

		6	3	5	0	●
4	5	6	7	8	9	10

4.2 ONE-DRCTN ADT AT END OF ANALYSIS PERIOD (VEH./DAY)

	1	1	8	0	0	●
14	15	16	17	18	19	20

4.3 ONE-DRCTN CUMULATIVE 18 KSA AFTER 20 YEARS

	2	0	9	8	0	0	0	●
22	23	24	25	26	27	28	29	30

4.4 PROPORTION OF ADT ARRIVING EA. HR. OF CONST. (%)

7	●	0
37	38	39

4.5 TYPE OF ROAD: 1 = RURAL, 2 = URBAN

1
50

Code Sheet 2 of 7

FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS-7

RESTRICTIONS - CARD NO. 5

5.1 MINIMUM TIME TO FIRST OVERLAY (YEARS) 2
8 9

5.2 MINIMUM TIME BETWEEN OVERLAYS (YEARS) 3
18 19

5.3 TIME TO FIRST SEAL COAT (YEARS) 5
28 29

5.4 TIME BETWEEN SEAL COATS (YEARS) 3
38 39

5.5 MAXIMUM FUNDS AVAILABLE PER S.Y. FOR INTL. CONST. ($) 5.00
47 48 49 50

5.6 MAXIMUM TOTAL THICKNESS OF INITIAL CONSTRUCTION (INCHES) 30.00
56 57 58 59 60

5.7 MINIMUM OVERLAY THICKNESS (INCHES) 0.50
67 68 69 70

5.8 MAXIMUM TOTAL THICKNESS OF ALL OVERLAYS (INCHES) 5.00
77 78 79 80

OVERLAY PARAMETERS - CARD NO. 6

6.1 ASPH. CONC. PRODUCTION RATE (TONS/HR) 75
6 7 8

6.2 ASPH. CONC. COMPACTED DENSITY (TONS/C.Y.) 1.98
17 18 19 20

6.3 ℄ DISTANCE OVER WHICH TRAF. IS SLOWED IN THE O.D.* (MI) 1.0
27 28 29

6.4 ℄ DISTANCE OVER WHICH TRAF. IS SLOWED IN THE N.O.D.** (MI) 1.0
37 38 39

6.5 DETOUR DISTANCE AROUND THE OVERLAY ZONE (MI)*** 0.0
47 48 49

6.6 OVERLAY CONSTRUCTION TIME (HOURS/DAY) 11
57 58

6.7 NO. OF OPEN LANES IN RESTRICTED ZONE IN O.D.* 1
70

6.8 NO. OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.** 2
80

* O.D. = OVERLAY DIRECTION

** N.O.D. = NON-OVERLAY DIRECTION

*** Input zeros for Traf. Models 1-4

Code Sheet 3 of 7

FLEXIBLE PAVEMENT SYSTEM
FPS-7

OVERLAY PARAMETERS (Continued) - CARD NO. 7

7.1 PROPORTION OF VEH. STOPPED BY ROAD EQUIP. IN O.D. (%) ____

	0	●	0	1
6	7	8	9	10

7.2 PROPORTION OF VEH. STOPPED BY ROAD EQUIP. IN N.O.D. (%) ____

	0	●	0	1
16	17	18	19	20

7.3 AVG. TIME A VEH. IS STOPPED BY ROAD EQUIP. O.D. (HRS) ____

0	●	0	0	4	0
25	26	27	28	29	30

7.4 AVG. TIME A VEH. IS STOPPED BY ROAD EQUIP. N.O.D. (HRS) ____

0	●	0	0	4	0
35	36	37	38	39	40

7.5 AVG. APPROACH SPEED TO THE OVERLAY ZONE (MPH) ____

6	0
47	48

7.6 AVG. SPEED THROUGH OVERLAY ZONE IN O.D. (MPH) ____

3	0
57	58

7.7 AVG. SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH) ____

5	0
67	68

7.8 TRAF. MODEL USED IN THE ANALYSIS ____

3
80

COST VARIABLES - CARD NO. 8

8.1 FIRST YEAR COST OF ROUTINE MAINT. (DOLLARS/LANE-MI) ____

	5	0	●	0	0
5	6	7	8	9	10

8.2 INCREMENTAL INCREASE IN MAINT. COST/YEAR (DOLLARS/LANE-MI) ____

	2	0	●	0	0
15	16	17	18	19	20

8.3 COST OF A SEAL COAT (DOLLARS/LANE-MI) ____

1	0	0	0	●	0	0
24	25	26	27	28	29	30

8.4 INTEREST RATE OR TIME VALUE OF MONEY(%) ____

	7	●	0
36	37	38	39

FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS-7

MATERIAL PARAMETERS - CARD NO. 9

9.1 LAYER DESIGNATION NUMBER ______ 1 (4)

9.2 LETTER CODE OF MATERIAL ______ 4 (8)

9.3 NAME OF THE TYPE OF MATERIAL ______ ACP (12 13 14 15 16 17 18 19 20 2 22 23 24 25 26 27 28 29)

9.4 IN PLACE COST/COMP.-C.Y. ______ 26●00 (31 32 33 34 35)

9.5 STIFFNESS COEFFICIENT ______ 0●75 (40 41 42 43)

9.6 MIN. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.) ______ 1●50 (47 48 49 50 51)

9.7 MAX. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.) ______ 6●00 (55 56 57 58 59)

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORGINAL COST ______ 10 (63 64 65)

MATERIAL PARAMETERS - CARD NO. 10

9.1 LAYER DESIGNATION NUMBER ______ 2 (4)

9.2 LETTER CODE OF MATERIAL ______ B (8)

9.3 NAME OF THE TYPE OF MATERIAL ______ CRUSHED STONE (12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29)

9.4 IN PLACE COST/COMP.-C.Y. ______ 4●33 (31 32 33 34 35)

9.5 STIFFNESS COEFFICIENT ______ 0●60 (40 41 42 43)

9.6 MIN. ALLOWABLE THICKNESS IN INITIAL COST. (IN.) ______ 4●00 (47 48 49 50 51)

9.7 MAX. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.) ______ 12●00 (55 56 57 58 59)

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORGINAL COST ______ 80 (63 64 65)

Code Sheet 5 of 7

FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS-7

MATERIAL PARAMETERS - CARD NO. 11

9.1 LAYER DESIGNATION NUMBER

2
4

9.2 LETTER CODE OF MATERIAL

C
8

9.3 NAME OF THE TYPE OF MATERIAL

B	L	E	N	D	E	D		C	.	S		+		G	R	V	L
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

9.4 IN PLACE COST/COMP.-C.Y.

	3	●	5	0
31	32	33	34	35

9.5 STIFFNESS COEFFICIENT

0	●	5	0
40	41	42	43

9.6 MIN. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.)

	4	●	0	0
47	48	49	50	51

9.7 MAX. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.)

1	2	●	0	0
55	56	57	58	59

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORGINAL COST

	8	0
63	64	65

MATERIAL PARAMETERS - CARD NO. 12

9.1 LAYER DESIGNATION NUMBER

3
4

9.2 LETTER CODE OF MATERIAL

D
8

9.3 NAME OF THE TYPE OF MATERIAL

G	R	A	V	E	L												
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

9.4 IN PLACE COST/COMP.-C.Y.

	1	●	5	0
31	32	33	34	35

9.5 STIFFNESS COEFFICIENT

0	●	4	0
40	41	42	43

9.6 MIN. ALLOWABLE THICKNESS IN INITIAL COST. (IN.)

	4	●	0	0
47	48	49	50	51

9.7 MAX. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.)

1	2	●	0	0
55	56	57	58	59

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORGINAL COST

1	0	0
63	64	65

FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS-7

MATERIAL PARAMETERS - CARD NO. 13

9.1 LAYER DESIGNATION NUMBER

4

9.2 LETTER CODE OF MATERIAL

8

9.3 NAME OF THE TYPE OF MATERIAL

S	U	B	G	R	A	D	E										
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

9.4 IN PLACE COST/COMP.-C.Y.

		●		
31	32	33	34	35

9.5 STIFFNESS COEFFICIENT

0	●	2	3
40	41	42	43

9.6 MIN. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.)

		●		
47	48	49	50	51

9.7 MAX. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.)

		●		
55	56	57	58	59

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORGINAL COST

63	64	65

MATERIAL PARAMETERS - CARD NO. ___

9.1 LAYER DESIGNATION NUMBER

4

9.2 LETTER CODE OF MATERIAL

8

9.3 NAME OF THE TYPE OF MATERIAL

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

9.4 IN PLACE COST/COMP.-C.Y.

		●		
31	32	33	34	35

9.5 STIFFNESS COEFFICIENT

	●		
40	41	42	43

9.6 MIN. ALLOWABLE THICKNESS IN INITIAL COST. (IN.)

		●		
47	48	49	50	51

9.7 MAX. ALLOWABLE THICKNESS IN INITIAL CONST. (IN.)

		●		
55	56	57	58	59

9.8 MATERIAL'S SALVAGE VALUE AS % OF ORGINAL COST

63	64	65

Code Sheet 7 of 7

```
  DATE     DIST.     HIGHWAY     CONT.  SECT.  IPE           COMMENTS
03/26/70    19     US 59 N-SBL    218     01              SECT. NO.1 STA.825-855

           THE CONSTRUCTION MATERIALS UNDER CONSIDERATION ARE              FPS-7
         MATERIALS               COST     STR.     MIN.     MAX.  SALVAGE
LAYER CODE          NAME        PER CY   COEFF.   DEPTH    DEPTH    PCT.
  1     A    ACP                26.00    0.75     1.50     6.00    10.00
  2     B   CRUSHED STONE       4.33     0.60     4.00    12.00    80.00
  2     C   BLENDED C.S + GRVL  3.50     0.50     4.00    12.00    80.00
  3     D   GRAVEL              1.50     0.40     4.00    12.00   100.00
            SUBGRADE            0.0      0.23     0.0      0.0      0.0

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

   DISTRICT TEMPERATURE CONSTANT                                            25.0
   SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                             4.2
   SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                  4.4
   MINIMUM SERVICEABILITY INDEX P2                                           3.0
   SWELLING CLAY PARAMETERS -- P2 PRIME                                     1.50
                                   B1                                     0.0200

   ONE-DIRECTION ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)        6350.
   ONE-DIRECTION ADT AT END OF ANALYSIS PERIOD (VEHICLES/DAY)             11800.
   ONE-DIRECTION 20.-YR ACCUMULATED NO. OF EQUIVALENT 18-KIP AXLES     2098000.
   PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)            7.0
   THE ROAD IS IN A RURAL AREA.

   MINIMUM TIME TO FIRST OVERLAY (YEARS)                                     2.0
   MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                     3.0
   TIME TO FIRST SEAL COAT AFTER INITIAL OR OVERLAY CONST.(YEARS)            5.0
   TIME BETWEEN SEAL COATS (YEARS)                                           3.0
   MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)              5.00
   MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)               30.0
   MINIMUM OVERLAY THICKNESS (INCHES)                                        0.5
   ACCUMULATED MAXIMUM DEPTH OF ALL OVERLAYS (INCHES)                        5.0

   ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                           75.0
   ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                         1.98
   C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE O.D. (MILES)           1.00
   C.L. DISTANCE OVER WHICH TRAFFIC IS SLOWED IN THE N.O.D. (MILES)         1.00
   DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                          0.0
   OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                    11.0
   NUMBER OF OPEN LANES IN RESTRICTED ZONE IN O.D.                             1
   NUMBER OF OPEN LANES IN RESTRICTED ZONE IN N.O.D.                           2

   PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN O.D. (PERCENT)     0.01
   PROPORTION OF VEHICLES STOPPED BY ROAD EQUIPMENT IN N.O.D. (PERCENT)   0.01
   AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN O.D. (HOURS)                  0.004
   AVERAGE TIME STOPPED BY ROAD EQUIPMENT IN N.O.D. (HOURS)                0.004
   AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH)                         60.0
   AVERAGE SPEED THROUGH OVERLAY ZONE IN O.D. (MPH)                         30.0
   AVERAGE SPEED THROUGH OVERLAY ZONE IN N.O.D. (MPH)                       50.0
   TRAFFIC MODEL USED IN THE ANALYSIS                                          3

   FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE MILE)              50.00
   INCREMENTAL INCREASE IN MAINT. COST PER YEAR (DOLLARS/LANE MILE)        20.00
   COST OF A SEAL COAT (DOLLARS/LANE MILE)                               1000.00
   INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                            7.0
```

```
     DATE     DIST.     HIGHWAY     CONT.  SECT.  IPE            COMMENTS
   03/26/70    19     US 59 N-SBL    218     01              SECT. NO.1 STA.825-855

  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   ACP                26.00    0.75    1.50     6.00   10.00
           SUBGRADE              0.0     0.23    0.0      0.0     0.0

   1   THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
         FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
               ACP                        6.00 INCHES

         THE SCI OF THE INITIAL STRUCTURE  =  1.157
         THE LIFE OF THE INITIAL STRUCTURE =  2.16 YEARS
         THE OVERLAY SCHEDULE IS
               2.00 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER  2.16 YEARS.
               1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER  6.23 YEARS.
               1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER 10.83 YEARS.
               1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER 16.13 YEARS.
              TOTAL LIFE =      22.17 YEARS

         SEAL COATS SHOULD OCCUR AFTER
              (1)  15.83 YEARS

         THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
              INITIAL CONSTRUCTION COST           4.333
              TOTAL ROUTINE MAINTENANCE COST      0.127
              TOTAL OVERLAY CONSTRUCTION COST     2.865
              TOTAL USER COST DURING
                        OVERLAY CONSTRUCTION      0.264
              TOTAL SEAL COAT COST                0.048
              SALVAGE VALUE                      -0.159
              TOTAL OVERALL COST                  7.480


         NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --        1


           AT THE OPTIMAL SOLUTION,THE FOLLOWING
           BOUNDARY RESTRICTIONS ARE ACTIVE--
                    1. THE MAXIMUM DEPTH OF LAYER  1
```

```
    DATE     DIST.     HIGHWAY    CONT.  SECT.  IPE           COMMENTS
  03/26/70    19     US 59 N-SBL   218    01             SECT. NO.1 STA.825-855

 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   ACP                  26.00     0.75     1.50     6.00    10.00
  2     B  CRUSHED STONE          4.33     0.60     4.00    12.00    80.00
           SUBGRADE               0.0      0.23     0.0      0.0      0.0

  2    THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
        FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
               ACP                     1.50 INCHES
              CRUSHED STONE           10.00 INCHES

        THE SCI OF THE INITIAL STRUCTURE  =  0.454
        THE LIFE OF THE INITIAL STRUCTURE =  9.19 YEARS
        THE OVERLAY SCHEDULE IS
               1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER  9.19 YEARS.
              TOTAL LIFE =      20.30 YEARS

        SEAL COATS SHOULD OCCUR AFTER
              (1)    5.00 YEARS
              (2)    8.00 YEARS
              (3)   14.19 YEARS
              (4)   17.19 YEARS

        THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
              INITIAL CONSTRUCTION COST            2.286
              TOTAL ROUTINE MAINTENANCE COST       0.205
              TOTAL OVERLAY CONSTRUCTION COST      0.589
              TOTAL USER COST DURING
                          OVERLAY CONSTRUCTION     0.059
              TOTAL SEAL COAT COST                 0.284
              SALVAGE VALUE                       -0.286
              TOTAL OVERALL COST                   3.137

        NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --      112


          AT THE OPTIMAL SOLUTION,THE FOLLOWING
          BOUNDARY RESTRICTIONS ARE ACTIVE--
                     1. THE MINIMUM DEPTH OF LAYER  1
```

```
      DATE    DIST.    HIGHWAY    CONT.  SECT.  IPE          COMMENTS
    03/26/70   19    US 59 N-SBL   218    01             SECT. NO.1 STA.825-855

  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   ACP                 26.00    0.75     1.50     6.00    10.00
   2     B  CRUSHED STONE         4.33    0.60     4.00    12.00    80.00
   3     D  GRAVEL                1.50    0.40     4.00    12.00   100.00
            SUBGRADE              0.0     0.23     0.0      0.0      0.0

   3   THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
        FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
              ACP                  1.50 INCHES
             CRUSHED STONE         4.00 INCHES
             GRAVEL               12.00 INCHES

        THE SCI OF THE INITIAL STRUCTURE  =  0.410
        THE LIFE OF THE INITIAL STRUCTURE = 10.41 YEARS
        THE OVERLAY SCHEDULE IS
              1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER 10.41 YEARS.
             TOTAL LIFE =      22.88 YEARS

        SEAL COATS SHOULD OCCUR AFTER
             (1)    5.00 YEARS
             (2)    8.00 YEARS
             (3)   15.41 YEARS
             (4)   18.41 YEARS

        THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
             INITIAL CONSTRUCTION COST           2.064
             TOTAL ROUTINE MAINTENANCE COST      0.208
             TOTAL OVERLAY CONSTRUCTION COST     0.551
             TOTAL USER COST DURING
                     OVERLAY CONSTRUCTION        0.057
             TOTAL SEAL COAT COST                0.277
             SALVAGE VALUE                      -0.266
             TOTAL OVERALL COST                  2.892

        NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --      315

          AT THE OPTIMAL SOLUTION,THE FOLLOWING
          BOUNDARY RESTRICTIONS ARE ACTIVE--
                      1. THE MINIMUM DEPTH OF LAYER  1
                      2. THE MINIMUM DEPTH OF LAYER  2
                      3. THE MAXIMUM DEPTH OF LAYER  3
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    DATE     DIST.     HIGHWAY    CONT.   SECT.   IPE            COMMENTS
  .03/26/70   19     US 59 N-SBL    218     01               SECT. NO.1 STA.825-855

 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    ACP               26.00     0.75     1.50      6.00    10.00
  2     C   BLENDED C.S + GRVL  3.50     0.50     4.00     12.00    80.00
            SUBGRADE            0.0      0.23     0.0       0.0      0.0

  4    THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
         FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
                ACP                       1.50 INCHES
               BLENDED C.S + GRVL     12.00 INCHES

         THE SCI OF THE INITIAL STRUCTURE  =  0.507
         THE LIFE OF THE INITIAL STRUCTURE =  7.97 YEARS
         THE OVERLAY SCHEDULE IS
                1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER  7.97 YEARS.
                1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER 17.58 YEARS.
               TOTAL LIFE =       27.66 YEARS

         SEAL COATS SHOULD OCCUR AFTER
               (1)    5.00 YEARS
               (2)   12.97 YEARS
               (3)   15.97 YEARS

         THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
               INITIAL CONSTRUCTION COST             2.250
               TOTAL ROUTINE MAINTENANCE COST        0.187
               TOTAL OVERLAY CONSTRUCTION COST       0.951
               TOTAL USER COST DURING
                         OVERLAY CONSTRUCTION        0.102
               TOTAL SEAL COAT COST                  0.208
               SALVAGE VALUE                        -0.288
               TOTAL OVERALL COST                    3.411


         NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --       94


           AT THE OPTIMAL SOLUTION,THE FOLLOWING
           BOUNDARY RESTRICTIONS ARE ACTIVE--
                      1. THE MINIMUM DEPTH OF LAYER  1
                      2. THE MAXIMUM DEPTH OF LAYER  2
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      DATE     DIST.     HIGHWAY    CONT.  SECT.  IPE           COMMENTS
    03/26/70    19    US 59 N-SBL    218    01              SECT. NO.1 STA.825-855

  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    ACP                26.00     0.75     1.50     6.00   10.00
   2      C   BLENDED C.S + GRVL   3.50     0.50     4.00    12.00   80.00
   3      D   GRAVEL               1.50     0.40     4.00    12.00  100.00
              SUBGRADE             0.0      0.23     0.0      0.0     0.0

   5    THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
          FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
                  ACP                    1.50 INCHES
                 BLENDED C.S + GRVL      7.50 INCHES
                 GRAVEL                  8.25 INCHES

          THE SCI OF THE INITIAL STRUCTURE  =  0.418
          THE LIFE OF THE INITIAL STRUCTURE = 10.16 YEARS
          THE OVERLAY SCHEDULE IS
                  1.50 INCH(ES) (INCLUDING 1 INCH LEVEL-UP) AFTER 10.16 YEARS.
                 TOTAL LIFE =      22.20 YEARS

          SEAL COATS SHOULD OCCUR AFTER
                 (1)    5.00 YEARS
                 (2)    8.00 YEARS
                 (3)   15.16 YEARS
                 (4)   18.16 YEARS

          THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE
                 INITIAL CONSTRUCTION COST             2.156
                 TOTAL ROUTINE MAINTENANCE COST        0.208
                 TOTAL OVERLAY CONSTRUCTION COST       0.551
                 TOTAL USER COST DURING
                         OVERLAY CONSTRUCTION          0.057
                 TOTAL SEAL COAT COST                  0.277
                 SALVAGE VALUE                        -0.277
                 TOTAL OVERALL COST                    2.972


          NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET --      283


            AT THE OPTIMAL SOLUTION,THE FOLLOWING
            BOUNDARY RESTRICTIONS ARE ACTIVE--
                    1. THE MINIMUM DEPTH OF LAYER  1
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  DATE     DIST.     HIGHWAY     CONT.  SECT.  IPE            COMMENTS
03/26/70    19    US 59 N-SBL    218     01              SECT. NO.1 STA.825-855



A SUMMARY OF THE BEST DESIGN FOR EACH COMBINATION
  OF MATERIALS, IN ORDER OF INCREASING TOTAL COST

       DESIGN NUMBER    TOTAL COST
             3             2.892
             5             2.972
             2             3.137
             4             3.411
             1             7.480

 ALL MATERIAL COMBINATIONS HAVE AT LEAST ONE FEASIBLE DESIGN.
```

```
   DATE     DIST.    HIGHWAY    CONT.  SECT.  IPE           COMMENTS
 03/26/70    19    US 59 N-SBL   218    01              SECT. NO.1 STA.825-855

                             SUMMARY OF THE BEST DESIGN STRATEGIES
                               IN ORDER OF INCREASING TOTAL COST

                         1      2      3      4      5      6      7      8
********************************************************************************
MATERIAL ARRANGEMENT     ABD    ABD    ABD    ABD    ACD    ACD    ABD    ACD
INIT. CONST. COST       2.064  2.089  2.606  2.630  2.156  2.142  2.269  2.312
OVERLAY CONST. COST     0.551  0.551  0.0    0.0    0.551  0.515  0.450  0.420
USER COST               0.057  0.056  0.0    0.0    0.057  0.055  0.051  0.048
SEAL COAT COST          0.277  0.277  0.388  0.388  0.277  0.339  0.293  0.291
ROUTINE MAINT. COST     0.208  0.208  0.316  0.316  0.208  0.213  0.228  0.237
SALVAGE VALUE          -0.266 -0.263 -0.369 -0.365 -0.277 -0.282 -0.300 -0.317
********************************************************************************
********************************************************************************
TOTAL COST              2.892  2.918  2.941  2.969  2.972  2.981  2.991  2.992
********************************************************************************
********************************************************************************
NUMBER OF LAYERS         3      3      3      3      3      3      3      3
********************************************************************************
LAYER DEPTH (INCHES)
     D(1)               1.50A  1.50A  1.50A  1.50A  1.50A  1.50A  1.50A  1.50A
     D(2)               4.00B  5.50B  8.50B 10.00B  7.50C  5.75C  7.00B  7.50C
     D(3)              12.00D  8.25D 12.00D  8.25D  8.25D 12.00D  8.25D 12.00D
********************************************************************************
********************************************************************************
NO.OF PERF.PERIODS       2      2      1      1      2      2      2      2
********************************************************************************
PERF. TIME (YEARS)
     T(1)              10.406  9.750 21.375 20.750 10.156 11.063 13.438 13.875
     T(2)              22.875 21.469  0.0    0.0   22.203 24.047 29.328 30.094
********************************************************************************
OVERLAY POLICY(INCH)
(EXCLUDING LEVEL-UP)
     D(1)               0.5    0.5    0.0    0.0    0.5    0.5    0.5    0.5
********************************************************************************
NUMBER OF SEAL COATS     4      4      6      6      4      5      4      4
********************************************************************************
SEAL COAT SCHEDULE
   (YEARS)
   SC(1)                5.000  5.000  5.000  5.000  5.000  5.000  5.000  5.000
   SC(2)                8.000  8.000  8.000  8.000  8.000  8.000  8.000  8.000
   SC(3)               15.406 14.750 11.000 11.000 15.156 11.000 11.000 11.000
   SC(4)               18.406 17.750 14.000 14.000 18.156 16.063 18.438 18.875
   SC(5)                0.0    0.0   17.000 17.000  0.0   19.063  0.0    0.0
   SC(6)                0.0    0.0   20.000 20.000  0.0    0.0    0.0    0.0
********************************************************************************
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```
   DATE     DIST.     HIGHWAY    CONT.  SECT.  IPE           COMMENTS
 03/26/70    19     US 59 N-SBL   218     01             SECT. NO.1 STA.825-855

                                  SUMMARY OF THE BEST DESIGN STRATEGIES
                                   IN ORDER OF INCREASING TOTAL COST

                                  9       10      11      12      13      14      15      16
*********************************************************************************************
MATERIAL ARRANGEMENT           ABD     ACD     ABD     ACD     ABD     ABD     ACD     ABD
INIT. CONST. COST            2.245   2.326   2.269   2.750   2.425   2.786   2.483   2.245
OVERLAY CONST. COST          0.420   0.450   0.515   0.0     0.321   0.0     0.343   0.515
USER COST                    0.049   0.051   0.054   0.0     0.041   0.0     0.042   0.055
SEAL COAT COST               0.346   0.293   0.271   0.388   0.351   0.388   0.307   0.339
ROUTINE MAINT. COST          0.237   0.228   0.213   0.316   0.287   0.316   0.273   0.213
SALVAGE VALUE               -0.303  -0.312  -0.268  -0.398  -0.341  -0.406  -0.352  -0.271
*********************************************************************************************
*********************************************************************************************
TOTAL COST                   2.994   3.036   3.054   3.056   3.084   3.085   3.095   3.095
*********************************************************************************************
*********************************************************************************************
NUMBER OF LAYERS               3       3       3       3       3       3       3       3
*********************************************************************************************
LAYER DEPTH (INCHES)
     D(1)                    1.50A   1.50A   1.75A   1.50A   1.50A   1.50A   1.50A   1.75A
     D(2)                    5.50B   9.25C   5.50B  12.00C   7.00B  10.00B   9.25C   4.00B
     D(3)                   12.00D   8.25D   8.25D  12.00D  12.00D  12.00D  12.00D  12.00D
*********************************************************************************************
*********************************************************************************************
NO.OF PERF.PERIODS             2       2       2       1       2       1       2       2
*********************************************************************************************
PERF. TIME (YEARS)
     T(1)                   14.125  13.031  10.531  20.063  17.938  24.375  16.563  11.188
     T(2)                   30.859  28.266  23.141   0.0    39.594   0.0    36.063  24.547
*********************************************************************************************
OVERLAY POLICY(INCH)
(EXCLUDING LEVEL-UP)
     O(1)                     0.5     0.5     0.5     0.0     0.5     0.0     0.5     0.5
*********************************************************************************************
NUMBER OF SEAL COATS           5       4       4       6       5       6       4       5
*********************************************************************************************
SEAL COAT SCHEDULE
  (YEARS)
   SC(1)                     5.000   5.000   5.000   5.000   5.000   5.000   5.000   5.000
   SC(2)                     8.000   8.000   8.000   8.000   8.000   8.000   8.000   8.000
   SC(3)                    11.000  11.000  15.531  11.000  11.000  11.000  11.000  11.000
   SC(4)                    14.000  18.031  18.531  14.000  14.000  14.000  14.000  16.188
   SC(5)                    19.125   0.0     0.0    17.000  17.000  17.000   0.0    19.188
   SC(6)                     0.0     0.0     0.0    20.000   0.0    20.000   0.0     0.0
*********************************************************************************************
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  DATE    DIST.    HIGHWAY    CONT.  SECT.  IPE          COMMENTS
03/26/70   19    US 59 N-SBL   218    01           SECT. NO.1 STA.825-855

                          SUMMARY OF THE BEST DESIGN STRATEGIES
                           IN ORDER OF INCREASING TOTAL COST

                            17      18      19      20      21      22      23      24
*******************************************************************************
MATERIAL ARRANGEMENT        ABD     ACD     ABD     ABD     ACD     ABD     ABD     ACD
INIT. CONST. COST          2.272   2.337   2.425   2.810   2.417   2.786   2.453   2.323
OVERLAY CONST. COST        0.515   0.515   0.393   0.0     0.450   0.0     0.393   0.481
USER COST                  0.055   0.054   0.047   0.0     0.050   0.0     0.047   0.052
SEAL COAT COST             0.339   0.271   0.307   0.388   0.293   0.388   0.307   0.333
ROUTINE MAINT. COST        0.213   0.213   0.248   0.316   0.228   0.316   0.248   0.219
SALVAGE VALUE             -0.292  -0.282  -0.308  -0.403  -0.322  -0.373  -0.329  -0.287
*******************************************************************************
*******************************************************************************
TOTAL COST                 3.102   3.108   3.112   3.112   3.116   3.117   3.118   3.122
*******************************************************************************
*******************************************************************************
NUMBER OF LAYERS             3       3       3       3       3       3       3       3
*******************************************************************************
LAYER DEPTH (INCHES)
    D(1)                   1.50A   1.75A   1.75A   1.50A   1.50A   1.75A   1.50A   1.75A
    D(2)                   8.50B   7.50C   5.50B  11.50B  12.00C   8.50B  10.00B   5.75C
    D(3)                   4.00D   8.25D  12.00D   8.25D   4.00D  12.00D   4.00D  12.00D
*******************************************************************************
*******************************************************************************
NO.OF PERF.PERIODS           2       2       2       1       2       1       2       2
*******************************************************************************
PERF. TIME (YEARS)
    T(1)                  11.375  10.875  15.000  23.750  12.750  22.125  15.125  11.781
    T(2)                  24.875  23.719  32.813   0.0    27.609   0.0    33.031  25.656
*******************************************************************************
OVERLAY POLICY(INCH)
(EXCLUDING LEVEL-UP)
    O(1)                   0.5     0.5     0.5     0.0     0.5     0.0     0.5     0.5
*******************************************************************************
NUMBER OF SEAL COATS        5       4       4       6       4       6       4       5
*******************************************************************************
SEAL COAT SCHEDULE
  (YEARS)
  SC(1)                    5.000   5.000   5.000   5.000   5.000   5.000   5.000   5.000
  SC(2)                    8.000   8.000   8.000   8.000   8.000   8.000   8.000   8.000
  SC(3)                   11.000  15.875  11.000  11.000  11.000  11.000  11.000  11.000
  SC(4)                   16.375  18.875  14.000  14.000  17.750  14.000  14.000  16.781
  SC(5)                   19.375   0.0     0.0    17.000   0.0    17.000   0.0    19.781
  SC(6)                    0.0     0.0     0.0    20.000   0.0    20.000   0.0     0.0
*******************************************************************************


       THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS       805
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APPENDIX D

“REQUEST FORMS”

TEXAS HIGHWAY DEPARTMENT
HIGHWAY DESIGN DIVISION
RESEARCH SECTION

DYNAFLECT REQUEST FORM

DATE______________________________

DISTRICT__________ SECTION____
(Residency, Laboratory, Design, etc.)

PROJECT IDENTIFICATION:

Highway (s)____

Control and Section (s)____

Project (s) total length: _______________ miles

* DATE NEEDED:

From:______________________________To:______________________________

INSTRUCTIONS:

Signature__________________________ Title__________________________

Mailing Address:____

Phone Number:______________________

* The time needed can roughly be estimated at 5 minutes per reading plus travel time.

TEXAS HIGHWAY DEPARTMENT
FORM 1305

Your Reference Number
Dist. No.________ Residency________
Div. No.________ Section ________
Date________________________

DIVISION OF AUTOMATION SERVICES REQUEST FORM

____
Date Received

INSTRUCTIONS: ____

SIGNATURE: ________________________ TITLE: ____________________

<table>
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<tr><td>1</td><td>AUTH.</td><td colspan="3">EQUIP. NO. OR COST ACCOUNTING NO.</td><td rowspan="5">FUNCT. (12)</td></tr>
<tr><td rowspan="2">3</td><td>I.P.E.</td><td colspan="3">○</td></tr>
<tr><td>H.P.R.</td><td colspan="3">RESEARCH JOB NO.</td></tr>
<tr><td>5</td><td>PROJ. DESIG.</td><td colspan="3">PARCEL / UTILITY NO.</td></tr>
<tr><td>7</td><td>MAINT. SECT. NO.
SPECIAL JOB NO.</td><td>CONTROL NO.</td><td>CONT. SEC.</td><td>CLASS</td></tr>
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<tr><td colspan="7"></td></tr>
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RETURN TO:
Name:____________________
Address:____________________
City:____________________
Telephone____________ Ext.________

SERVICES REQUEST NUMBER:

NOTICE: Only One Budget and Auth. or I.P.E. Number on Each Order. One Order Is Sufficient For Any Job.

District____________________
I.P.E. No.________ P.D. No.________
Hwy. No.________ County ________
Proj. No.________ Control________
Section ________ Res. No.________
Proj. Limits____________________

SPECIAL COMPUTER INSTRUCTIONS:
PLOT: Yes ________ No ________
Pen Size: 1 2 3 Ball Pt.
Paper: Plain ____ Grid ____

About the Authors

James L. Brown: Senior Designing Engineer, Research Section, Highway Design Division, Texas Highway Department.

Larry J. Buttler: Senior Designing Research Engineer, Research Section, Highway Design Division, Texas Highway Department.

Hugo E. Orellana: ADP Programmer II, Research Section, Highway Design Division, Texas Highway Department.