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16. Abstract

The major purpose of this study was to develop regression models for the prediction of distress in CRCP in Texas for use by the SDHPT in making decisions concerning the allocation of funds for rehabilitation of these pavements. Use of these models in the manner recommended in this report will facilitate making the choice among rehabilitation alternatives and give greatly improved efficiency with regard to utilization of these funds.

First, condition survey data from two separate surveys (four years apart) were analyzed to establish repeatability, variability over time and the effect of directionalized traffic. Next, analysis of variance was performed to determine the relative contributions to distress in the pavements of a series of different factors. Multiple regression techniques were then utilized to obtain distress prediction models in terms of these factors. Finally, guidelines for a procedure for utilization of these models in decision making among rehabilitation alternatives as part of a rigid pavement evaluation system (RPES) were outlined. It is anticipated that the models and procedures developed here will be implemented by the Texas SDHPT in the near future.

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DISTRESS PREDICTION MODELS FOR CRCP

by

C. S. Noble

B. F. McCullough

Research Report Number 177-21

Development and Implementation of the Design, Construction
and Rehabilitation of Rigid Pavements

Research Project 3-8-75-177

conducted for

Texas
State Department of Highways and Public Transportation

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

by the

CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

March 1981

PREFACE

This is the twenty-first in the series of 22 reports describing the work done in the project entitled "Development and Implementation of the Design, Construction, and Rehabilitation of Rigid Pavements." This project is being conducted at the Center for Transportation Research, The University of Texas at Austin, as part of the cooperative Highway Research Program sponsored by the State Department of Highways and Public Transportation and the Federal Highway Administration.

This report presents the results of an analytical study undertaken to develop regression models for the prediction of distress in CRC pavements in Texas from construction properties, environmental considerations and condition survey measurements.

The writers are particularily grateful to the entire staff of the Center for Transportation Research who provided support throughout the analysis and preparation stages of this report.

Christopher S. Noble
B. Frank McCullough

March 1981

LIST OF REPORTS

Report No. 177-1, "Drying Shrinkage and Temperature Drop Stresses in Jointed Reinforced Concrete Pavement," by Felipe R. Vallejo, B. Frank McCullough, and W. Ronald Hudson, describes the development of a computerized system capable of analysis and design of a concrete pavement slab for drying shrinkage and temperature drop. August 1975.

Report No. 177-2, "A Sensitivity Analysis of Continuously Reinforced Concrete Pavement Model CRCP-1 for Highways," by Chypin Chiang, B. Frank McCullough, and W. Ronald Hudson, describes the overall importance of this model, the relative importance of the input variables of the model and recommendations for efficient use of the computer program. August 1975.

Report No. 177-3, "A Study of the Performance of the Mays Ride Meter," by Yi Chin Hu, Hugh J. Williamson, B. Frank McCullough, and W. Ronald Hudson, discusses the accuracy of measurements made by the Mays Ride Meter and their relationship to roughness measurements made with the Surface Dynamics Profilometer. January 1977.

Report No. 177-4, "Laboratory Study of the Effect of Non-Uniform Foundation Support on CRC Pavements," by Enrique Jiminez, B. Frank McCullough, and W. Ronald Hudson, describes the laboratory tests of CRC slab models with voids beneath them. Deflection, crack width, load transfer, spalling and cracking are considered. Also used is the SLAB 49 computer program that models the CRC laboratory slab as a theoretical approach. The physical laboratory results and the theoretical solutions are compared and analyzed, and the accuracy is determined. August 1977.

Report No. 177-6, "Sixteenth Year Progress Report on Experimental Continuously Reinforced Concrete Pavement in Walker County," by Thomas P. Chesney and B. Frank McCullough, presents a summary of data collection and analysis over a 16-year period. During that period, numerous findings resulted in changes in specifications and design standards. These data will be valuable for shaping guidelines and for future construction. April 1976.

Report No. 177-7, "Continuously Reinforced Concrete Pavement: Structural Performance and Design/Construction Variables," by Pieter J. Strauss, B. Frank McCullough, and W. Ronald Hudson, describes a detailed analysis of design, construction, and environmental variables that may have an effect on the structural performance of a CRCP. May 1977.

Report No. 177-9, "CRCP-2, An Improved Computer Program for the Analysis of Continuously Reinforced Concrete Pavements," by James Ma and B. Frank McCullough, describes the modification of a computerized system capable of analysis of a continuously reinforced concrete pavement based on drying shrinkage and temperature drop. August 1977.

Report No. 177-10, "Development of Photographic Techniques for Performance Condition Surveys," by Pieter J. Strauss, James Long, and B. Frank McCullough, discusses the development of a technique for surveying heavily trafficked highways without interrupting the flow of traffic. May 1977.

Report No. 177-11, "A Sensitivity Analysis of Rigid Pavement-Overlay Design Procedure," by F. C. Nayak, B. Frank McCullough, and W. Ronald Hudson, gives a sensitivity analysis of input variables of Federal Highway Administration computer-based overlay design procedure RPOD1. June 1977.

Report No. 177-12, "A Study of CRCP Performance: New Construction versus Overlay," by James I. Daniel, B. Frank McCullough, and W. Ronald Hudson, documents the performance of several continuously reinforced concrete pavements (CRCP) in Texas. April 1978.

Report No. 177-13, "A Rigid Pavement Overlay Design Procedure for Texas SDHPT," by Otto Schnitter, B. Frank McCullough, and W. Ronald Hudson, describes a procedure recommended for use by the Texas SDHPT for designing both rigid and flexible overlays on existing rigid pavements. The procedure incorporates the results of condition surveys to predict the existing pavements remaining life, field and lab testing to determine material properties, and elastic layer theory to predict the critical stresses in the pavement structure. May 1978.

Report No. 177-15, "Precast Repair of Continuously Reinforced Concrete Pavement," by Gary E. Elkins, B. Frank McCullough, and W. Ronald Hudson, describes an investigation into the applicability of using precast slabs to repair CRCP, presents alternate repair strategies, and makes new recommendations on installation and field testing procedures. May 1979.

Report No. 177-16, "Nomographs for the Design of CRCP Steel Reinforcement," by C. S. Noble, B. F. McCullough, and J. C. M. Ma, presents the results of an analytical study undertaken to develop regression equations and nomographs for use as a supplementary tool in the design of steel reinforcement in continuously reinforced concrete pavement by the Texas State Department of Highways and Public Transportation. August 1979.

Report No. 177-17, "Limiting Criteria for the Design of CRCP," by B. Frank McCullough, J. C. M. Ma, and C. S. Noble, presents a set of criteria which limits values of a set of variables to be used in the design of CRCP. These criteria are to be used in conjunction with Report No. 177-16. August 1979.

Report No. 177-18, "Detection of Voids Underneath Continuously Reinforced Concrete Pavemtnts," by John Birkhoff and B. Frank McCullough, presents the results of an investigation in which three methods for detecting voids underneath CRC pavements (deflection, pumping and vibration) are evaluated with respect to reliability of successful void detection. August 1979.

Report No. 177-19, "Manual for Condition Survey of Continuously Reinforced Concrete Pavements" by Arthur Taute and B. Frank McCullough, presents the condition survey method used during the 1978 statewide CRCP condition survey. In addition, proposals for a condition survey procedure for jointed concrete pavement are presented. February 1981.

Report No. 177-20, "Summary Report for 1978 CRCP Condition Survey in Texas," by Manuel Gutierrez de Velasco and B. Frank McCullough, presents a qualitative analysis of the distress condition of CRCP in the State of Texas using field data collected in 1974 and 1978. Also, criteria are developed in order to weight the different distress manifestations in deciding when to overly a CRCP. January 1981.

Report No. 177-21, "Distress Prediction Models for CRCP," by C.S. Noble and B. Frank McCullough, describes a detailed analysis of the condition survey data collected in 1974 and 1978, and presents distress prediction models developed from this data. Recommendations are made for the establishment of an overall rigid pavement evaluation system. March 1981.

ABSTRACT

The major purpose of this study was to develop regression models for the prediction of distress in CRCP in Texas for use by the SDHPT in making decisions concerning the allocation of funds for rehabilitation of these pavements. Use of these models in the manner recommended in this report will facilitate making the choice among rehabilitation alternatives and give greatly improved efficiency with regard to utilization of these funds.

First, condition survey data from two separate surveys (four years apart) were analyzed to establish repeatability, variability over time and the effect of directionalized traffic. Next, analysis of variance was performed to determine the relative contributions to distress in the pavements of a series of different factors. Multiple regression techniques were then utilized to obtain distress prediction models in terms of these factors. Finally, guidelines for a procedure for utilization of these models in decision making among rehabilitation alternatives as part of a rigid pavement evaluation system (RPES) were outlined. It is anticipated that the models and procedures developed here will be implemented by the Texas SDHPT in the near future.

KEY WORDS: CRCP, distress, prediction models, rehabilitation, fund allocation, condition survey, regression, analysis of variance, decision making.

SUMMARY

The CRCP distress condition survey data collected in 1974 and 1978 for a series of pavements extending throughout Texas, as described in Research Report Numbers 177-19 and 177-20, provided a solid base from which to develop distress prediction models. Analysis of variance and multiple regression techniques were applied to these data, as well as to information on construction and environmental variability in the development of such models. First order procedures for using these models in making decisions among rehabilitation alternatives were developed and outlined as part of a rigid pavement evaluation system (RPES).

IMPLEMENTATION STATEMENT

It is hoped that the distress prediction models and procedures outlined in this report for use of these models, when making decisions among rehabilitation alternatives, will be implemented by the Texas SDHPT within the near future. Also, it is anticipated that work will continue on the establishment of a comprehensive rigid pavement evaluation system, preliminary guidelines for which have been outlined in this report.

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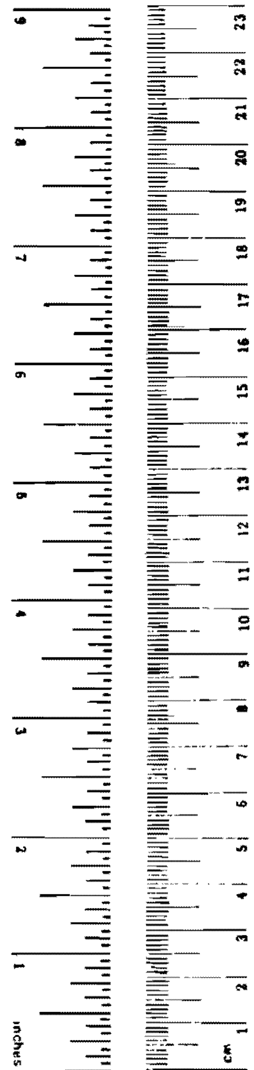
METRIC CONVERSION FACTORS

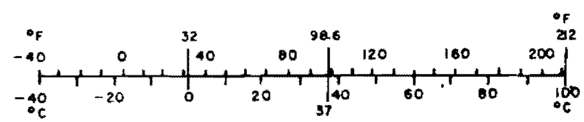
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CHAPTER 1. INTRODUCTION

Background

In 1974 a detailed, visual condition survey of all the sections of continuously reinforced concrete pavement (CRCP) in use on highways throughout the State of Texas was performed by the Center for Transportation Research (CTR) at The University of Texas at Austin as part of a cooperative research program with the Texas State Department of Highways and Public Transportation (SDHPT). A description of the survey procedure, along with examples of the rating forms which were used, may be found in Reference 1. The results of the survey and the subsequent analysis of the data were reported in Reference 2. In 1978 a similar survey was completed. The procedures used and the results obtained are documented in References 3, 4, and 5.

Objectives

It is the purpose of this report to present the results of a series of analyses which have been performed using data from both the above mentioned surveys. Specifically, these analyses have been made with five separate objectives in mind. These are as follows:

(1) to investigate the reliability of the chosen condition survey rating procedures with respect to precision or repeatability (Chapter 2),

(2) to evaluate the significance of any changes in distress between the 1974 and 1978 conditions surveys (Chapter 3),

(3) to establish the breakdown of traffic, according to direction, for sections of CRCP throughout the State of Texas (Chapter 4),

(4) to evaluate the effect of material properties, construction procedures, environment, traffic loads, aging and previous pavement condition upon pavement distress at any point in time by developing and testing models for the prediction of distress in terms of these variables using multiple regression analysis techniques (Chapter 5),

(5) to develop pavement distress utility functions using discriminant analysis techniques (Chapter 6), for incorporation into a comprehensive rigid pavement evaluation system and to make recommendations (Chapter 7), for the establishment of such a system.

Scope

This report thus describes and presents the results of a set of analyses which were performed on data obtained from surveys in 1974 and 1978 concerning the condition of a large number of CRCP sections extending throughout the State of Texas (Chapters 2 to 6). Recommendations for the use of a general rigid pavement evaluation system incorporating data collection, design, and maintenance procedures are made on the basis of the results of the analyses (Chapter 7).

CHAPTER 2. RELIABILITY OF CRCP CONDITION SURVEY PROCEDURES

Introduction - Description of CRCP Condition Survey Procedures

A detailed visual condition survey of a large number of sections of CRCP on highways extending throughout the State of Texas was performed in 1974 by rating teams from the CTR at The University of Texas at Austin, and the Texas SDHPT (Refs 1 and 2). The same sections were surveyed again in 1978 and a complete description of the procedures used, the sections surveyed and the results obtained is given in Refs 3, 4 and 5. Two rating teams were used, one from each of the above bodies. The teams worked independently and surveyed approximately equal lengths of highway overall. The highways which were surveyed were divided into 0.2-mile sections for reporting purposes. Data were collected on the following eight distress manifestations for each 0.2-mile interval:

number of minor spalled cracks,
number of severely spalled cracks,
percent minor pumping,
percent severe spalling,
number of minor punchouts,
number of severe punchouts,
number of portland cement concrete patches, and
number of asphalt patches.

These data were then temporarily stored in computer files at the Center for Transportation Research as a precursor for later storage at the Texas SDHPT. A computer program was written to record and classify the data, perform simple calculations with it and print the results of these exercises in summary form. In this manner, summary reports of both 1974 and 1978 surveys were produced for all districts in Texas which were involved in the survey. A comprehensive summary report for the entire State was then prepared (Ref 3).

Replication in 1978 Condition Survey - Rating Precision

Description of Replication Procedure

It is the purpose of this section to present the results of a study performed by CTR personnel to evaluate the repeatability (precision) of the CRCP condition survey (Refs 3, 4, and 5) rating procedures. Several sections of highways from each of seven districts throughout the State were all surveyed by two separate teams. This duplicate rating was used to determine the effect of any variation in condition survey ratings which might be attributable to variability in rating team procedures caused by changes in personnel. That is, in order to obtain an estimate of the reliability of the rating procedures used, a number of sections of highway, in each of seven districts, were rated twice as part of the 1978 condition survey and the results were examined for any significant differences. It was assumed that differences in results caused by any variation in a given individual rater's perception of the pavement condition would be negligible. That is, if a given rater were to examine the same section twice, he would tend to obtain virtually identical results. A total of 86 sections of pavement from seven districts were rated according to eight distress types by two rating teams (Ref 6). The results were compared using both graphical and statistical techniques.

Graphical Comparison of Results of Replicate Surveys

A typical example of the comparison of the two ratings for a section of CRCP in District 13, for the "severe spalling," "minor spalling," and "minor pumping" distress conditions is shown in Fig 2.1. A scattergram of the number of spalled cracks and of the percent pumping in each section in the district has been plotted for the two teams. A complete set of such scattergrams for all relevant distress types is included as Appendix A of this report. From these plots, it is apparent that any variability caused by the different teams is essentially small.

Statistical Analysis of Results of Replicate Surveys

A statistical evaluation of the differences in the results of the comparison was also performed for all the distress manifestations on all sections

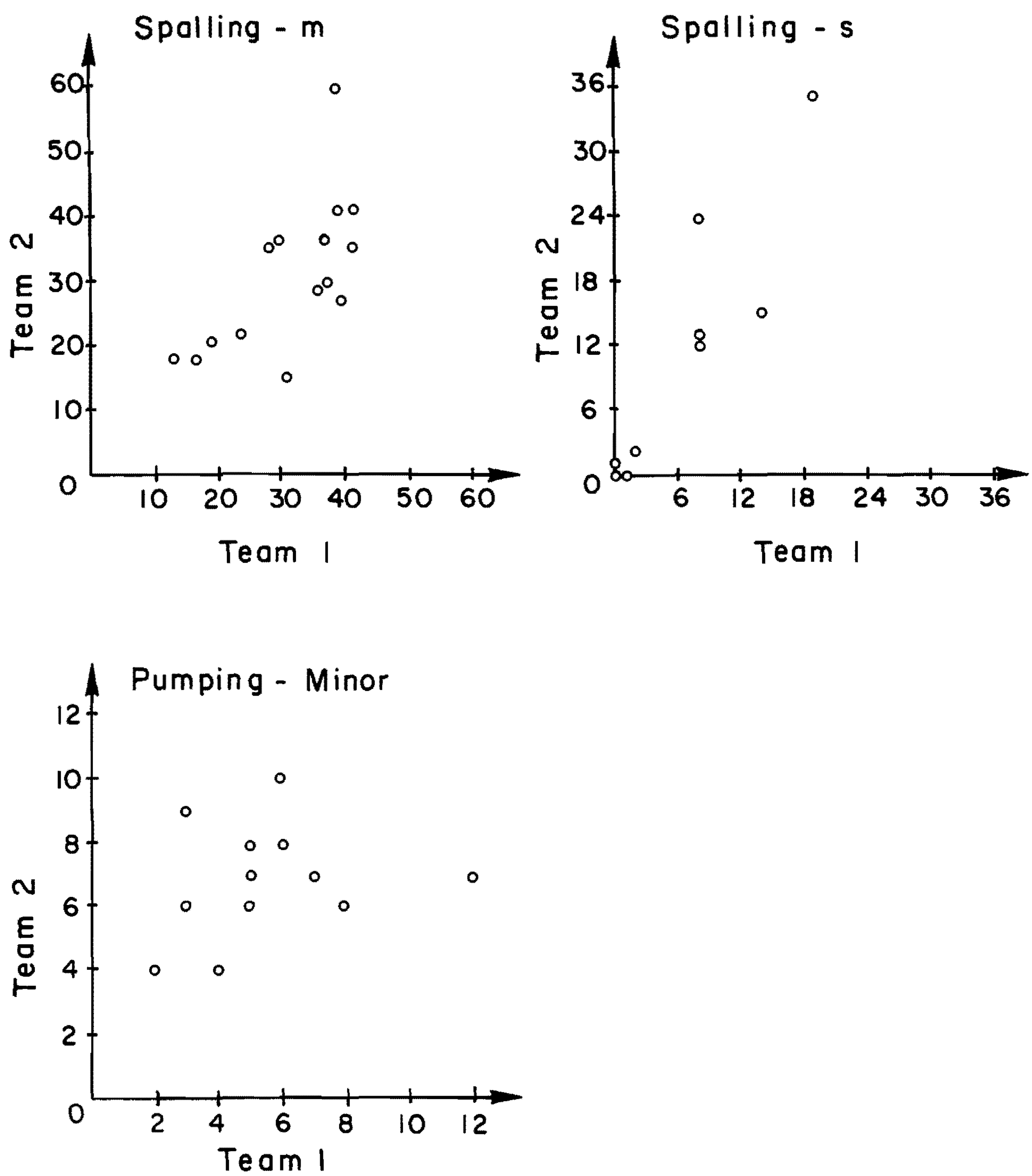


Fig 2.1. Scattergrams for replicate condition surveys for District 13.

which were rated twice. A nonparametric statistical test called the "sign" test (Ref 7) was used to determine whether any differences in the results recorded by the two teams were significant.

The null hypothesis tested by the sign test is that

$$p(X_A > X_B) = \frac{1}{2}$$

where X_A is the judgment or score under one of the conditions (or after the treatment) and X_B is the judgement or score under the other condition (or before the treatment). That is, X_A and X_B are the two "scores" for a matched pair. Another way of stating H_0 is: the median difference is zero.

In applying the sign test, we focus on the direction of the differences between every "i^{th}" pair of observations, X_{Ai} and X_{Bi}, noting whether the sign of the difference is plus or minus. Under H_0, we would expect the number of pairs which have $X_A > X_B$ to equal the number of pairs which have $X_A < X_B$. That is, if the null hypothesis were true, we would expect about half of the differences to be negative and half to be positive. H_0 is rejected if too few differences of one sign occur. For small samples (< 30 observations) the probability associated with the occurrence of a particular number of pluses and minuses is determined using the binomial distribution with $P = Q = \frac{1}{2}$, where N = the number of pairs. If a matched pair shows no difference (i.e., the difference, being zero, has no sign) it is dropped from the analysis of N is thereby reduced.

It should be noted that traditional parametric hypothesis tests could not be used because the requirement of homogeneity of variance of the parameters under consideration was not satisfied and replicate observations by each team were not available.

The results of the statistical analysis are summarized in Table 2.1. It is apparent from Table 2.1 that no significant differences were observed for all distress types in each of the seven districts except for two cases. These exceptions were in Districts 3 and 4 where the minor spalling recorded by the two teams showed significant differences at the 99.9 percent and 99.6 percent levels, respectively. However, these two exceptions merely reflect a source of variability within the manifestation rating itself, this being a consequence of the high degree of subjectivity associated with making assessments of degree of minor spalling.

TABLE 2.1. COMPARISON OF RATING TEAMS - RESULTS OF SIGN TEST FOR EQUALITY OF RATING PROCEDURES

Distress Type	District	Sign Test (Ref 7)				Decision on Hypothesis that Median Difference is Zero (H_o)
		Number Obser-vations*	Number Negative Differ-ences	Number Positive Differ-ences	Level of Signif-icance (Percent)	
Minor Spalling	3	15	1	14	0.1	Reject at 0.01 per-cent level
	4	9	9	0	0.4	Reject at 0.5 per-cent level
	10	11	2	9	6.6	Do not re-ject at 5 percent level
	13	14	7	7	100.0	Do not re-ject at 5 percent level
	19	5	0	5	6.3	
	24	27	10	17	24.6	
	25	5	1	4	37.6	
Severe Spalling	3	4	1	3	62.5	Do not re-ject at 5 percent level
	4	4	0	4	12.5	
	10	7	3	4	100.0	
	13	9	7	2	18.0	
	24	11	7	4	54.8	
Minor Pumping	3	11	1	10	12.0	Do not re-ject at 5 percent level
	4	4	0	4	12.5	
	10	8	6	2	29.0	
	13	12	9	3	14.6	
	24	19	12	7	36.0	

(Continued)

Table 2.1. (Continued)

Distress	District	Sign Test (Ref 7)				Decision on Hypothesis that Median Difference is Zero (H_o)
		Number Obser-vations*	Number Negative Differ-ences	Number Positive Differ-ences	Level of Signif-icance (Percent)	
Severe	10	9	6	3	50.2	Do not re-ject at 5 percent level
Pumping	24	3	0	3	25.0	
Minor	10	7	6	1	12.4	Do not re-ject at 5 percent level
Punchouts	24	4	1	3	62.5	
(<20 ft.^{2})	25	4	2	2	100.0	
Severe Punchouts (<20 ft.^{2})	10	8	1	7	7.0	Do not re-ject at 5 percent level
Asphalt Concrete Patch	10	8	8	0	0.8	Reject at 1 percent level
Portland Cement Concrete Patch	10	6	5	1	3.2	Reject at 5 percent level

*One observation is the value of the distress variable under consideration for a highway section of CTR Project. (i.e., "n" observations imply "n" CTR projects in a district).

Time History Analysis of Condition Survey Data - Rating Accuracy

Following the analysis described above, which was performed to evaluate the precision of the techniques used in the condition survey, another analysis was performed in order to estimate the accuracy of the ratings. Using information made available from Texas SDHPT maintenance records (Appendix B), a time history of the cumulative number of repair patches made along two long sections of CRCP highway in District 1 was prepared. These were 25 miles of IH-30 in Franklin and Hopkins Counties and nine miles of US 75 in Grayson County. The estimates of patches obtained from the 1974 and 1978 surveys were then compared graphically with these histories for the appropriate sections. This comparison is shown in Fig 2.2.

It is clear that in each case the condition survey estimates were in good agreement with the maintenance records both in 1974 and 1978. The small discrepancies that do occur are not considered significant enough to affect the conclusions drawn from analyses performed on the condition survey data (Chapter 3 to 7). It should be noted that as the data bank of condition survey results which was discussed previously is updated over time, the analyses described in the Chapter should be extended to include new information as it arrives. In this manner, a continued check on the accuracy of the condition survey ratings can be maintained.

It should also be noted that the values plotted from the 1978 condition survey are for total failures, as the Texas SDHPT value plotted in each case in these sections immediately following the 1978 condition survey. Finally, the reader should be aware that the last SDHPT value plotted in each case was obtained as a separate estimate by CTR personnel in May 1979.

Conclusions

It is generally concluded that any variation in condition survey results due to the use of different rating groups does not contribute significantly to differences observed between the 1974 and 1978 surveys. However, care should be taken when analyzing measurements of the degree of minor spalling in in any pavement because of the high degree of subjectivity associated with such measurements. The results obtained from the accuracy study also confirm

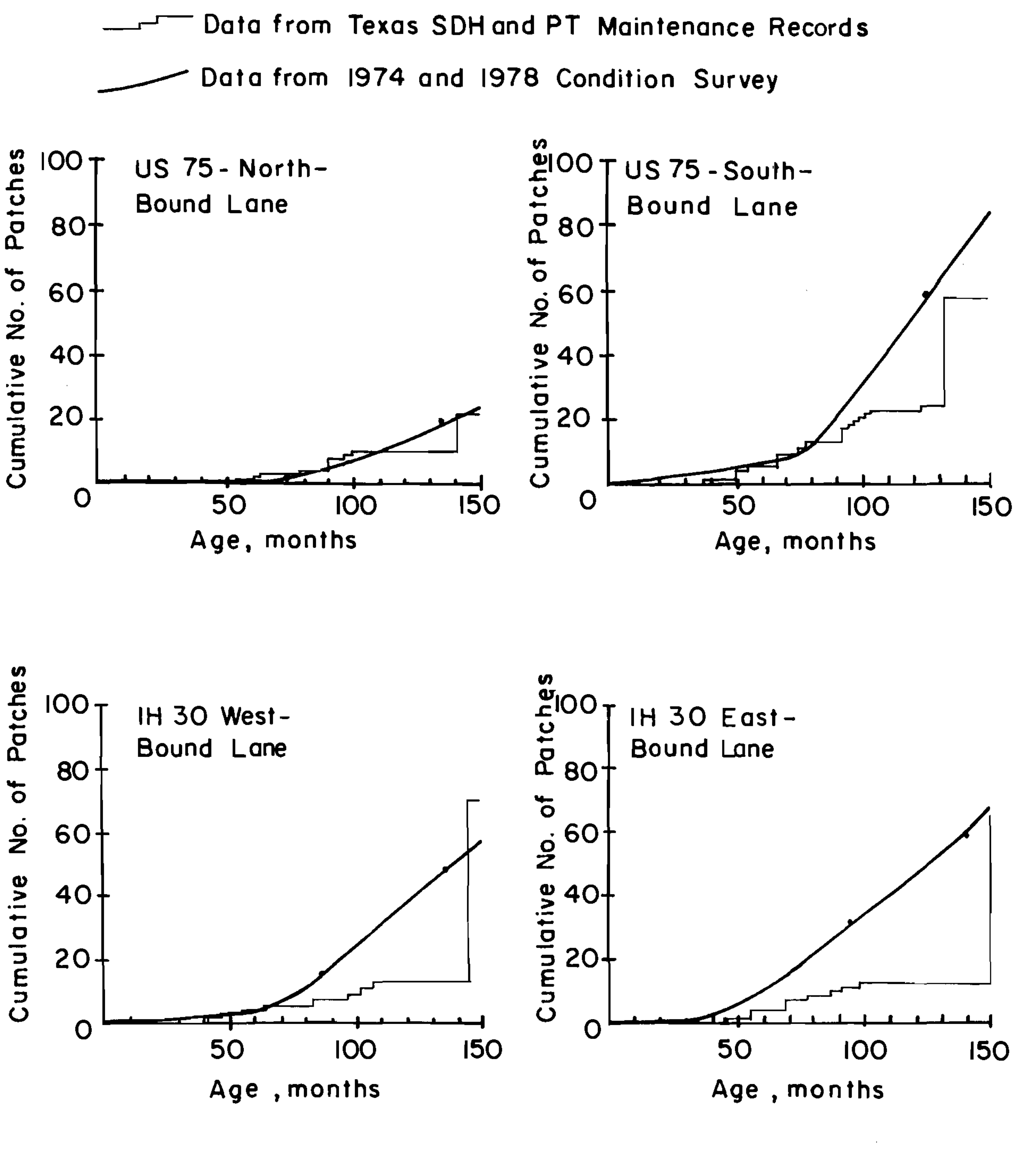


Fig 2.2. Time history of patching - condition survey compared with Texas SDHPT maintenance records for District 1.

that the rating procedures recommended in Reference 4 give very reasonable estimates of the true state. Accordingly, inferences made from analyses performed on the data are well justified.

CHAPTER 3. STATISTICAL COMPARISON OF DISTRESS IN 1974 AND 1978

Analysis Procedure-Test of Hypothesis of no Change in Condition

In order to determine whether or not significant changes in the degree of distress of the CRC pavements which were rated in the 1974 and 1978 condition surveys occurred during the four year interval between surveys, a simple statistical test was performed on the data. The "student t-test" (Ref 8, pp 1 to 6) was used to test the hypothesis that the mean value of a particular distress manifestation (for example, number of failures per mile) in a given district did not change significantly. This test was applied to three different distress manifestations (number of failures, number of punchouts per mile and serviceability index) for each district.

Limitations and Notes on the Analysis

It should be noted that the total number of separate projects in a district (Ref 3) is equal to the number of observations of the value of the distress variable under consideration in a district.

Homogeneity of variance (Bartlett's Test, Ref 8) and normality (Burr-Foster Q-Test, (Ref 8) were tested initially. For all districts, the variance of the distress variable changed significantly with the size of the distress variable. Specifically, the hypotheses of homogeneity of variance and normality were both rejected at the 0.001 and 0.01 levels respectively for all districts, except one. Consequently, appropriate transformations were applied to the data. Since the sample mean varied directly with the sample variance, a square root tranformation was utilized (Ref 8). The hypothesis of homogeneity of variance was then not rejected at the 0.1-percent and 1 percent levels. The result was also substantiated by the Q-test on the transformed data.

Finally, a summary of the data used in the analysis may be obtained from Appendix A of reference 3.

Results of the Analysis

The results of the hypothesis tests on data from all districts are summarized in Table 3.1.

(1) Number of failures and punchouts. It is clear from Table 3.1., that significant changes occurred in both the number of failures and the number of punchouts in all districts of the State, covering both wet and dry areas, except for Districts 1, 9 and 20. For District 1, there was no appreciable change in the number of failures, but a significant change (level of significance $<$ one percent) in the number of punchouts. For District 9, there was a significant change in the number of failures but not in the number of punchouts (level of significance greater than 5 percent). For District 20, there were only slight changes in both (level of significance less than three percent).

(2) Serviceability Index. Data from two districts only were analyzed and both showed significant differences between 1974 and 1978 (level of significance less than 0.05 percent).

Conclusions

Based on the results summarized in Table 3.1, the decision was made to conduct the analyses described in Chapters 5, 6 and 7 as it was apparent that in most districts, significant changes had occurred in distress between 1974 and 1978.

TABLE 3.1. RESULTS OF STATISTICAL COMPARISON OF DISTRESS BETWEEN 1974 AND 1978

Distress Variable	District	Results of t-test (paired data, one sided) Degrees of Freedom	t-value	Level of Significance (LOS) (percent)	Decision on Hypothesis of No Significant Change in Distress
	1*	16	1.175	> 10	Do not reject at 10 percent LOS
	3***	23	3.158	<0.5	Reject at 0.5 percent LOS
Number	4**	19	3.445	<0.1	Reject at 0.1 percent LOS
of	9	12	2.887	<1.0	Reject at 1.0 percent LOS
Failures	10*	25	9.123	<0.1	Reject at 0.1 percent LOS
per	13***	58	6.524	<0.1	Reject at 0.1 percent LOS
Mile	17*	13	4.200	<0.1	Reject at 0.1 percent LOS
	19**	26	7.536	<0.1	Reject at 0.1 percent LOS
	20**	18	2.033	<3.0	Reject at 3.0 percent LOS
	24***	16	3.791	<0.1	Reject at 0.1 percent LOS
	25*	9	4.071	<0.1	Reject at 0.1 percent LOS

(Continued)

TABLE 3.1. (Continued)

Distress Variable	District	Results of t-test (paired data, one sided): Degrees of Freedon	t-value	Level of Significance (LOS) (percent)	Decision on Hypothesis of No Significant Change in Distress
Number of Punchouts per Mile	1	16	2.873	<1.0	Reject at 1.0 percent LOS
	3	23	homogeneity of variance criterion not satisfied		
	4***	19	2.798	<1.0	Reject at 1.0 percent LOS
	9**	12	1.759	>5.0	Do not reject at 5 percent LOS
	10**	25	6.469	<0.1	Reject at 0.1 percent LOS
	13	58	homogeneity of variance criterion not satisfied		
	17**	13	4.886	<0.1	Reject at 0.1 percent LOS
	19**	26	6.612	<0.1	Reject at 0.1 percent LOS
	20	18	2.036	<3.0	Reject at 3.0 percent LOS
	24	Insufficient data available			
	25***	9	2.083	<3.0	Reject at 3.0 percent LOS

Continued

TABLE 3.1. (Continued)

Distress Variable	District	Results of t-test (paired data, one-sided)			Decision on Hypothesis of No Significant Change in Distress
		Degrees of Freedom	t-value	Level of significance (LOS) (percent)	
	9	13	5.196	<0.05	Reject at 0.05 percent LOS
Serviceability Index	17	17	5.831	<0.05	Reject at 0.05 percent LOS

*Homogeneity of variance hypothesis not rejected at 1 percent LOS using square root transform

**Homogeneity of variance hypothesis not rejected at 1 percent LOS using square root transform

***Homogeneity of variance hypothesis not rejected at .1 percent LOS using fourth root transform

CHAPTER 4. TRAFFIC DIRECTION DISTRIBUTION ANALYSIS

Introduction

The purpose of this chapter is to document the development of a relationship between the percent of failures and the percent of traffic to be assigned to each direction of a highway. The use of this relationship to estimate the traffic distribution for existing CRCP in Texas is also discussed.

The distribution of the number of failures per mile has been observed to vary according to direction for a large number of Texas CRCP highway sections. The most likely reason for this is the variation in the distribution of traffic between directions. That is, although the total number of vehicles can be similar, the 18-kip ESALS may be different. Furthermore, the percentage distribution of failures between directions appears to be constant along the length of a given highway. This result supports the hypothesis that the percentage of failures in any direction implies the percentage of road use for that direction. Accordingly, the relationship between the number of failures for a given section of CRCP and the associated traffic, has been modelled using condition survey data, as described in the rest of this chapter.

Procedure

Data on the number of failures per mile and the total traffic were available for 122 CRCP sections in Texas (Ref. 3, 9). Using these data, a simple, least-squares regression analysis was performed with the traffic and number of failures as the dependent and independent variables respectively (Ref. 8). The effects of other variables and associated interactions were neglected as they were expected to be relatively insignificant. Logarithmic transformations were used to facilitate the analysis.

Theoretical Model

Under the assumption that the equation to be developed was to be used to estimate the ratio of traffic between the two different directions of a highway, an exponential model was proposed (Ref 8).

That is,

$$t = \lambda + \alpha f^{\beta} \quad \ldots \quad (4.1)$$

where

t = traffic in millions of 18-kip ESALS,

f = number of failures per mile,

λ = constant,

α = constant,

β = constant,

If we assume that for $t = 0$, we must have $f = 0$, then $\lambda = 0$.

Hence,

$$t = \alpha f^{\beta} \quad \ldots \quad (4.2)$$

Using logarithmic transforms,

$$\log t = \log \alpha + \beta \log f \quad \ldots \quad (4.3)$$

To satisfy appropriate boundary conditions, the following transformation was used,

$$\text{Log}\,(t + 1) = \log \alpha + \beta \log (f + 1) \quad \ldots \quad (4.4)$$

Results of the Analysis

Using the non-directionalised data (after logarithmic transformation) summarized in Refs 3 and 9, a simple linear regression analysis gave equation 4.5. That is,

$$\text{Log}\,(t + 1) = 0.375 + 0.497 \log (f + 1) \quad (4.5)$$

Relevant summary statistics for the analysis were

$R^2 = 0.346$ and

MSE + 0.237.

Revising the transformation, we get

$$t = 1.271\,(f + 1)^{0.497} - 1.0 \quad (4.6)$$

Clearly, the low value of R^2(34.6%) indicates that this model cannot be used for prediction purposes. However, it is felt that a successful preliminary step has been taken towards estimating the traffic volume breakdown, according to direction, from pavement condition.

Directional Distribution Estimates for Texas CRCP

Finally, estimates of the percentages of traffic according to direction, for those sections of Texas CRCP from which the regresssion data were obtained, were calculated. This was done by applying the equation 4.6 to the appropriate f failure rate for each direction for all the 122 CRCP sections. The results are summarized in Figure 4.1 and Appendix C.

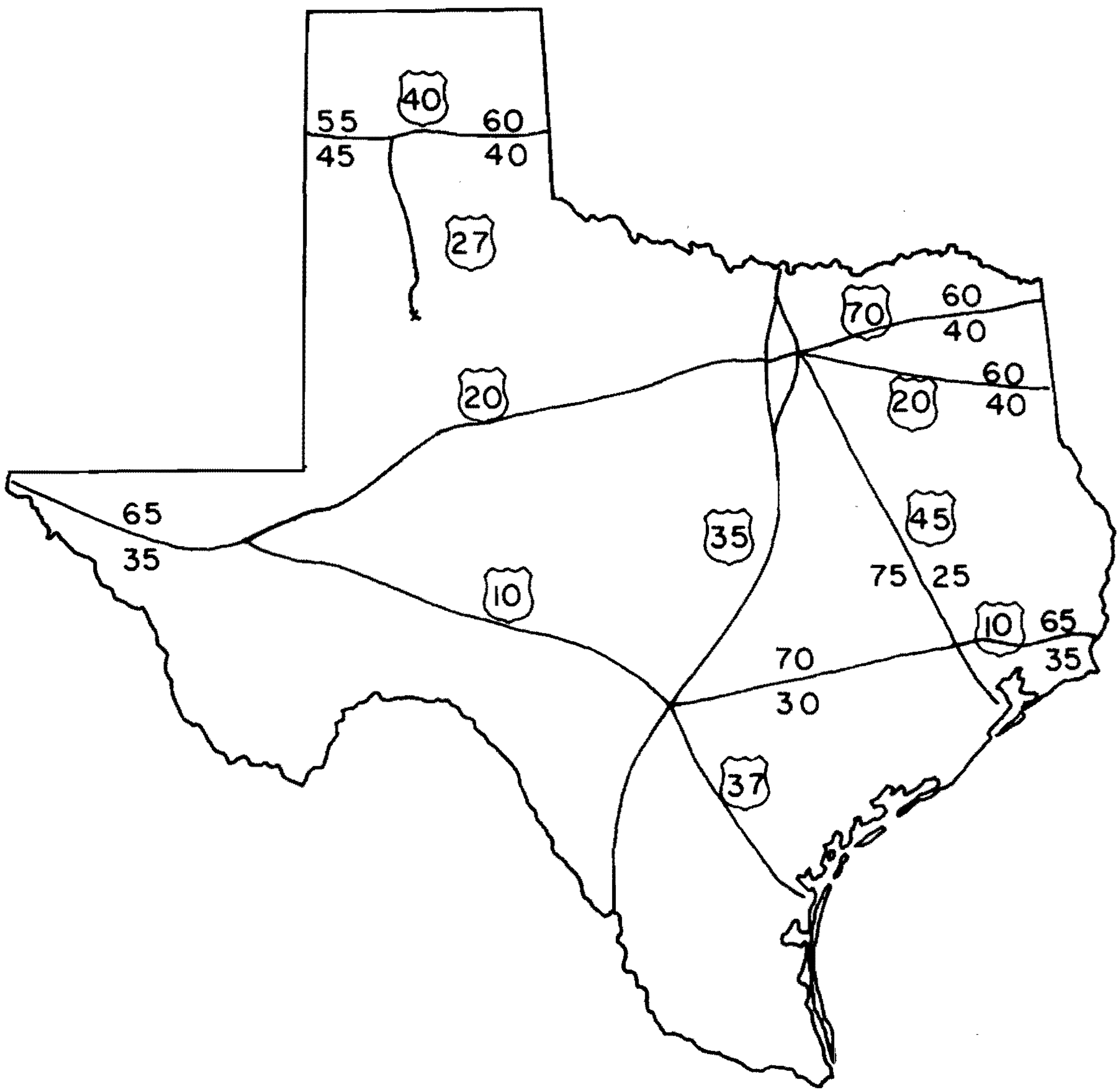


Fig 4.1. Percent of failures found in each direction of CRCP in Texas.

CHAPTER 5. DISTRESS PREDICTION MODELS

This chapter describes an attempt to obtain, through regression analysis, a prediction model for distress in continuously reinforced concrete pavements (CRCP). Using field observations, the following model was developed:

Number of failures per mile = F(environment, materials, construction, previous distress).

Data Base

The data base utilized in this study is partly the same as that presented by Machado et al in Ref 2, and partly more recent data which has been collected on the same Texas highway sections during a statewide condition survey four years later. Certain restrictions were placed on the collection of these data in order to assure its quality and homogeniety. These restrictions included:

(1) All data parameters utilized must be common to every observation. This restriction was made in an effort to eliminate gaps in the data and so that for pavement sections not in the study it would be possible to test the prediction models.

(2) All data must be easily obtainable for those parties wishing to forecast performance. Since one of the objectives behind this regression modelling is to develop quick and easy methods for predicting future distress, it would be self-defeating to include parameters which are difficult or expensive to determine.

(3) The minimum roadway length for inclusion in the study was set at one mile. This was to eliminate any undue bias in the results which might be caused by extremely short sections.

(4) All distress data was "nondirectionalized." Directional distress measurements collected in condition surveys (Ref 3) were converted to average per length of pavement. This was done to compensate for the lack of available directionalized traffic data.

Five types of data were utilized for this development of the prediction models. Specifically these were data on:

(1) environmental factors,

(2) construction factors,

(3) traffic,

(4) age of pavement, and

(5) pavement distress factors.

The selection of factors was made on the basis of data availability and the results of an ANOVA which was performed prior to the regression analysis.

(1) Environmental Factors. The environmental factors chosen for this investigation reflect the various local soil and climatic conditions which may contribute to the deterioration of pavement performance. Those factors which were included are described below.

(a) Moisture: The moisture content of the soil directly beneath the pavement structure is a function of rainfall, humidity, evaporation, transpiration, soil suction and other factors. A moisture index which describes the moisture characteristics was developed by Thornwaite (Ref 17). Contours for constant index values are shown for Texas in Fig. 5.1. This index relates the maximum yearly surplus and deficit of available water to the potential evapo-transpiration of the area. Thornwaite's moisture index can be calculated from the following equation:

$$Im = \frac{100s - 60d}{Ep}$$

where

Im = moisture index,

s = surplus of water in inches of groundwater table,

d = deficit of water in inches of groundwater table, and

Ep = potential evapo-transpiration in inches.

(b) Temperature. Three temperature related variables were used to describe temperature effects: solar radiation (Fig 5.2), thermal fatigue (Fig 5.3) and regional temperature variation (Table 5.1). Solar radiation quantifies the amount of heat from the sun to which the area is exposed, thermal fatigue is characterized by the number of annual freeze-thaw cycles and regional temperature variation is represented by Texas SDHPT temperature constant (Ref 18).

(c) Clay activity. The shrink-swell characteristics of the subgrade soil determine the potential for differential movement within the subgrade. This can lead to longitudinal surface waves and the formation of voids beneath the pavement. Swelling clays typically found in Texas are listed in Ref 19 and Appendix A of Reference 20.

(d) Regional factor. The State of Texas was divided into major regions. Although the regional factor is primarily a geographical demarcation, inherently it includes other factors

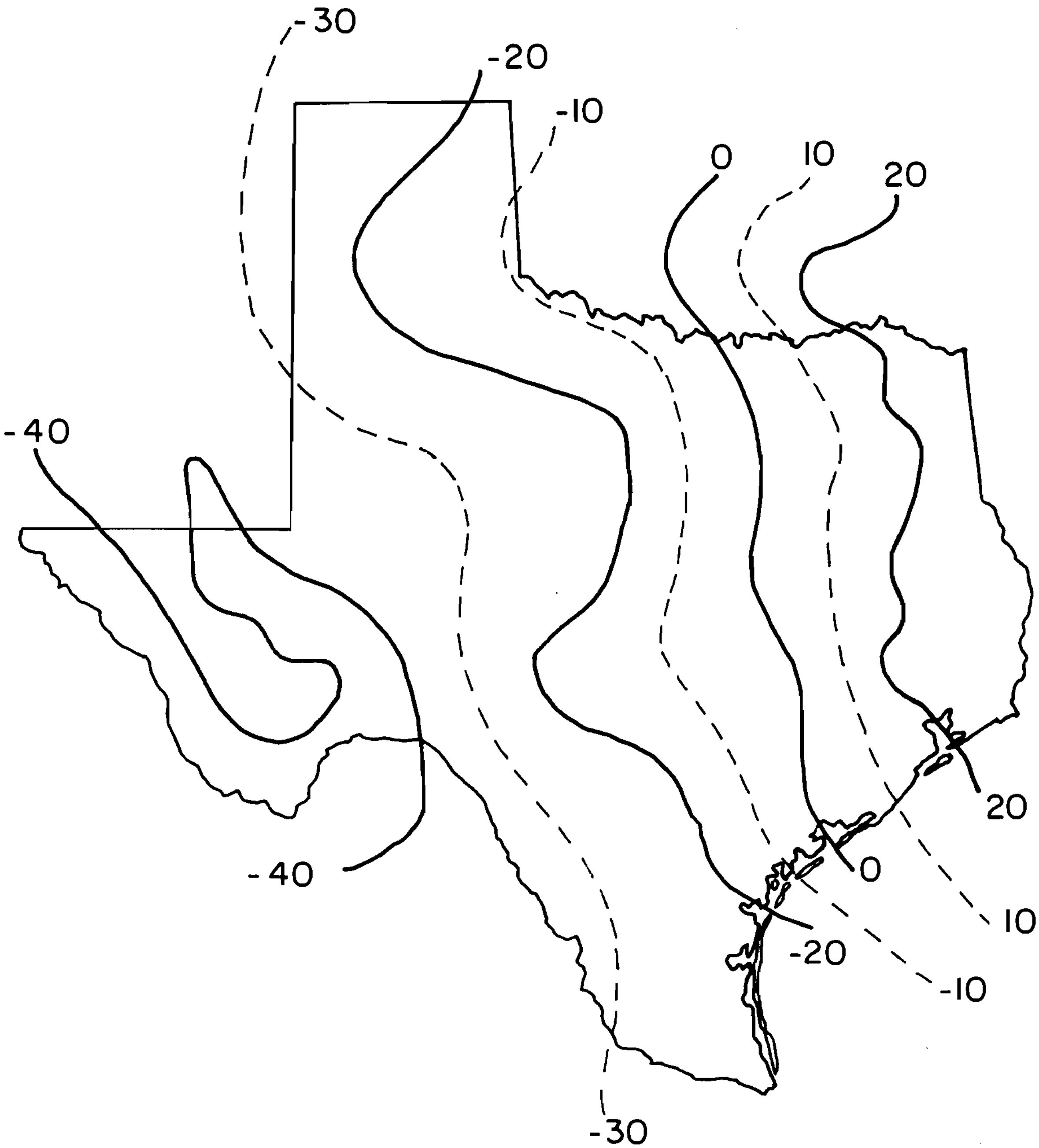


Fig 5.1. Contours of Thornwaite moisture index for Texas (Ref 17).

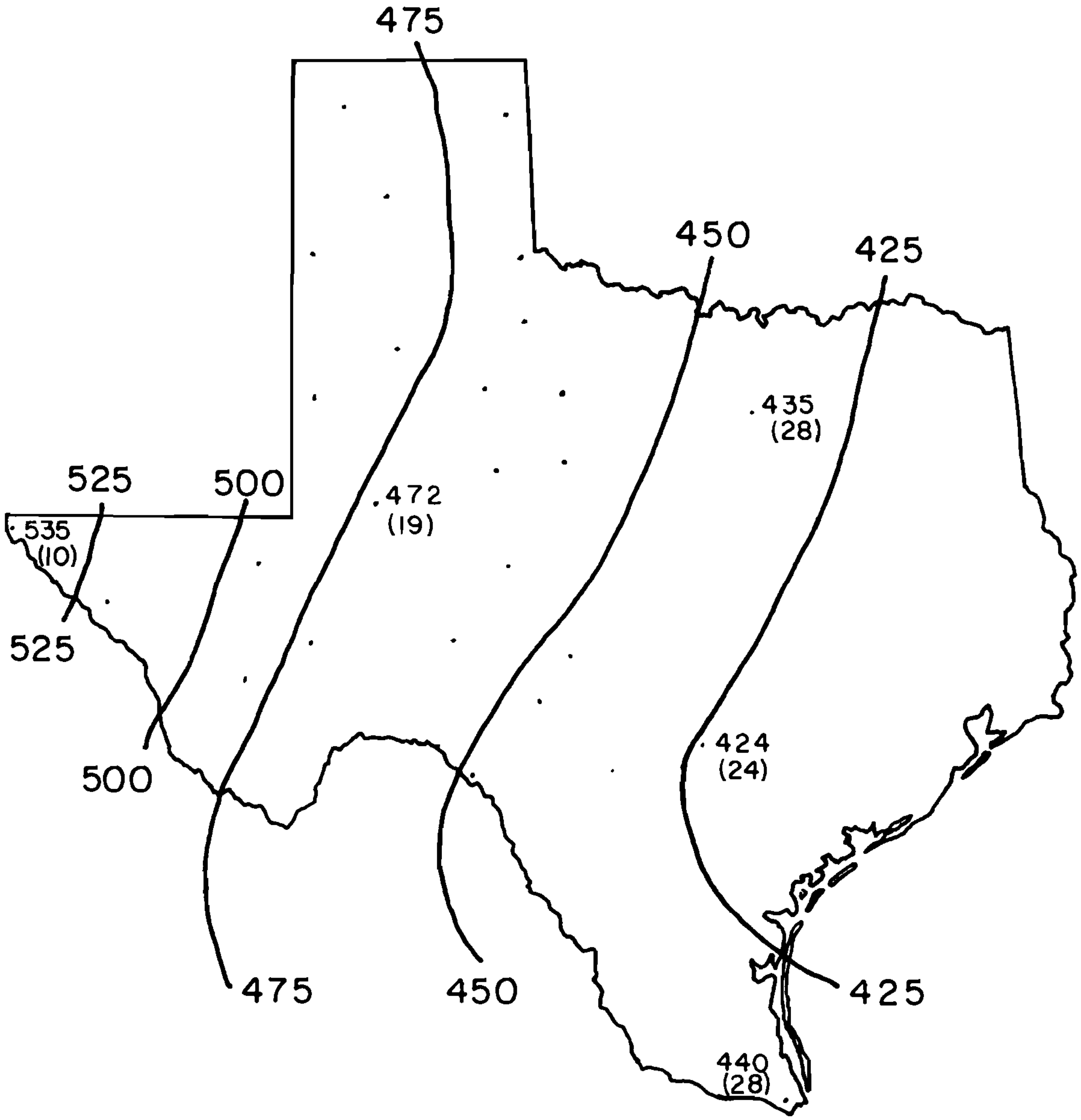


Fig 5.2. Contours of solar radiation (Langleys/Day) for Texas (Ref 18).

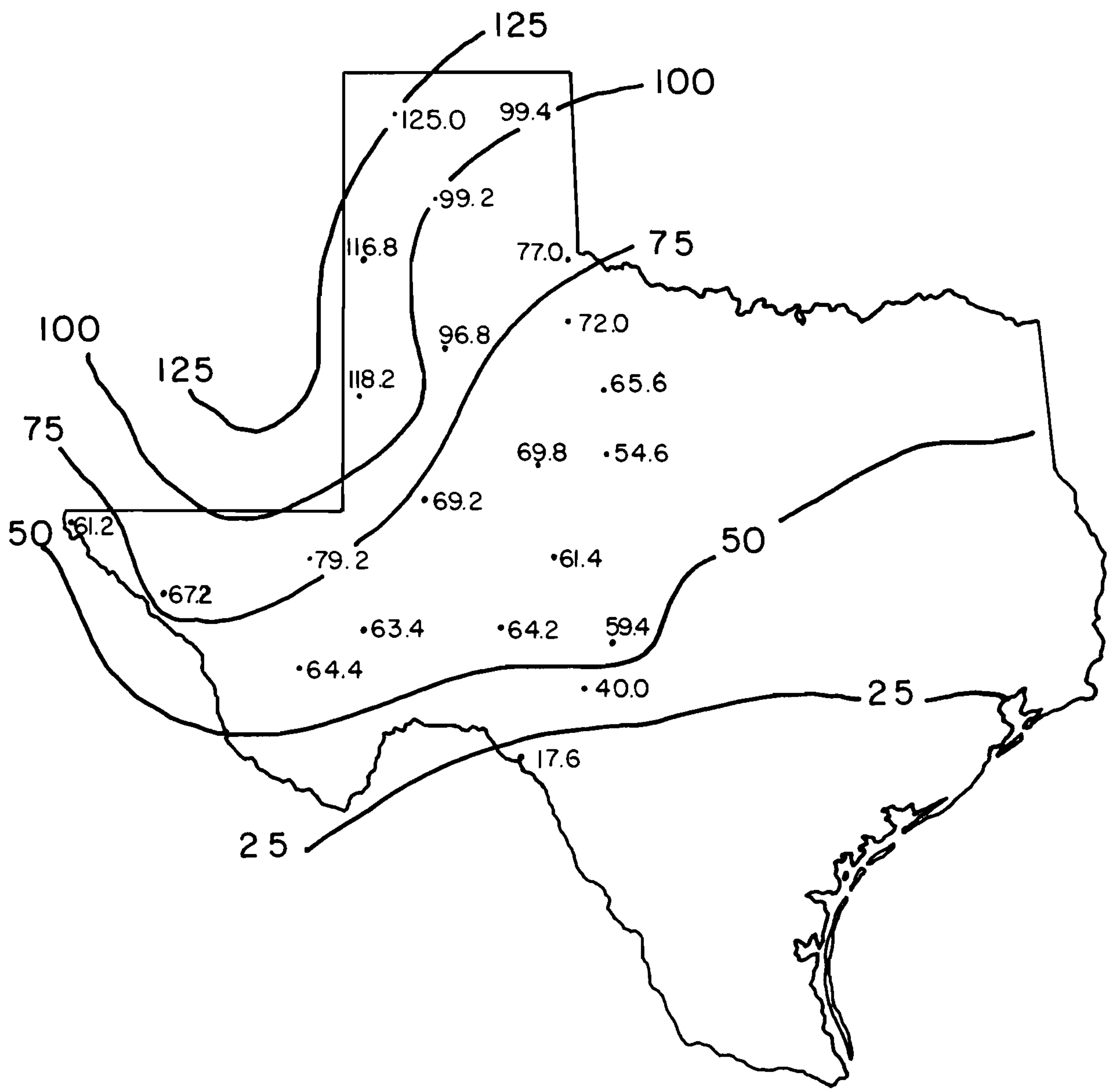


Fig 5.3. Contours of annual average freeze-thaw cycle for Texas (Ref 18).

TABLE 5.1. TEXAS SDHPT TEMPERATURE CONSTANT ($\bar{\alpha}$) BY DISTRICT (REF 18)

District	Temperature Constant ($\bar{\alpha}$)
1	21
2	22
3	22
4	9
5	16
6	23
7	26
8	26
9	28
10	24
11	28
12	33
13	33
14	31
15	31
16	36
17	30
18	26
19	25
20	32
21	38
22	31
23	25
24	24
25	19

such as vegetation type, humidity and hydrologic conditions. The regional factors as used in this study are shown in Fig 5.4.

(2) Construction factors. The data on construction factors utilized in this study were collected for four different layers associated with concrete pavement construction. These were:

(a) concrete layer properties,

(b) subbase layer properties,

(c) subgrade layer properties, and

(d) shoulder layer properties.

Each of these categories included items such as layer thickness, constituents, quantity, etc.

(3) Traffic. Traffic data for each of the observations were obtained from SDHPT D-10 and were reported in cumulative equivalent 18-kip axle loads. This is consistent with previous work done in pavement design, where pavements were designed to adequately accommodate the expected 20-year equivalent 18-kip axle loading.

(4) Age. The age of the pavement was reported in months, as measured from the time of completion of pavement construction.

(5) Pavement distress. Measurements of pavement condition were collected in two surveys. The first was conducted during 1974 and the second during 1978. The 1974 data were reported in the form of three parameters,

(a) quantity of failures in number per mile (number of failures = number of punchouts + number of patches,

(b) quantity of spalling in percent of spalled cracks, and

(c) low and mean serviceability as measured by the Mays meter.

The same pavement sections were surveyed in 1974 and 1978; however, some of the sections were overlayed after the 1974 survey and were not included in the 1978 data set. In summary, data were collected on 87 sections in 1974 and on 61 sections in 1978, bringing the total number of observations to 148.

Full details of all factors used are given in Appendix F.

Inference Space

The inference space for the regression model has, as an upper bound, the population from which the observations have been drawn. The extent to which the actual inference space approaches the upper bound is dependent upon the degree of restriction placed on the sampling from this population.

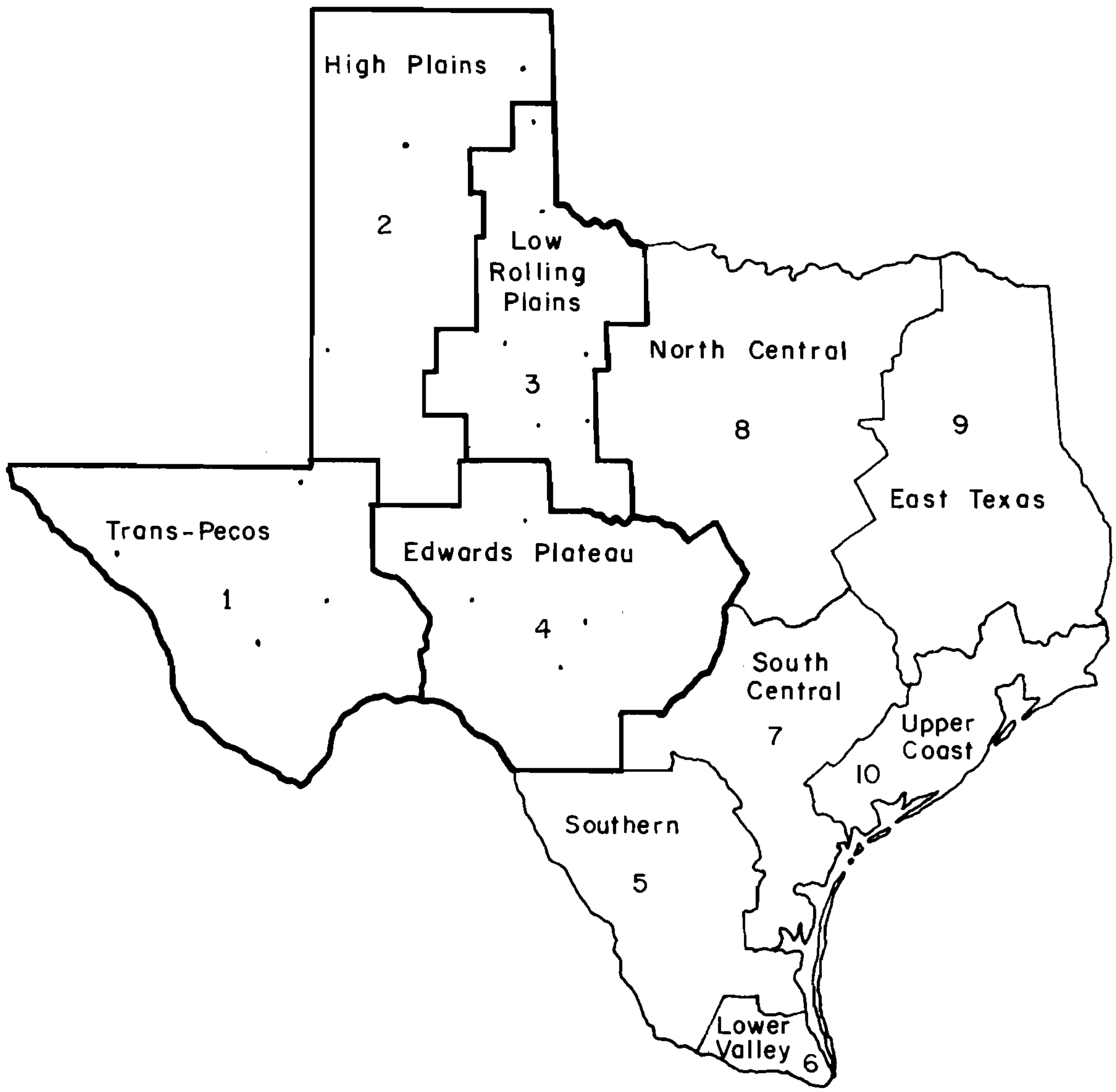


Fig 5.4. Topographical and geological regional separation of Texas as utilized in this report.

The model developed in this regression has, as its inference space, Texas CRC pavements of 8-inch thickness which are between 2 and 15 years of age. Extreme caution should be exercised when attempting to apply this model outside this inference space as unrealistic predictions may result.

A detailed description of the inference space may be obtained from Appendix F. This summarizes all factors considered in the Regression Analysis and the ranges over which they were worked. From these data the inference space of the model may be obtained.

Method of Regression

The large number of independent variables in this analysis made it impossible to include the complete set of variables in the model. Therefore, a regression procedure which would select a "best set" from the complete set of variables was needed. Several procedures in current use were available to perform the necessary calculations. These included: (1) all possible regressions, (2) backward elimination, (3) forward selection, and (4) stepwise regression.

The first procedure involves performing all possible regressions. The regressions are then divided into sets and each set is ordered according to come criterion. This criterion is usually the R^2 obtained from at least squares fit (Ref 13). The leaders of each set are examined and the selection of which equation to use is then made. As already noted, due to the large number of variables, this procedure is impractical in this case.

The backward elimination procedure is an improvement on the all possible regressions technique. In this procedure a regression equation containing all the variables is computed. The partial F-test value is computed for every variable as if it were the last to enter the equation. The lowest F-value is compared to a preselected minimum F-value, which corresponds to a percentage point in the F distribution. If the lowest F falls below the minimum value, the variable which gave rise to it is removed. The regression is recomputed without the variable and the procedure is repeated. If the lowest partial F-value is greater than the minimum, the procedure is completed.

The forward selection procedure inserts variables into the equation until it becomes satisfactory. At each step in the procedure R^2 is calculated and the partial F-value for the last variable to enter the equation is examined for significance. When this value becomes nonsignificant, the process is completed.

Stepwise regression is an improvement of the forward selection procedure. As each new variable enters the equation, the variables which are already in the equation are re-examined, and any which are found to be nonsignificant are then removed. It is possible that a variable which was the most significant at an earlier step may become nonsignificant due to its relationships to variables which have since entered the equation. The re-examination procedure removes the superfluous variables and reduces the total number of variables in the equation.

Stepwise regression utilizes the partial F criterion for selecting variables to enter and for re-examining variables already in the equation. At each step, the partial F-values for all variables are calculated as if they were the last to have entered the equation. If the partial F-value for a variable in the equation falls below a preselected minimum F -to-remove, the variable is removed. The variables not in the equation are then examined and the one with the highest partial F-value is entered into the equation, provided it exceeds a preselected minimum F-to-enter. This is repeated until no more variables are entered or removed and the equation is complete.

Because of its advantages over the other procedures, a stepwise regression was performed in this analysis. The computer program STEP01 (Ref 20) from the Biomedical package was chosen to do the stepwise regression and the full results are summarized in Ref 20 and Appendix H of this report. For the analysis, the F-to-enter and the F-to-remove were both set to a value of 1.32. The resulting equation is described in the following section.

Description of Distress Prediction Model

The distress prediction model obtained from the analysis discussed above is summarized on the following page. Details of how to use this model are outlined on page 34.

Assuming visual condition survey information is taken at some time in the life of a selected CRC pavement, it should be used with the equation given below for the prediction of distress at some later time during the pavement's life. The equation is as follows,

$$N = -0.381 - 0.0356X_1 + 0.000131{X_2}^2 + 0.0461\,X_3(X_2 - X_1) + 0.0000494\,X_2X_4 + X_5 \quad (5.1)$$

where

N = number of failures per mile (punchouts + patches) at future time chosen for prediction,

X_1 = pavement age at time of condition survey (months),

X_2 = pavement age at future time chosen for distress prediction,

X_3 = "N" at time of condition survey,

X_4 = Texas SDHPT temperature constant (Table 5.1),

X_5 = $-5.840 + 0.0988\,X_2$ for pit run gravel subbase aggregate, and
0 for other subbase aggregates.

Relevant summary statistics for the regression analysis from which the equation was determined are:

R^2 = 0.672 and
MSE = 2.436.

Care should be taken when using the equation in the light of these statistics.

A complete summary of the results of the regression analysis is given in Appendix H which contains a copy of the computer printout from the final regression calculations.

Procedure for the Use of Distress Prediction Model

The prediction equation discussed above requires the following input parameters:

(1) condition survey data on the number of failures per mile,

(2) pavement age at the time of the survey (expressed in months),

(3) pavement age at the time in the future for which the prediction is desired (months),

(4) SDHPT temperature constant for the region in Texas in which the pavement is located, and

(5) subbase aggregate type.

Example of Use of Distress Prediction Model

The data (values of input parameters) for the selected Texas CRCP section (CTR Section #1006) were obtained from Appendix F as follows:

X_1 = 105 months (1974 condition survey),

X_2 = 155 months,

X_3 = 3.86 failures per mile (1974 condition survey),

X_4 = 24 and

X_5 = 0 (subbase aggregated is processed material).

Substituting in equation 5.1 gives

$$N = -0.381 - 0.0356\ (105) + 0.000131\ (155)^2, +0.0461\ (3.86)\ (155-105) + 0.0000494\ (155)(24), = 8.11 \text{ failures per mile.}$$

Hence, the predicted number of failures per mile for CTR Section number in 1978, based on 3.9 failures in 1974, is 8.1. This compares favorably the actual number of failures per mile which was recorded during the 1978 condition survey of 7.3 (Appendix F).

Conclusions and Redommendations

Conclusions

An examination of the regression analysis results and the plots of residuals leads to the following conclusions. Full information may be obtained with reference to Appendix H.

(1) The R^2 (.67) and standard error of prediction (2.4) statistics show that the equation has an acceptable precision of prediction*.

(2) The equation tends to slightly overestimate the lower values of predicted distress and underestimates the higher values.

(3) The equation may be conservative due to the fact that the more highly distressed sections had been removed from the sample for analysis purposes. This was because they had been overlayed since 1974.

(4) The plot of predicted distress versus residuals indicates that there may be some nonhomogeneity of variance (Appendix H).

(5) The plot of observed distress versus predicted distress indicates a good fit and supports conclusion number (1) (Appendix H).

Recommendations

(1) The ongoing collection of condition survey data should be performed on a regular basis to provide insight into the behavior of CRCP over time.

(2) The prediction equation should be regularly updated by the inclusion of the additional survey data recommended.

*Inclusion of additional terms would have increased the R^2 but would have tended to over-fit the data, detracting from the model's predictive usefulness.

CHAPTER 6. USE OF DISCRIMINANT ANALYSIS TO EVALUATE THE DISTRESS CONDITION OF CRCP*

Introduction

This chapter describes an application of discriminant analysis (Ref 22, 23) techniques to the evaluation of the distress condition of CRCP for the purpose of defining the terminal point for major rehabilitation. The specific objectives considered in this evaluation were:

(1) the development of a utility function to assign a quality score to a CRC pavement, and

(2) the definition of a criterion for use in determining the need for either major rehabilitation or an overlay on CRCP of known condition.

Background

The data used in this analysis were obtained during the distress condition surveys of CRCP in Texas which were performed in 1974 and 1978 (Ref 2, 3). Several manifestations of distress were recorded, namely punchouts and patches per mile (together recorded as patches per mile), percent of minor spalling, percent of severe spalling and percent of pumping. Some of the pavements surveyed during 1974 were overlayed prior to the survey in 1978 (Appendix I). Discriminant Analysis was applied to these data to establish criteria to facilitate making the decision to overlay. Specifically, by using data on several distress manifestations from two groups of pavements (overlayed and nonoverlayed) to describe their difference, the discriminant analysis provided a suitable utility function and set of criteria. Table 6.1 summarizes some statistical parameters of the sample data.

Discriminant Analysis

A major problem encountered in previous attempts to develop combined overall quality indicators for pavements lies in selecting specific values of the combined index as critical values or terminal values. The logical boundaries or ranges of acceptability for this overall rating can potentially

*Ref. 21.

TABLE 6.1. STATISTICAL PARAMETERS OF THE SAMPLE (APPENDIX I)

DISTRESS MANIFESTATION	MEAN VALUE			STANDARD DEVIATION		
	OVERLAID SECTIONS	NON-OVERLAID SECTIONS	TOTAL SECTIONS	OVERLAID SECTIONS	NON-OVERLAID SECTIONS	TOTAL SECTIONS
Number of failures/mile	14.08	4.20	8.14	15.56	2.01	3.99
Minor Spalling (%)	22.38	12.76	15.16	32.12	19.52	21.36
Severe Spalling (%)	5.61	6.11	6.08	4.96	2.74	3.06
Pumping (%)	6.54	5.73	5.90	5.79	3.43	3.77

be determined through the use of discriminant analsis, which is specifically geared to determining natural groupings of composite variables. This is accomplished by selecting composite variables on the basis of maximum differences among group means of composite scores, coupled with minimum overlap in the distributions of these scores.

Essentially then, the discriminant analysis is a statistical technique used to classify data into groups. Its objective is to construct a boundary, which is referred to as a discriminant equation, such that the elements of each group can be separated. Also, once the equation is defined, any new element can be assigned into one of the predetermined groups. The technique has been used here to establish relations which distinguish whether or not a pavement falls into a "group of pavements" requiring a particular rehabilitation activity, based on visual condition survey information. Using data from Appendix I, the discriminant function (equation) has been determined here for a group of CRC pavements in Texas, as discussed in the next section of this chapter.

In the development of the discriminant function, a subprogram called 'discriminant' of the statistical package SPSS was used (Ref 10).

Analysis Procedure, Development of Discriminant Function

It was decided that the data obtained for percent pumping was not representative of the population, and so the analysis was carried out without considering percent of pumping as a variable. Specifically, the discriminant function (equation) developed to discriminate between groups was of the form

$$z' = \sum_{i=1}^{n} a_i z_i \qquad (i = 1, \ldots , n) \qquad (6.1)$$

where

z' = discriminant score,

a_i = weighting coefficients, and

z_i = standardized values of the n discriminating variables (distress measures) used in the analysis.

The standardized values, z_i , were calculated as follows:

$$z_i = \frac{x_i - \bar{x}_i}{\sigma_{x_i}} \qquad (i = 1, \ldots, n) \qquad (6.2)$$

where

x_i = value of the distress manifestation , i , for the case being classified,

$\bar{x}_i$ = mean value of the distress manifestation , i , and

σ_{x_i} = standard deviation for $\bar{x}_i$.

Hence, for any particular pavement, data on each x_i should be substituted into Equation 6.1 and equation 6.2 in order to obtain a value of z´, the discriminant score for that pavement. This value is called the z´-score or zeta´-score for that pavement.

Interpretation of Discriminant Score

If "z´-scores" for all the pavements in the original (historical) data set are calculated, then mean z´-scores for each group may also be calculated. The individual z´-score will tend to be distributed normally about these means, and a frequency distribution for each of the two groups may be plotted (against z´-score) on one continuous horizontal axis. For the analysis performed here such a plot is shown in Figure 6.1. A grand mean (zero-point for the continuum) for all the z´-scores has also been calculated, and it lies between the two group means. Information for these calculations may be obtained from the computer output (Appendix I). If we assume that Figure 6.1 represents the distribution of the z´-score for a set of pavements, each of which is either in "bad" condition (overlayed) or "good" condtion (non-overlayed), then the z´-score for any particular individual pavement may be interpreted as follows:

z´ = -0.819, (grand mean); probability that the pavement belongs to group of good pavements = probability that it belongs to the group of bad pavements = 50%,

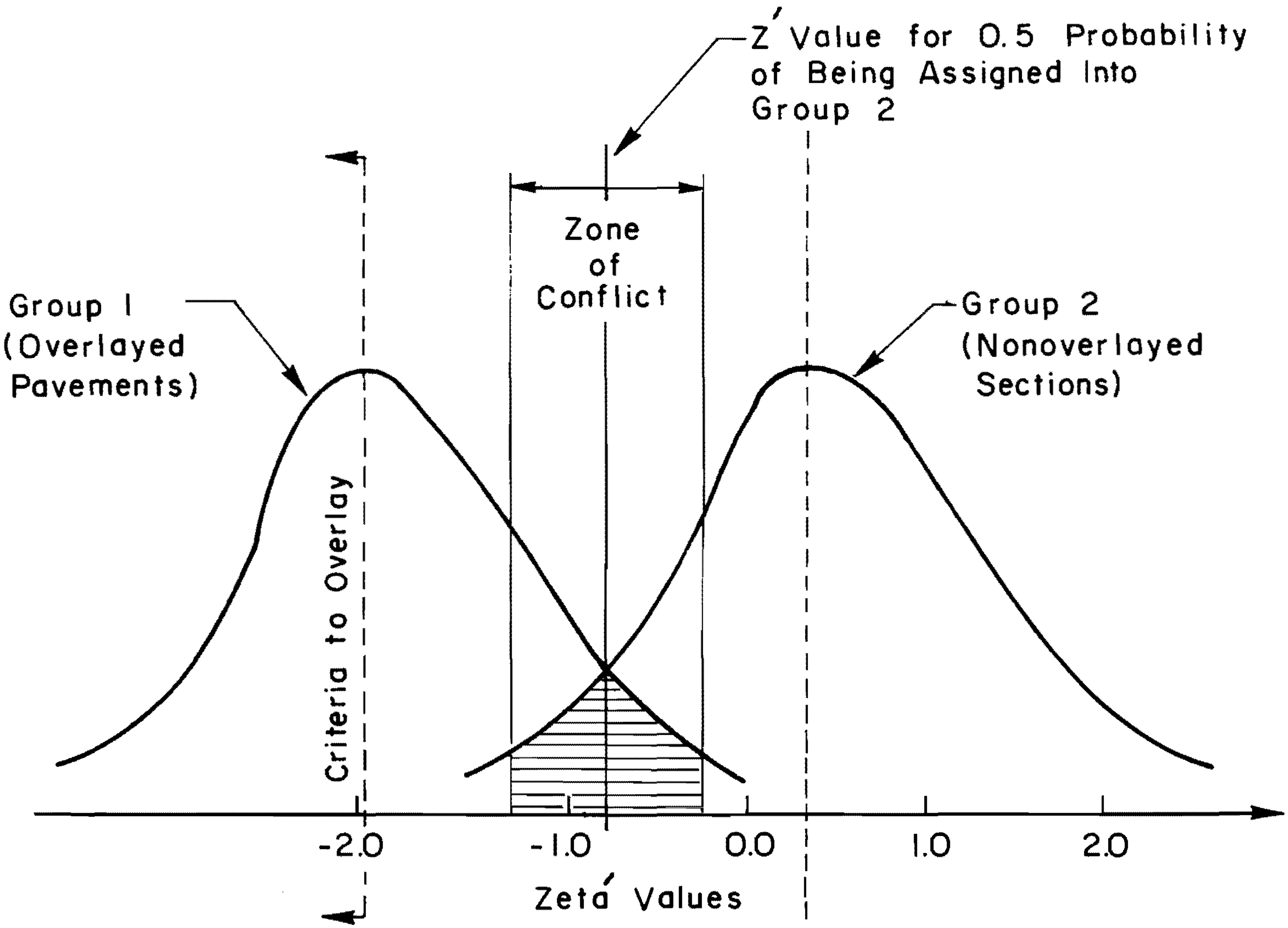


Fig 6.1. Representative distribution of z´ -scores for data set used in Discriminant Analysis (From Ref 21).

$z' < 0.819$, probability that pavement belongs to the group of good pavements < probability of belonging to the group of bad pavements,

$z' > 0.819$, probability that the pavement belongs to the group of good pavements > probability of belonging to the group of bad pavements.

More specifically, pavements located in the "zone of conflict" (zone of ignorance) are pavements whose classification is uncertain within the reliability of the analysis.

In order to simplify the interpretation of equation (6.1), the z' value can be modified so that scores are compared to zero, rather than to the grand mean (-0.819) by using the equation

$$z = z' - \text{Grand Mean}, \qquad (6.3)$$

i.e.

$$z = 0.819 + \sum_{i=i}^{n} a_i z_i . \qquad (6.4)$$

The modified distributions are shown in Figure 6.2.

Results of the Analysis

Table 6.2 summarized the parameters for the above equations which were obtained from the analysis.

By substituting the values from Table 6.2, the equation can be further simplified to the following;

$$z = 2.113 - 0.138_1 - 0.032X_2 - 0.020X_3, \qquad (6.5)$$

where

X_1 = number of failures per mile,

X_2 = minor spalling (percent), and

X_3 = severe spalling (percent).

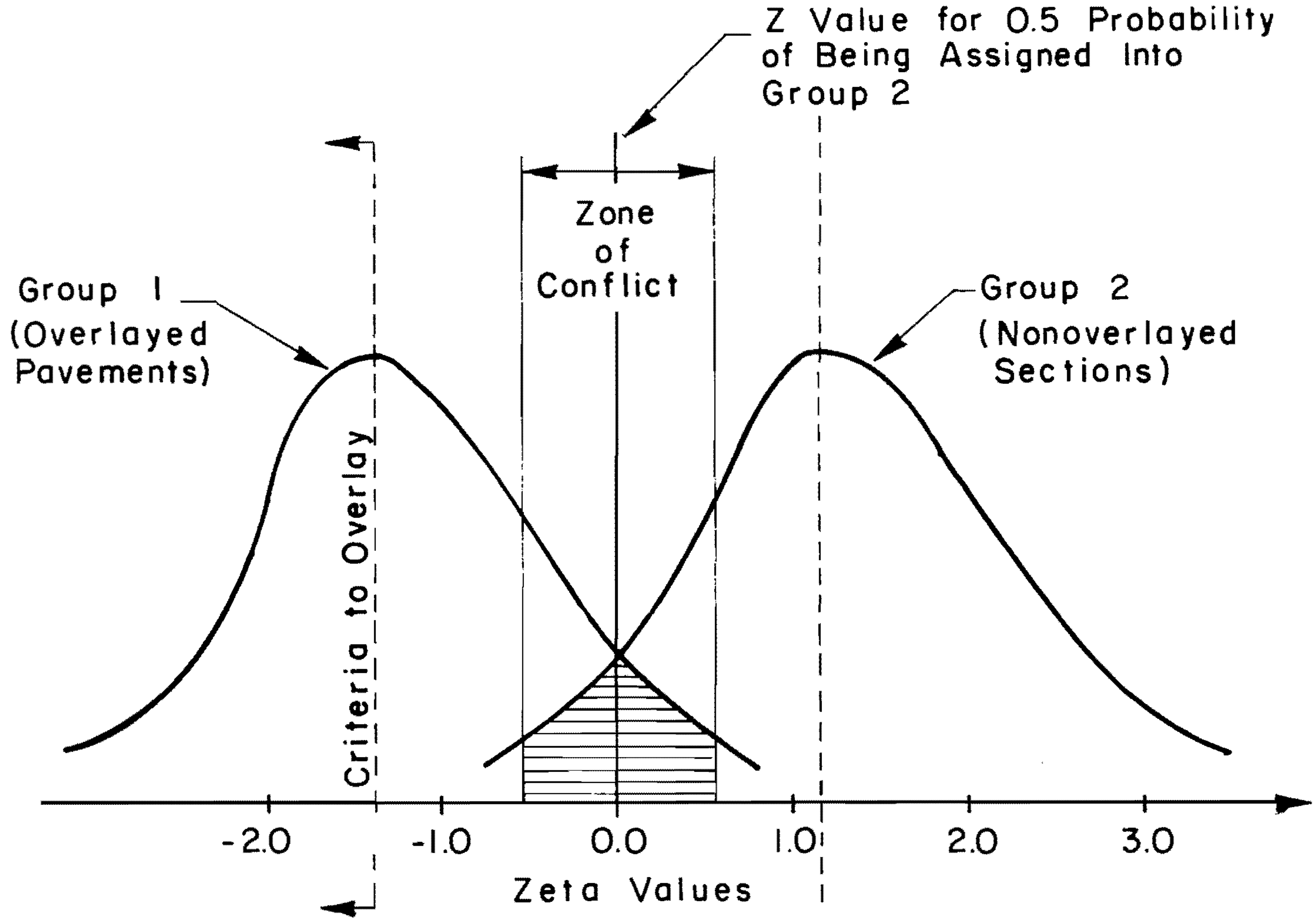


Fig 6.2. Modified distribution of z -scores for data set used in Discriminant Analysis (Ref 21).

TABLE 6.2. CONSTANTS TO BE USED WITH EQUATIONS 6.1 and 6.2.

i	Distress Manifestation	a_i	$\bar{x}_i$	σ_{x_i}
1	Failures per mile	-1.12	3.99	8.14
2	Minor spalling (percent)	-0.49	21.36	15.17
3	Severe spalling (percent	-0.12	3.07	6.08

Development of a Utility Function

Once the discriminant function has been developed, it can be used to assess a utility value for any CRCP under evaluation by developing a corresponding utility function. That is, the z value described above can be more easily interpreted if it is transformed to a Utility estimate from some Utility Function. The function must range from zero to one depending upon the degree of distress of the facility (how 'bad' or 'good' the pavement is). To achieve this, several options could be followed.

(1) Use of z function as it is. The z values not only discriminate between overlayed and nonoverlayed sections when compared to the boundary value, but depending on the magnitude of z , they indicate how good or how bad the distress in the CRCP is. The higher z , the better, and viceversa.

(2) Ignoring the sign of the z function. If the sign is ignored, each weighting coefficient, a_i , represents the relative contribution of its associated type of distress to the discriminant function. This weighting coefficient can be used in combination with utility curves of each type of distress.

The average utility being obtained from an equation of the form

$$AVU = u_f^a \times u_{ms}^b \times u_{ss}^c \times u_p^d \tag{6.6}$$

where

- AVU = average visual utility,
- u_f = utility assigned to the appropriate number of failures per mile for the pavement being evaluated (obtained from given curves),
- u_{ms} = utility assigned to the appropriate percent of minor spalling,
- u_{ss} = utility assigned to the appropriate percent of severe spalling, and
- u_p = utility assigned to the appropriate percent of pumping.

The exponents for Eq (6.4) may be defined as follows:

$$a = a_1/\Sigma|a_i|; \quad b = a_2/\Sigma|a_i|; \text{ etc.}$$

The remainder of the symbols are defined similarly.

(3) Utility developed from the z equation. There is a probability associated with each z value that can be used as a utility value for a CRCP facility. It is the probability that a given pavement belongs to the nonoverlayed pavement group. That is, if a pavement has a probability close to one, of belonging to the nonoverlayed group, then it is in good condition and its utility is equal to that probability. Conversely, if the pavement has a low probability of being in the nonoverlayed group, then its utility will be low.

In this report, only the third option is investigated further because it was felt to be the best approach of the three. The utility functions may be obtained more easily than with the second approach because of boundary value problems, interpretations is easier than for the first approach, and the utility function may be derived directly from the discriminant analysis.

Utility Function Developed from the z Equation

Figure 6.3 is a plot of z values against the probability of belonging to the nonoverlayed group for any distress modes combination. Under the assumption that this probability is normally distributed, either of two procedures may be used to obtain the required probabilities as follows:

(a) by the appropriate use of normal distribution probability tables, or

(b) by means of a numerical approximation procedure as show below.

The Equation that relates z to this probability for $z \geq 0$ is Ref 22, 23)

$$u(z) = 1.0 - f(z)(b_1t + b_2t^2 + b_3t^3 + b_4t^4 + b_5t^5) \qquad (6.7)$$

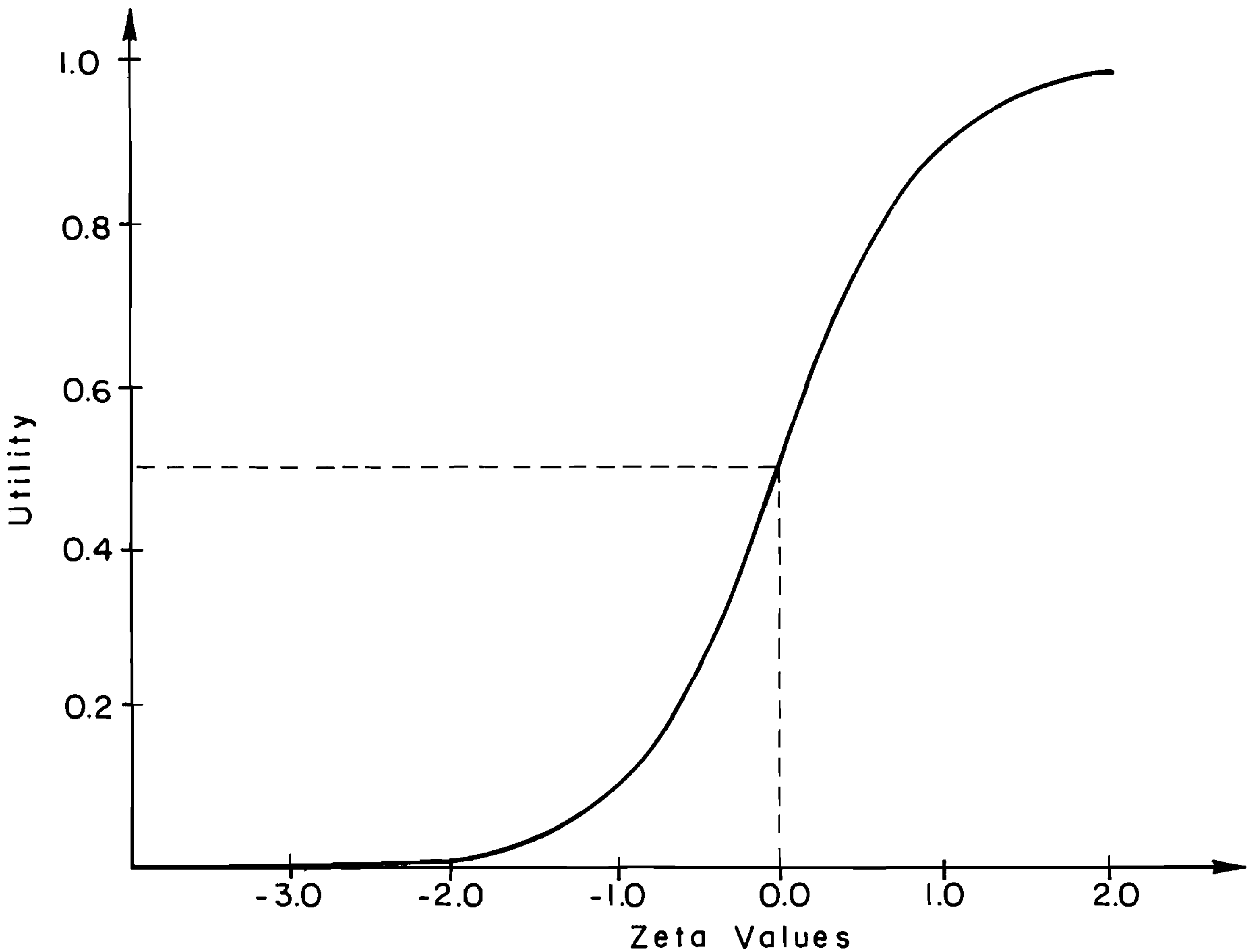


Fig 6.3. Average visual utility versus zeta values for CRCP.

where

$$u(z) = \text{utility assigned to a pavement for a combination of distress modes with a discriminant score } z \text{ ,}$$

$$f(z) = \frac{1}{\sqrt{2\Pi}} \exp[-\frac{1}{2}(z)^2],$$

$$t = \frac{1}{1 + 0.23164(z)} ,$$

$$b_1 = 0.31938,$$

$$b_2 = -0.35656,$$

$$b_3 = 1.78148,$$

$$b_4 = -1.82126,$$

$$b_5 = 1.33027,$$

In the case of $z < 0$

then

$$u(z) = f(z)(f_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4 + b_5 t^5) \quad (6.6)$$

where

$$t = \frac{1}{1 - 0.23164(z)} .$$

Then, if the appropriate equation is applied to find the probability associated with a given z , the utility of a pavement with such z is determined. This utility value ranges from zero to one; the closer the utility is to one, the better the condition of the CRCP.

Criteria for Major Rehabilitation

According to the discriminant function that has been developed, it its z is smaller than zero, a pavement would be classified as a candidate to be overlayed. Nevertheless, referring to Fig 6.2, it is found that a lower value of z should be adopted as criteria to decide when to overlay.

Figure 6.2 is an oversimplification of the distribution of the overlayed and nonoverlayed pavements. Pavements located in the "zone of conflict" are pavements that are not in an excessively bad condition, such that there is significant doubt as to whether they belong to either the overlayed or non-overlayed group. For this set of data, the derived z boundary value occurs in a position which is shifted to the right of its correct position because of the existence of sections with negligible distress that have been overlayed regardless. For these pavements, the criteria used in the decision to overlay apparently were not functions of the distress modes considered above.

With the above considerations, it was felt that a better criterion to use when deciding whether or not to overlay is the mean z value for the group of overlayed pavements. This mean z value is calculated by substituting the mean distress values calculated for this group into the discriminant equation. These mean distress values are summarized in Table 6.1.

From the discriminant function calculated above, this mean z value is

$$\begin{aligned} z &= 2.113 - 0.138X_1 - 0.032X_2 - 0.020X_3 \\ &= 2.113 - 0.138(15.56) - 0.032(32.12) - 0.020(4.96) \\ &= -1.17 \end{aligned}$$

The criteria proposed to decide when to overlay then become:

(a) Any pavement with utility $u(z) \leq 0.120$ should be overlayed, or

(b) If the cost of repairing a pavement is larger than the cost of overlaying, that pavement should be overlayed, whatever its utility.

Conclusions

At this stage it is important to mention some assumptions inherent to the approach we have followed and that might invalidate our results if not satisfied:

(1) The discriminant function obtained is linear, but this might not be correct. This situation arises from the fact that the mathematics involved in the discriminant analysis are based on the assumption that distributions of the groups are equivalent (variances and covariances should be the same in both groups).

(2) The variables have been assumed to be normally distributed.

(3) The subjective decisions of overlaying the sections that we have used in our analysis have been assumed to be correct.

(4) The data points used are not comprehensive. That is, for distress values outside the range of our data, the z equation drived is not applicable.

(5) Not all distress types have been included. The criteria followed to overlay some of the sections used in our analysis could have been different if a different set of distre-s types had been used.

Non-parametric and nonlinear discriminant analysis techniques could be used if assumptions (1) and (2) are found not to be valid.

Within the restrictions mentioned above, the prediction results obtained in a test analysis were encouraging. In Table 6.3, the observations from the data which were correctly classified by the z-equation are summarized. Although the data used to test the prediction capability of the discriminant function were also the data used to develop the equation, it is clear from Table 6.3 that suitable precision has been obtained.

Also, it is believed that this approach is a step further in the rationalization of the evaluation of the distress condition of the pavement. Full details of all calculations may be obtained from Appendices I and J.

TABLE 6.3. PREDICTION PRECISION OF DISCRIMINANT EQUATIONS

Pavement Group	Number of Observations	Number of Correct Predictions	Percent Correct
Overlayed	34	22	64.7
Nonoverlayed	199	185	93.0
Total	233	207	88.8

CHAPTER 7. PRELIMINARY GUIDELINES FOR A RIGID PAVEMENT EVALUATION SYSTEM (RPES)

Outline of System Functions

It is the purpose of this chapter to present a set of guidelines for the establishment of a rigid pavement evaluation system and its use in decision making concerning pavement design, maintenance and rehabilitation. A system is proposed here which could be used to determine a total "utility" or "value" at any point in time for any chosen pavement. This 'utility' would be represented as a total "pavement score (PS)" on a linear scale from 0 to 1, and would be determined from quantitative ratings of important pavement properties at the chosen time. The pavement score would be a function of the pavement's rated condition (as measured by visual condition survey), roughness, skid resistance quality, maintenance requirements and functional utility. These last two factors would reflect the pavement's utility to the community and the various costs or benefits occurring to the community for different rehabilitation activities in comparison with others. The system would incorporate a procedure for making decisions on the particular rehabilitation activity to be performed on the basis of maximizing utility as reflected directly in the pavement score . Alternately, the maintenance cost and functional considerations could be treated separately in the decision making process through the introduction of a total utility maximization process. The second alternative is discussed here.

Limitations of System Functions

It is important to remember that preliminary guidelines only, for a rigid pavement evaluation system are presented here. Development of a more complete system incorporating reliability into the decision making process is anticipated in the next year under CFHR project 249. Thus, the system presented here will only be useful for making recommendations for deciding among categories of rehabilitation. That is, for deciding whether or not, at the time of analysis, any chosen pavement should be completely rebuilt, levelled-up, patched or left untouched. Decisions concerning the extent and details of the particular rehabilitation program within the recommended category should be made as part of a separate analysis which would be performed after the category has been chosen.

Summary of System Components

Two specific objectives are considered in this evaluation; first, the development of a utility function which would assign a quality (utility, value, performance) score to any chosen rigid pavement; second, the definition of criteria for selecting from rehabilitation alternatives for the pavement. Essentially, for any rigid pavement, a total pavement score (PS) would be predicted in terms of a series of component utilities as listed below, and decisions made on the basis of the value of PS. That is

$$PS = F \quad (AVU, RQU, SRU, MCU, FCU)$$

where

F = Utility Function

PS = Pavement Score

AVU = Average Visual Utility (Distress Utility)

RQU = Ride Quality Utility (Distress Utility)

SRU = Skid Resistance Utility (Distress Utility)

MCU = Utility Accountable to the cost of any chosen rehabilitation activity (Maintenance Cost Utility)

FCU = Functional Classification Activity.

It should at all times be remembered that the PS is indicative of the need for rehabilitation.

Use of RPES: Calculation of Distress Utilities

The use of the proposed system to achieve the two specific objectives which were mentioned above, is disscussed here. Specifically, the recommended techniques for estimating individual pavement distress component utilities (AVU, RQU, SRU) are outlined.

(1) Establishment and Updating of a Pavement History Data Bank.

A data bank, containing the construction, environment, load, distress and repair history, for each pavement under consideration should be established. This data bank should be updated on a on a regular basis (preferably annually) particularly with regard to repairs, traffic, distress condition, ride quality and skid resistance. Preliminary steps toward the creation of such a pavement history data bank for rigid pavements in Texas, using a digital computer and appropriate data summary programs (Refs 3 and 4), have already been taken at the Texas SDHPT.

(2) Calculation of Average Visual Utility.

Information on the distress condition of the pavements under investigation at the time of analysis should be obtained using visual condition surveys. The type of data to be collected and the manner in which it should be recorded has been defined in Refs 4 and 5 for CRCP, JRCP and overlays. The new information should be added to the data bank discussed in Step 1. The updated information should then be used to compute the Average Visual Utility of the pavement at the time of analysis. Relations for this computation were presented in the preceding chapter.

(3) Calculation of Ride Quality Utility (RQU)

As with the visual condition survey, appropriate data on the ride quality of the pavement should be collected by taking roughness measurements using the procedures and reporting techniques established in Refs 4 and 5. These data should be added to the appropriate section of the data bank as discussed in Step 1. Utility accountable to ride quality for the pavement under consideration should then be calculated from this latest roughness data, which would be in the form of Serviceability Index (SI)(Refs 4 and 5) values. The relations for this calculation,which were obtained from Ref 24, are summarized in Table 7.1 and Fig 7.1 for different traffic loads and different pavement types.

(4) Calculation of Skid Resistance Utility (SRU)

As for the Ride Quality Utility, Skid Resistance Utility should be calculated after appropriate information (in terms of Skid Numbers) (Ref 23) has been collected and added to the data bank. The relations summarized in Table 7.2 and Fig 7.2 should be used with the appropriate traffic load and pavement type.

Use of RPES: Alternative Procedures for Making Rehabilitation Decisions

(1) Simplified Maintenance Approach

This simplified approach was developed at the CFHR in October 1979 (Ref 25) as a procedure for allowing rapid, rational decision-making, with regard to the most suitable choice of maintenance (or rehabilitation) activity for any given CRCP in Texas. It should be noted that the total pavement score concept, which was discussed at the beginning of this chapter, is not

TABLE 7.1. RIDE QUALITY RELATIONS FOR COMPOSITE PAVEMENTS (REF 24)

CURVE	UTILITY RELATION	INFERENCE SPACE
A	$\text{Utility} = 1.0$	$2.5 \le SI \le 5.0$
	$\text{Utility} = 1.0 - 0.10\left(\frac{2.5-SI}{0.5}\right)^2$	$2.0 \le SI \le 2.5$
	$\text{Utility} = -0.2666 + 0.58333SI$	$0.8 \le SI \le 2.0$
	$\text{Utility} = 0.20\left(\frac{SI}{0.8}\right)^2$	$0 \le SI \le 0.8$
B	$\text{Utility} = 1.0$	$3.0 \le SI \le 5.0$
	$\text{Utility} = 1.0 - 0.10\left(\frac{3.0-SI}{0.5}\right)^2$	$2.5 \le SI \le 3.0$
	$\text{Utility} = -0.5583 + 0.58333SI$	$1.3 \le SI \le 2.5$
	$\text{Utility} = 0.20\left(\frac{SI}{1.3}\right)^2$	$0 \le SI \le 1.3$
C	$\text{Utility} = 1.0$	$3.5 \le SI \le 5.0$
	$\text{Utility} = 1.0 - 0.10\left(\frac{3.5-SI}{0.5}\right)^2$	$3.0 \le SI \le 3.5$
	$\text{Utility} = -0.85 + 0.58333SI$	$1.8 \le SI \le 3.0$
	$\text{Utility} = 0.20\left(\frac{SI}{1.80}\right)^2$	$0 \le SI \le 1.8$

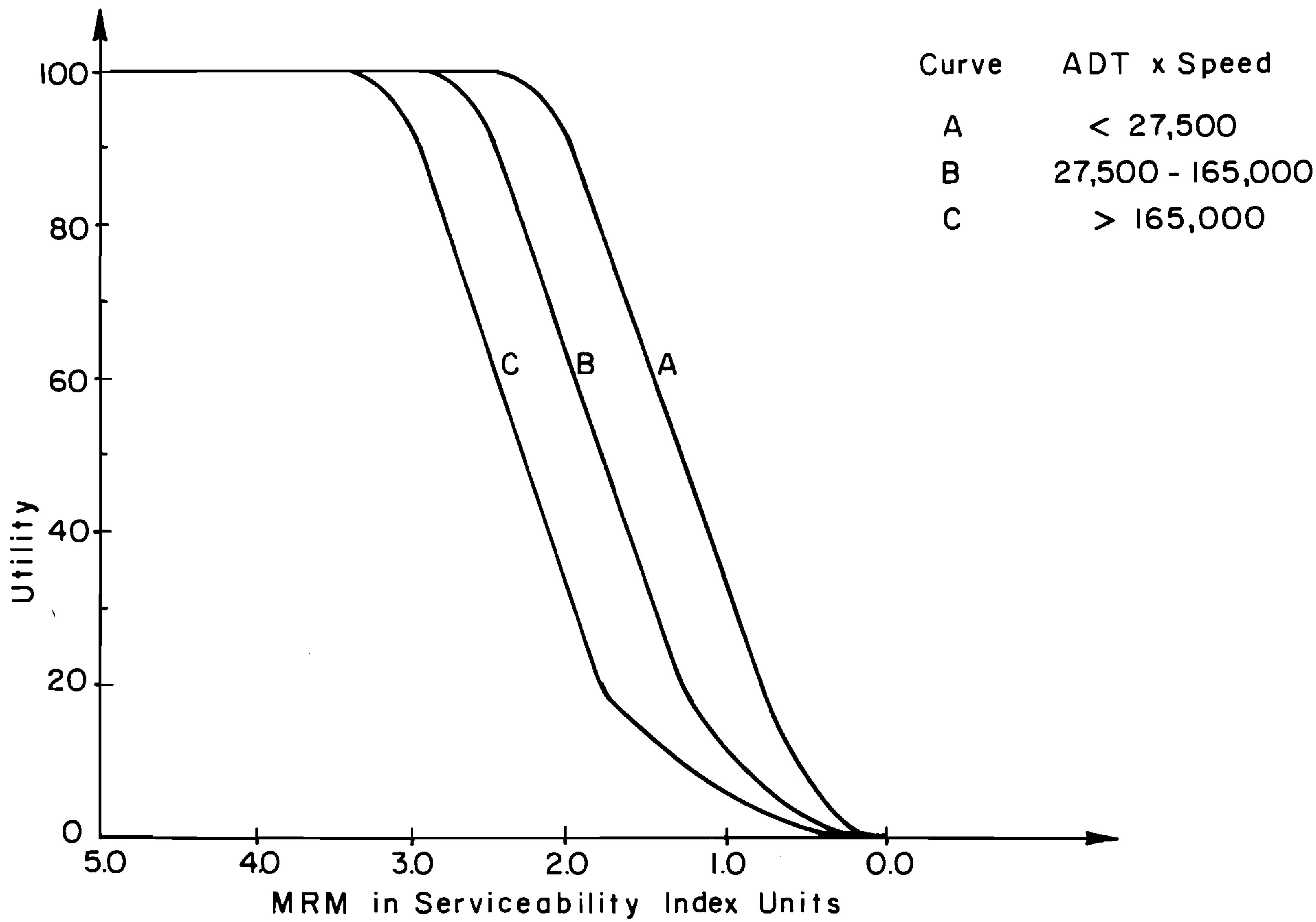


Fig 7.1. Ride quality utility relations for composite pavements (Ref 24).

TABLE 7.2. SKID RESISTANCE UTILITY RELATIONS FOR COMPOSITE PAVEMENTS (REF 24)

CURVE	UTILITY RELATION	INFERENCE SPACE
A	Utility = 1.0	$50 \leq SN \leq 75$
	Utility = $1.0 - 0.20\left(50-SN\right)^2$	$39 \leq SN \leq 50$
	Utility = $-1.4286 + 0.05714SN$	$2.85 \leq SN \leq 39$
	Utility = $0.20\left(\frac{SN-0}{28.5}\right)^2$	$0 \leq SN < 28.5$
B	Utility = 1.0	$50 \leq SN \leq 75$
	Utility = $1.0 - 0.20\left(\frac{50-SN}{17.5}\right)^2$	$32.5 \leq SN \leq 50$
	Utility = $-1.05714 + 0.05714SN$	$22 \leq SN \leq 32.5$
	Utility = $0.20\left(\frac{SN}{22}\right)^2$	$0 \leq SN \leq 22$
C	Utility = 1.0	$50 \leq SN \leq 75$
	Utility = $1.0 - 0.20\left(\frac{50-SN}{22.5}\right)^2$	$27.5 \leq SN \leq 50$
	Utility = $-0.7714 + 0.05714SN$	$17 \leq SN \leq 27.5$
	Utility = $0.20\left(\frac{SN}{17}\right)^2$	$0 \leq SN \leq 17$

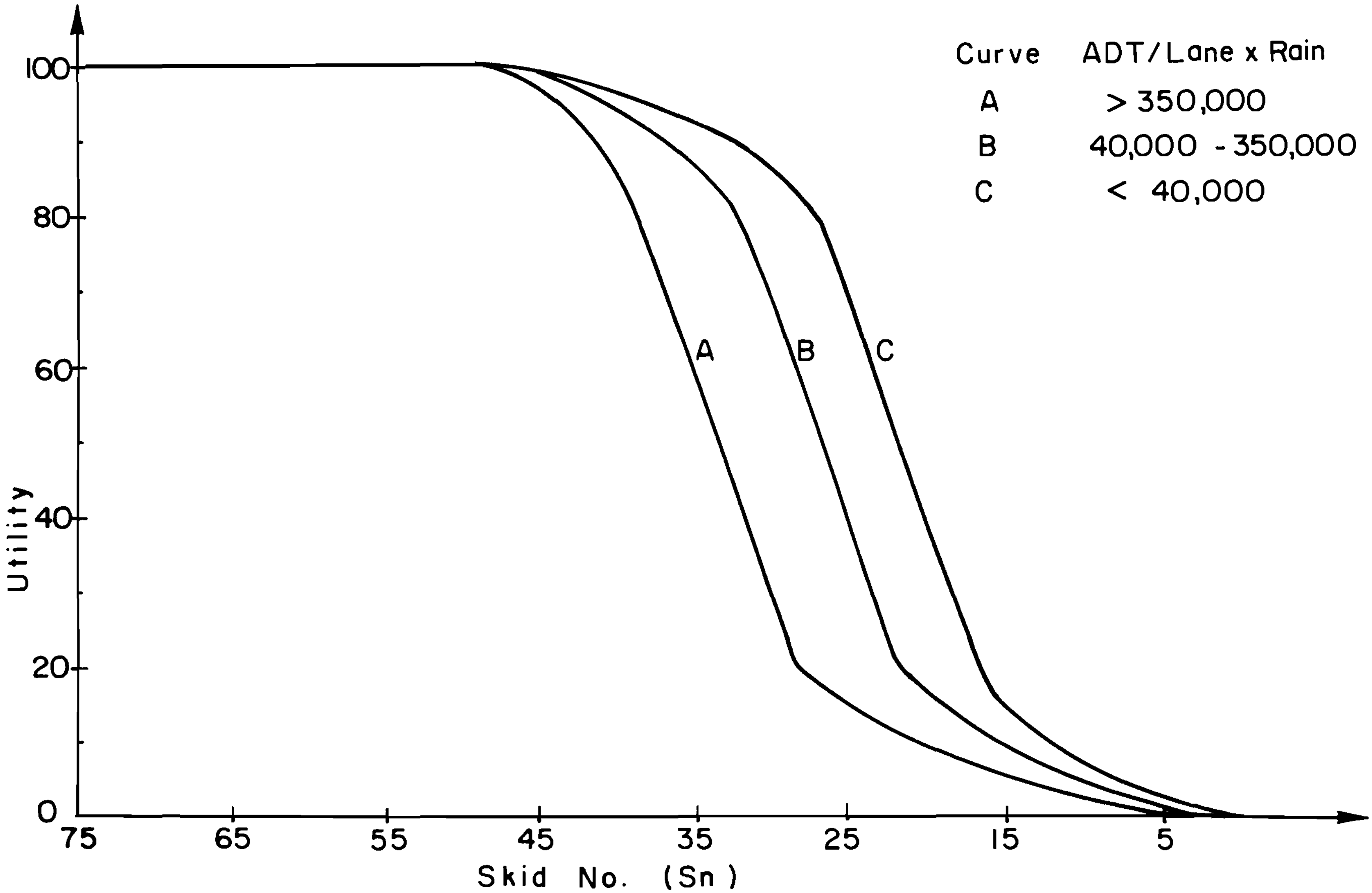


Fig 7.2. Skid resistance utility relations for composite pavements (Ref 24).

utilized here nor is the variation in distress after rehabilitation. Rather, the level of rehabilitation activity to be chosen is a function of the distress utilities at the time of analysis only (AVU, RQU, SRU). The functional classification utility of the pavement is not treated here, nor is the effect of the cost of each rehabilitation activity on the decision. However, some typical costs (1979 dollars) for the most important rehabilitation activities have been included here (Tables 7.3 and 7.4. If a more comprehensive decision analysis allowing for the effect of time is required, alternative procedures (b) should be considered. However, if a rapid analysis is needed, this simplified approach, as summarized in Fig 7.3, could be used.

Figure 7.3 is a flow chart of the maintenance approach suggested. The inputs required are the current utilities of the pavement related to distress, skid and riding quality, and limiting values for these utilities. In the flow chart, z has been used, rather than the corresponding utility. This z is a distress weighting function defined before (Refs 3 and 21). The outputs in Fig 7.3 are the alternative maintenance approaches, i.e., thick overlay, 2-inch overlay, roto-mill surface, and maintenance.

For a given pavement, it is necessary to define the inputs and decide which strategy to follow. If the z value is less than the chosen limiting value, the rehabilitation using a thick overlay is recommended. If z is larger, then the riding quality has to be checked. If the riding quality does not satisfy the limit imposed, a 2-inch overlay is recommended. If it is above the limit, the skid resistance has to be checked. The maintenance strategy proposed in the case where the skid resistance is below the limit, is to roto-mill the surface. If the skid resistance complies with the requirements, then only minor rehabilitation is required.

Once the type of maintenance has been defined, the cost can be determined:

(a) Thick overlay cost.

First, the thickness of the overlay has to be defined. Table 7.3 gives some indication of thicknesses depending on the type of soil and the average daily traffic expected.

Once an overlay thickness has been chosen, the cost per mile is selected from Table 7.4. The costs in this table were defined assuming that asphalt concrete has a cost of $30 per ton and a unit weight of 135 pounds per cubic foot; the overlay was assumed to be 30 feet wide including the shoulders for a typical 2-lane highway.

(b) Two-inch overlay cost.

The cost can be obtained from Table 7.4.

(c) Cost of roto-milling surface.

TABLE 7.3. AC OVERLAY THICKNESS BY SUBGRADE TYPE (REF 25)

Subgrade Type	Thickness of Overlay (inches)	
	<10,000 VPD* Traffic	>10,000 VPD* Traffic
Clay	7	8
Granular	5	6

*Vehicles per day

TABLE 7.4. COST PER MILE OF AC OVERLAYS (REF 25)

Thickness (inches)	Cost per mile (dollars)
2	61 000
3	91 000
4	121 000
5	152 000
6	182 000
7	212 000
8	242 000

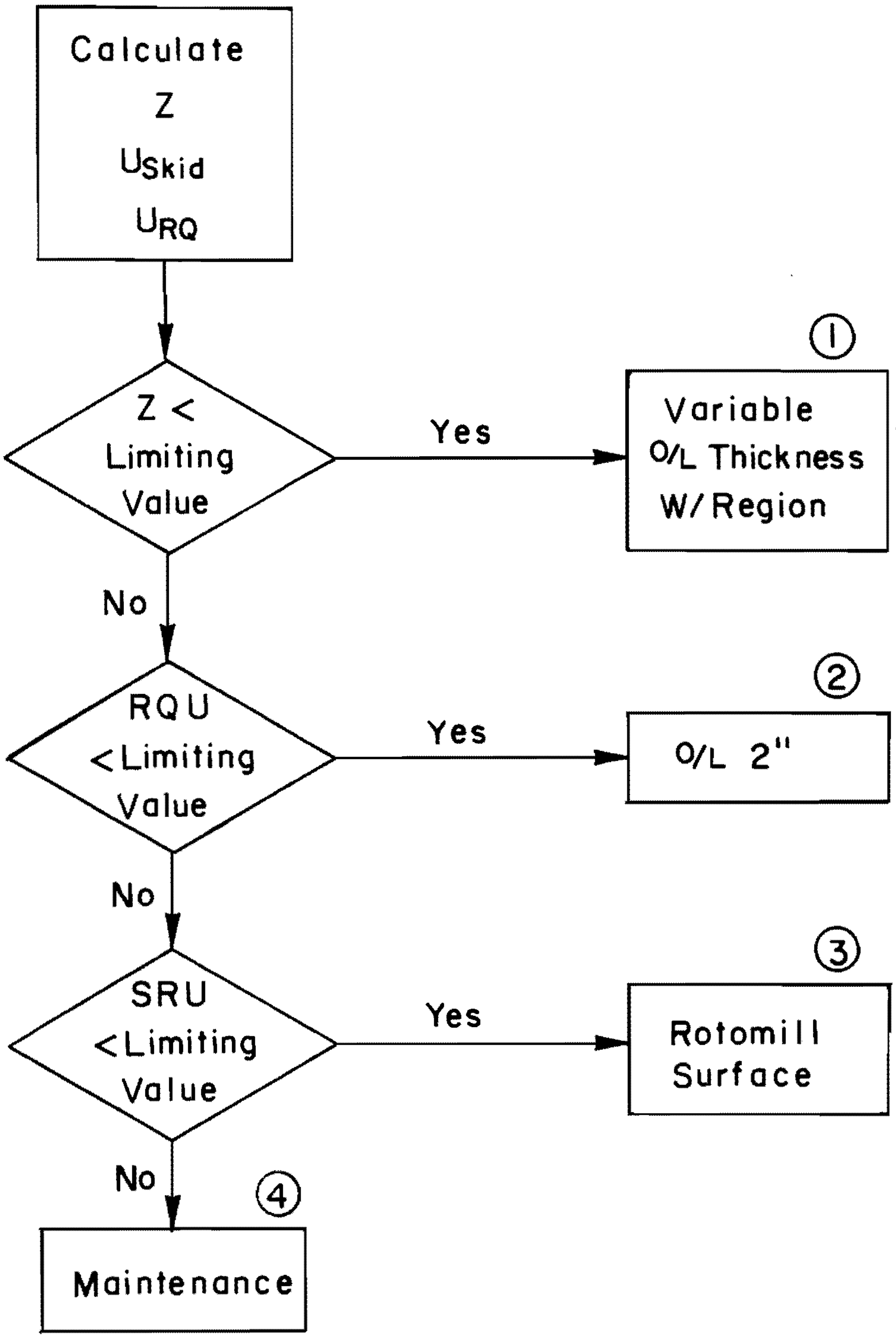


Fig 7.3. Simplified maintenance approach for CRCP rehabilitation decision making (Ref 25).

The cost of roto-milling was assumed to be $10,000 per mile. More details of the analysis can be found in Ref 26.

(d) Minor rehabilitation cost.

The following equation was derived in order to define an approximate cost of repairing punchouts and severe spalling:

cost per mile = ($1000 x punchouts per mile)
+ ($2 x 0.5 x number of severely spalled cracks per mile).

In this equation, a cost of $1000 per punchout and $2 per spalled crack was used. The factor of 0.5 in the above equation is used to estimate the number of spalled cracks to be repaired in one year relative to the total number of spalled cracks.

It should be remembered that the cost figures used here are approximate only and should be used for prefeasibility or feasibility estimates only. Detailed cost calculations should be made using appropriate local costs.

(2) Maximum Average Pavement Score Approach

This procedure allows the pavement designer to select a rehabilitation strategy which maximizes average total utility over the remaining life of the rehabilitated pavement as measured by the "pavement score" (PS) function which was described earlier. For this procedure, pavement score at any age would be defined as the product of visual, ride quality and skid resistance utilities of the pavement at that time. "Functional Classification" and "Maintenance (rehabilitation) Utility Cost" have not yet been included in this procedure owing to a lack of data. However, it would be a simple matter to include them in the pavement score function in the same manner as the visual utilities (product). This could be done once suitable ratings of the functional value of each pavement to the community and the relative costs of maintenance activities have been established.

Hence

$$PS = AVU \times RQU \times SRU$$

where all terms are as defined previously. The designer would thus take the following approach in order to arrive at a decision on rehabilitation for any given pavement. First, the previously mentioned data bank should be used to obtain appropriate CRCP distress utilities and properties. Then, using the distress prediction models described in Chapter 5 of this report, the average visual utility of the pavement should be calculated for a series of times in the future up to the end of the design life of the pavement, assuming the rehabilitation utility under consideration. This should be done on an annual basis and repeated for RQU and SRU using appropriate relations. In this manner an estimate of the variation in the PS over the anticipated life of the pavement can be made. Then, the average PS for the pavement and rehabilitation activity under consideration can be estimated graphically, or by summation, since

$$\text{Average PS} = \frac{1}{T} \int_{0}^{T} PS\,dt$$

where T is the life of the pavement in years and t is time in years, or

$$\begin{array}{l}\text{Average PS} \\ \text{over T years}\end{array} = \frac{1}{T} \sum_{t=1}^{T} PS\,\Delta t$$

where Δt is the time increment between estimates of PS.

Then, in order to choose between rehabilitation alternatives, this analysis would have to be performed for each alternative and the selection made on the basis of maximum average pavement score. An external weighting by functional classification or cost of activity could be performed at this stage if desired, and consideration should also be given to availability of funds.

A more complete analysis could be obtained by considering the network of all CRCP sections in the State at one time and the effect of any single rehabilitation on the entire network. Such an analysis would require more sophisticated models than are at present available. Preliminary concepts relevant to this end have been documented in Ref 27. Once this is done, the distribution of funds could be made on a completely rational basis using Decision Analysis techniques (Ref 28).

Summary

Guidelines for establishing a comprehensive rigid pavement rehabilitation evaluation and decision system have been outlined. Rational simplified techniques for using such a system have been established and described here. It is hoped that these simplified techniques will be implemented by the Texas SDHPT as soon as possible, and future research will accomplish the completion and establishment of the comprehensive system in the near future.

CHAPTER 8. CONCLUSIONS

Based on this study, the following observations were made:

(1) CRCP condition survey measurements obtained in 1974 and 1978 were sufficiently reliable for the purposes of the investigation concerning a large set of Texas pavements.

(2) Significant changes in distress occurred between 1974 and 1978 for the Texas CRC pavements under consideration in this analysis.

(3) Directional distribution estimates according to lane for traffic on the above mentioned pavements have been established.

(4) The relative importance of a large number of environmental, construction, load, and distress measurement variables with regard to their effect on visual distress has been established.

(5) Regression models have been developed for the prediction of distress in CRCP throughout Texas, in terms of these variables.

(6) Guidelines have been presented for the establishment of a rigid pavement evaluation system for the use in decision making concerning the allocation of funds for the purposes of rehabilitation of CRCP in Texas.

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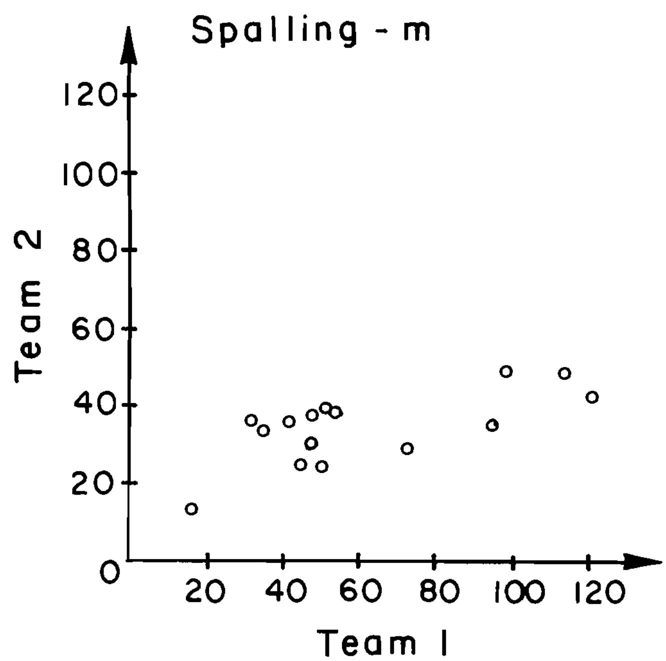
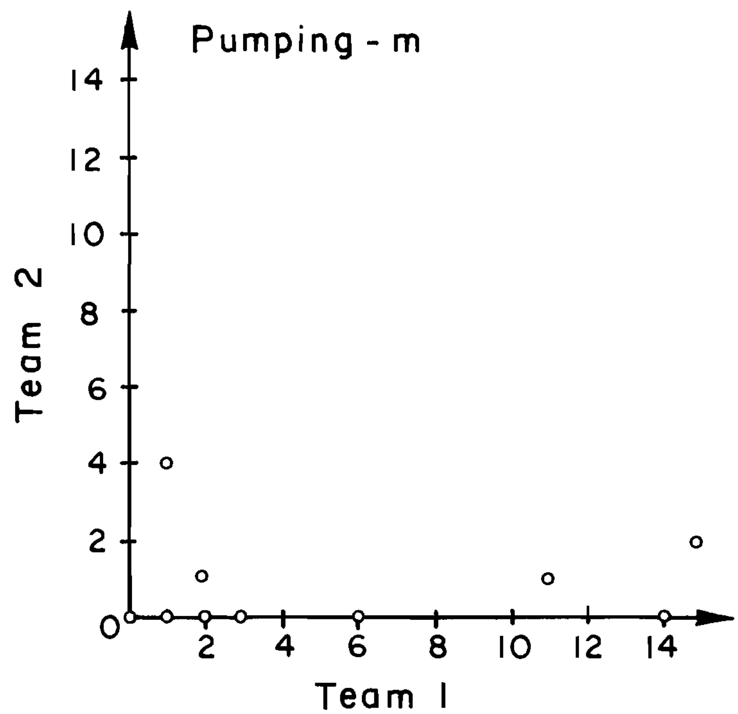
APPENDIX A

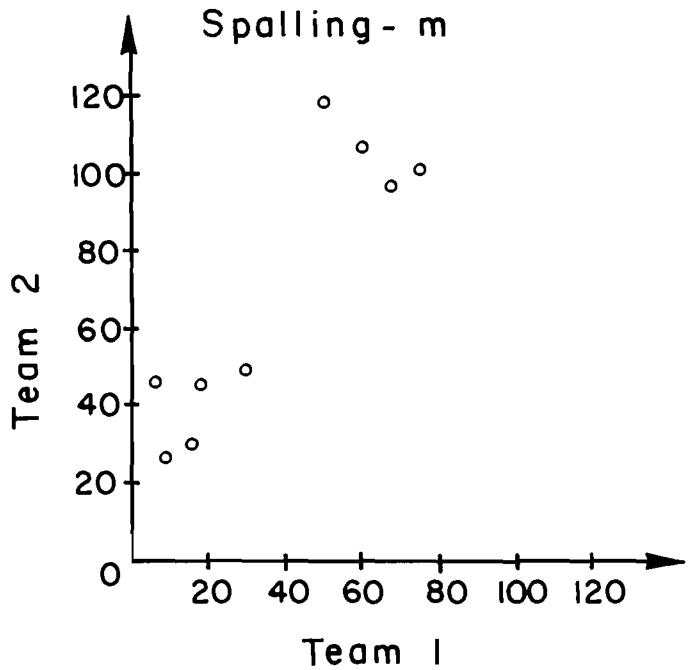
GRAPHICAL COMPARISON OF RESULTS OF CRCP CONDITION SURVEY REPLICATION





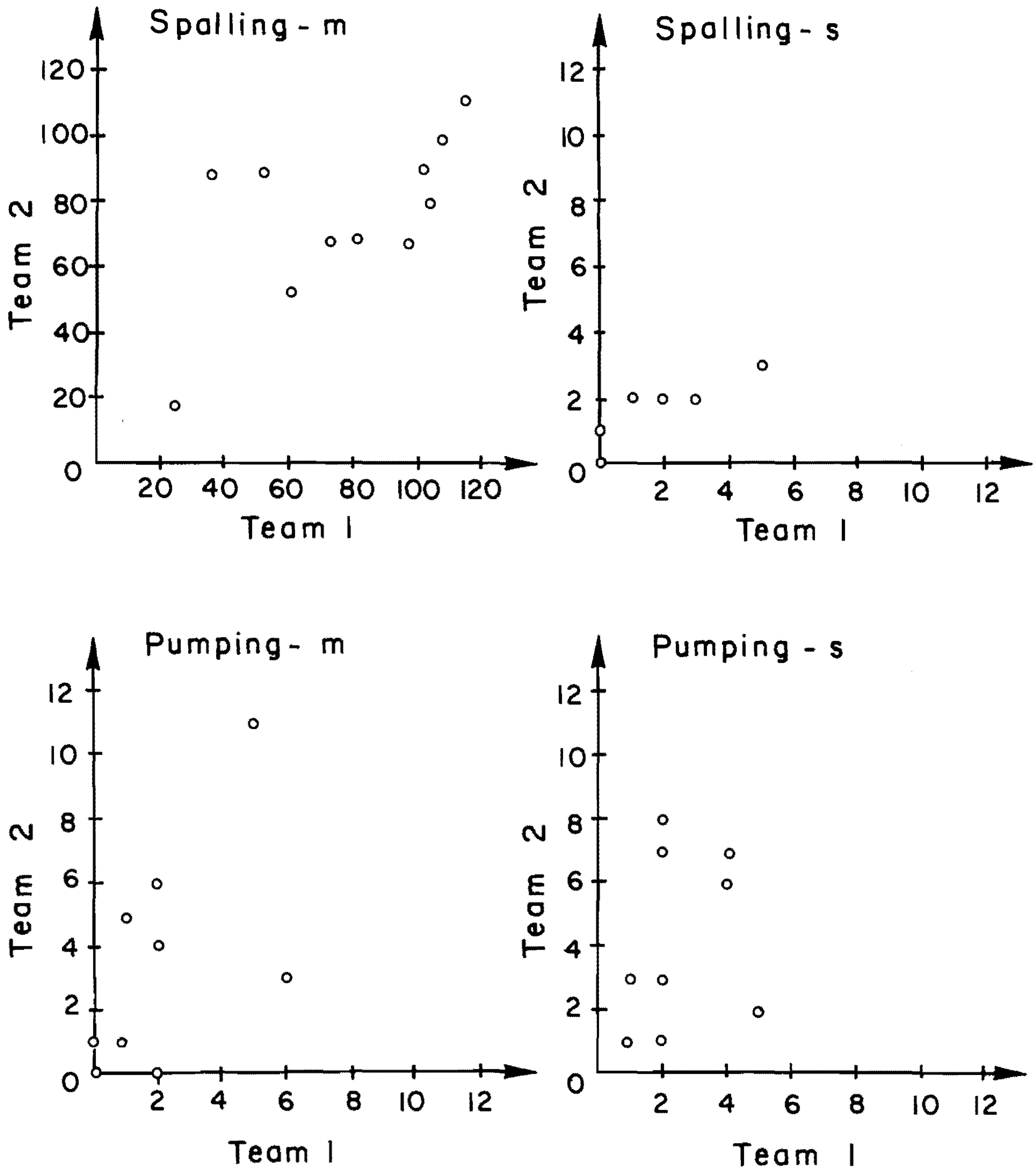
Note: M - minor, S - severe.

Fig A.1. Condition survey replication for District 3.



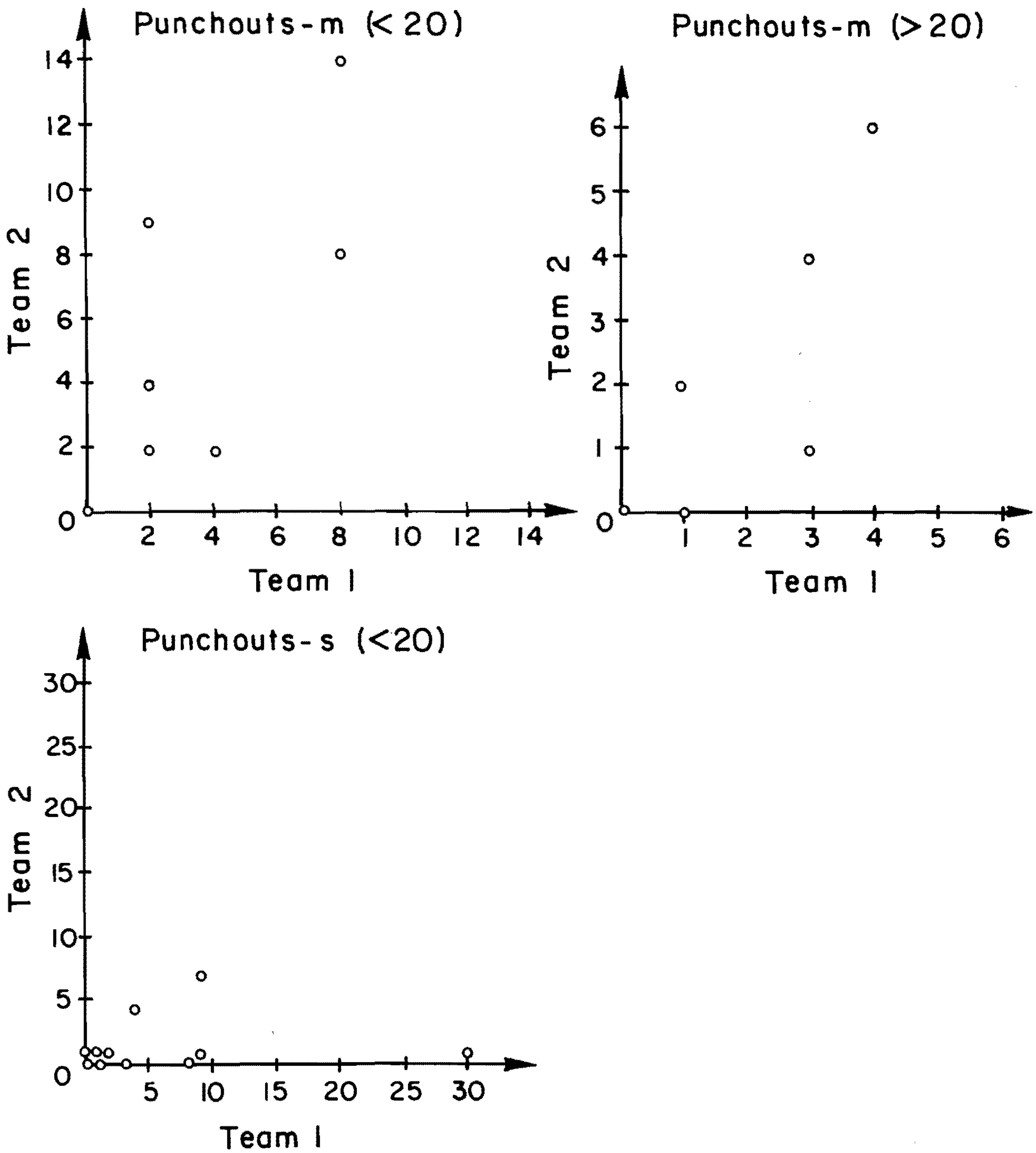
Note: M - minor, S - severe.

Fig A.2. Condition survey replication for District 4.



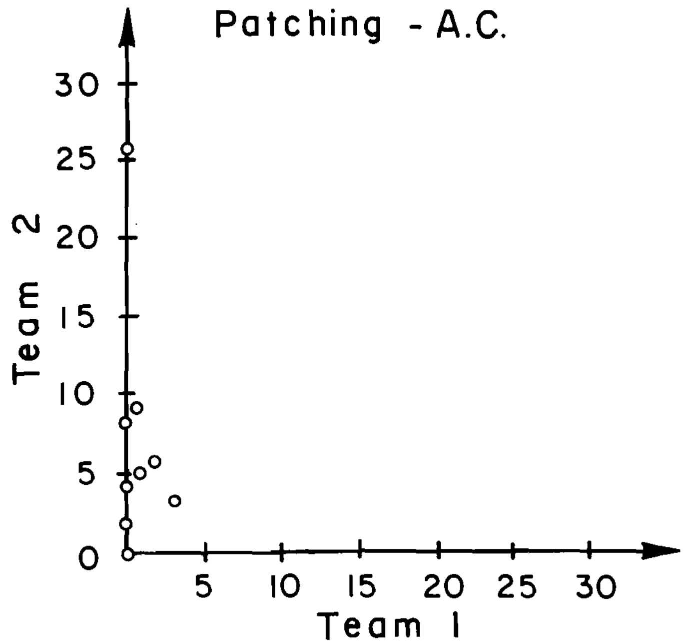
Note: M - minor, S - severe.

Fig A.3. Condition survey replication for District 10.



Note: M - minor, S - severe.

Fig A.3. Condition survey replication for District 10 (continued).



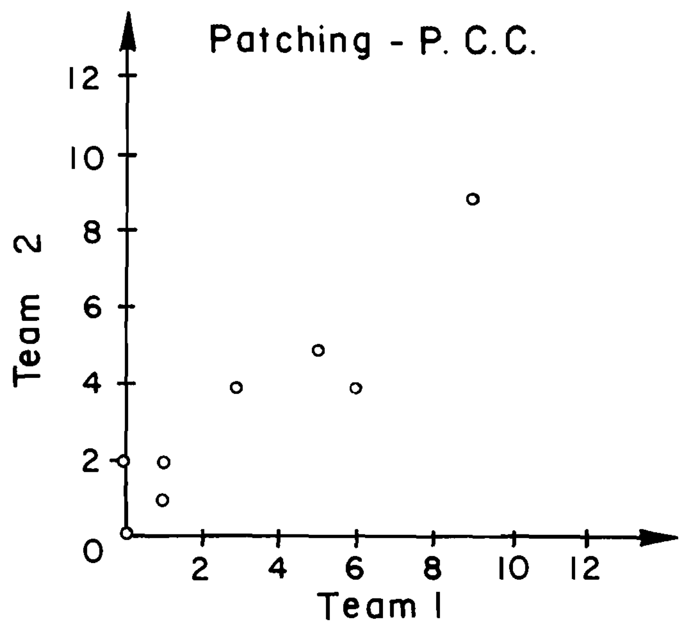
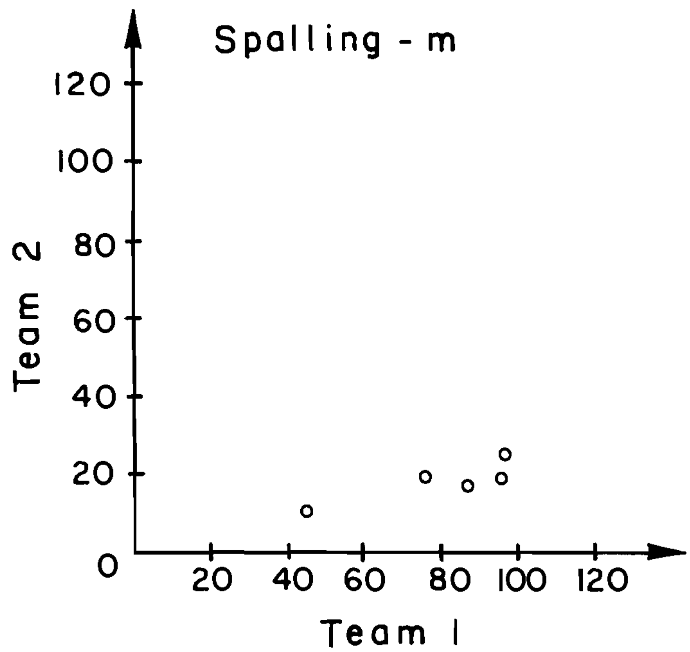
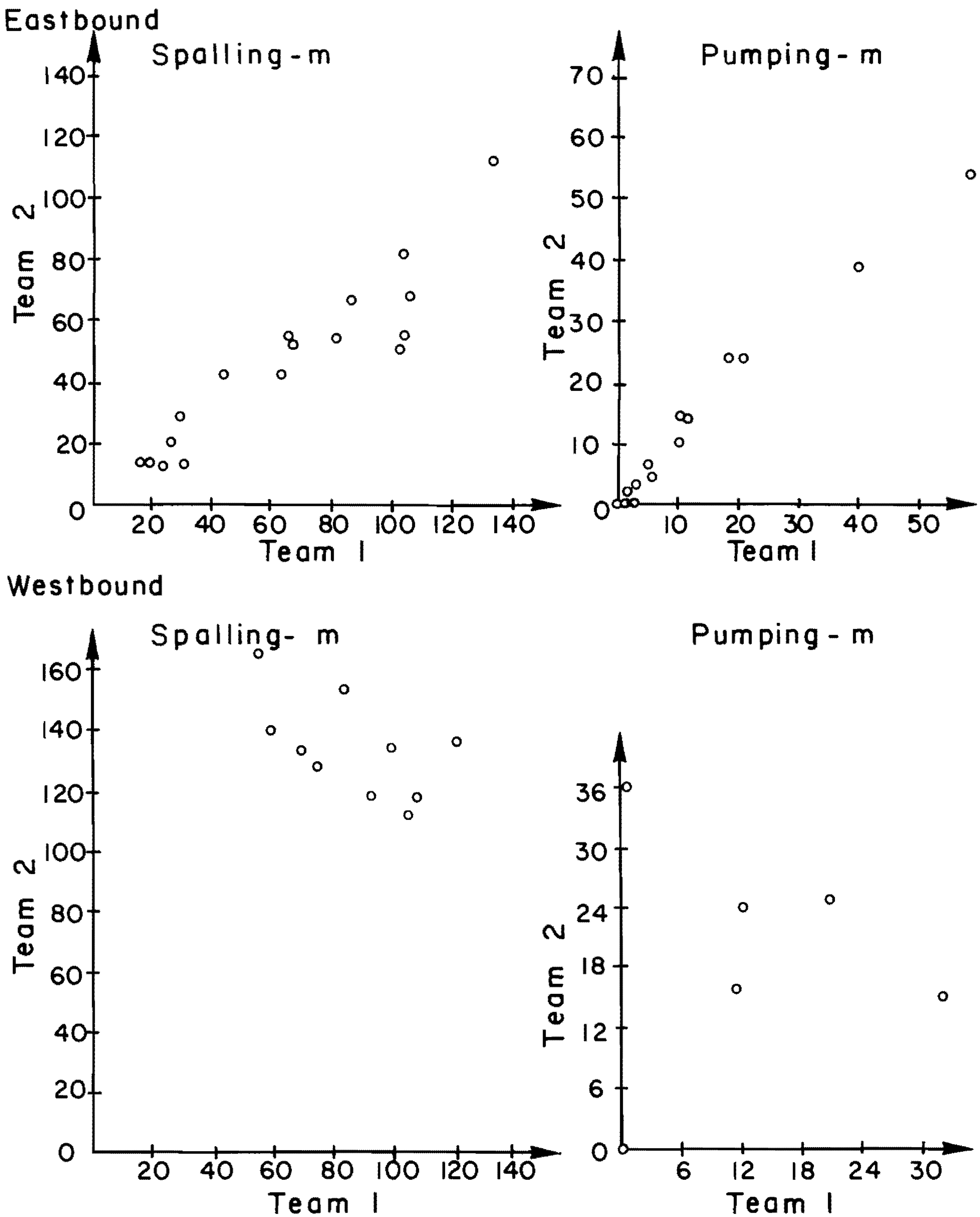


Fig A.3. Consition survey replication for District 10 (continued).



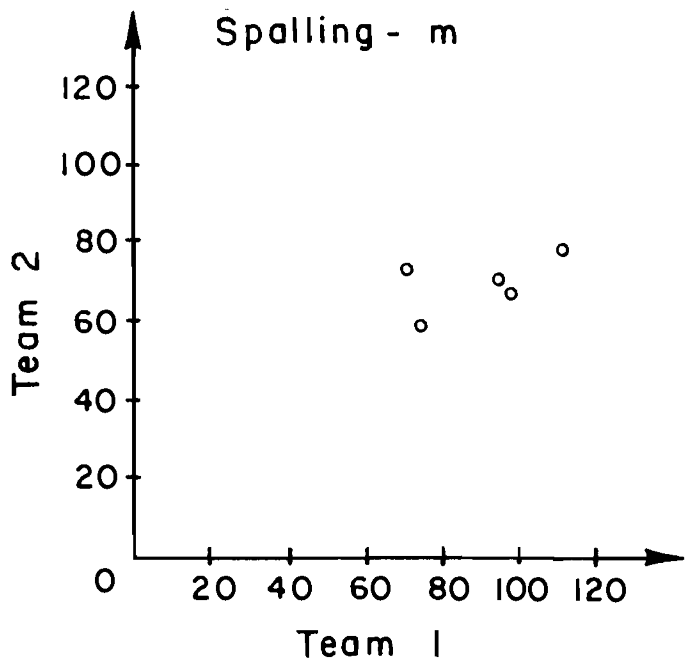
Note: M - minor, S - severe.

Fig A.4. Condition survey replication for District 19.



Note: M - minor, S - severe.

Fig A.5. Condition survey replication for District 24.



Note: M - minor, S - severe.

Fig A.6. Condition survey replication for District 25.

APPENDIX B

SUMMARY OF DATA ON HISTORY, LOCATION AND SIZE OF REPAIRS ALONG CRCP HIGHWAY SECTIONS IN DISTRICT 1

TABLE B.1. PATCH HISTORY, LOCATION AND SIZE IN DISTRICT 1-
DATA SUMMARY FROM TEXAS SDHPT MAINTENANCE RECORDS

Highway	CFTR Project Number	Location of Patch (Mile Post Limits)	Date Patched	Age of Pavement at Patching (months)	Area of Patch (ft^2)
US75-North Bound Lane	108	30.9-29.9	4.9.75	92	4
			4.4.75	92	6
	108	29.9-28.9	11.22.74	64	6
			11.12.75	97	4.2
			4.11.75	92	7.5
	108	28.9-27.9	4.11.75	92	6.0
	108	27.9-26.4	2.4.72	66	10.0
			11.12.75	99	8.0
			12.13.74	80	15.0
	108	25.7-24.7	2.4.72	54	22.5
	108	24.7-23.7	11.13.75	99	3.0
US75-South Bound Lane	108	22.1-22.3	10.27.70	38	20.0
			2.20.73	66	4.0
	108	24.3-25.3	1.23.74	77	24.0
	108	26.3-27.3	6.11.75	93	40.0
			2.20.73	66	6.0
			2.8.72	54	4.0
	108	27.3-28.3	2.20.73	66	5.0
			2.8.72	54	4.0
			4.8.75	91	16.5
			1.5.76	103	7.5
	108	28.3-29.3	11.9.77	123	8.0
			4.4.75	91	10.0
			11.1.76	101	25.0
			8.25.75	95	36.0
	108	29.3-30.3	1.5.76	99	28.0
			2.20.73	66	38.0
			11.22.72	52	12.0
			12.14.77	123	9.0
			2.7.72	55	8.0
			4.6.76	103	25.0
			4.14.75	92	6.0
			9.19.75	97	12.0
	108	30.3-31.3	1.22.74	77	8.0
			11.19.73	75	7.5
	108	31.3-31.7	11.19.73	75	13.3

Continued

TABLE B.1. PATCH HISTORY, LOCATION AND SIZE IN DISTRICT 1 - DATA SUMMARY FROM TEXAS SDHPT MAINTENANCE RECORDS

(Continued)

Highway	CTR Project Number	Location of Patch (Mile Post Limits)	Date Patched	Age of Pavement at Patching (months)	Area of Patch (ft^2)
IH30-West Bound Lane	105	150.0-149.0	11.6.69	48	7.5
	105		10.4.72	83	9.0
	105		10.4.72	83	20.0
	105	149.0-148.0	3.15.73	98	21.0
	105		4.15.74	101	10.0
	105		4.27.74	101	28.0
	105		9.30.74	106	5.5
	104	145.8-144.8	12.9.74	108	4.5
	103	141.4-140.4	9.4.73	97	15.0
	103	138.4-137.4	2.12.69	41	10.0
	103	137.4-136.4	11.14.69	40	48.0
	103	136.4-136.2	11.14.71	64	20.0
	101	134.4-133.4	11.25.68	54	1.0
IH30-East Bound Lane	101	128.4-129.4	10.22.71	87	1.0
	101	130.4-131.4	2.1.71	69	4.0
	101	131.4-132.4	3.9.70	56	12.0
	101	132.4-133.4	3.4.70	56	42.0
	101		3.10.70	56	12.0
	102	133.4-134.6	12.6.71	78	15.0
	102	134.6-135.6	3.6.70	70	20.0
	103	135.6-136.4	3.19.70	70	8.0
	103	136.4-137.4	11.27.72	87	30.0
	104	146.6-147.6	12.27.73	99	10.0
	104		5.28.69	45	24.0
	105	148.0-149.0	6.22.73	93	6.8

TABLE B.2. PATCH LOCATION AND SIZE IN DISTRICT 1 - DATA SUMMARY FROM DETAILED INSPECTION BY CTR PERSONNEL, MAY 1979

Highway: U.S. 75 South Bound Lane, CTR Project No. 108.

Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)
22.08	0.5	27.59	18.0	29.43	30.0
22.08	3.0	27.64	12.0	29.44	5.0
22.09	20.0	27.71	10.0	29.50	30.0
22.30	5.0	27.78	10.0	29.51	16.0
23.00	1.0	27.80	4.0	29.55	108.0
23.32	1.0	27.85	8.0	29.56	108.0
23.41	20.0	28.18	30.0	29.57	98.0
24.63	12.0	28.30	24.0	29.58	8.0
25.28	2.0	28.58	16.0	29.59	2.0
26.00	4.0	28.90	4.0	29.60	40.0
26.24	12.0	28.91	9.0	29.61	4.0
26.36	5 patches	28.95	36.0	29.69	116.0
26.39	40.0	28.97	16.5	30.30	36.0
26.88	6.0	29.99	30.0	30.35	42.0
27.00	4.0	29.00	8.0	30.46	10.0
27.20	20.0	29.09	30.0	30.99	12.0
27.38	1.0	29.12	15.0	31.35	36.0
27.50	12.0	29.20	9.0	31.35	4.0
27.55	18.0	29.29	42.0	57 Patches $\geq$ 1.0 ft^2	
27.58	2.0	29.36	18.0		

Highway: U.S. 75 North Bound Lane, CFTR Project No. 108.

Information on patch size was not recorded for the north bound lane, however, a count was performed resulting in a total of 22 patches $\geq$1.0 ft^2 being observed at this date.

TABLE B.2. PATCH LOCATION AND SIZE IN DISTRICT 1 - DATA SUMMARY FROM DETAILED INSPECTION BY CFTR PERSONNEL, MAY 1979

Highway: IH30 East Bound Lane, CFTR Project Nos. 101 to 105.

Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)
128.79-	6.0	131.82	24.0	133.58 to 133.63	Overlay
128.95 to 129.01	Overlay	132.02	<1.0	133.65 to 133.83	Overlay
129.12	24.0	132.10	1.0	133.84	4.0
129.22	18.0	132.14	9.0	133.84	24.0
129.28	9.0	132.18	200.0	134.85	6.0
129.30	42.0	132.30 to 132.40	Overlay	134.95	12.0
129.31	36.0	132.59	48.0	134.96	24.0
129.39	18.0	132.60	30.0	134.96	4.0
129.90	1.0	132.61	6.0	135.02	4.0
130.01	1.0	132.69	2.0	135.05	18.0
130.05	0.3	132.74 to 132.80	Overlay	135.29 to 135.31	Overlay
130.15	2.0	132.87 to 132.92	Overlay	135.60	<1.0
130.51	1.0	133.09	24.0	135.64	48.0
130.51	4.0	133.10	4.0	135.66	24.0
130.63	25.0	133.10	8.0	135.88	1.0
130.81	<1.0	133.12	3.0	135.89	18.0
130.83 to 131.01	Overlay	133.12	10.0	135.91	24.0
131.25	9.0	133.15	25.0	135.99	1.0
131.69	<1.0	133.21	4.0	136.05	30.0
131.79	6.0	133.55	15.0	136.19	16.0
131.80	36.0			136.25	36.0
131.81	8.0			136.49	18.0

TABLE B.2. PATCH LOCATION AND SIZE IN DISTRICT 1 - DATA SUMMARY FROM DETAILED INSPECTION BY CTR PERSONNEL, MAY 1979

Highway: IH30 East Bound Lane, CTR Project Nos. 101 to 105.

Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)
128.79-	6.0	132.59	48.0	135.64	48.0
128.95 to 129.01	Overlay	132.60	30.0	135.66	24.0
129.12	24.0	132.61	6.0	135.88	1.0
129.22	18.0	132.69	2.0	135.89	18.0
129.28	9.0	132.74 to 132.80	Overlay	135.91	24.0
129.30	42.0	132.87 to 132.92	Overlay	135.99	1.0
129.31	36.0	133.09	24.0	136.05	30.0
129.39	18.0	133.10	4.0	136.19	16.0
129.90	1.0	133.10	8.0	136.25	36.0
130.01	1.0	133.12	3.0	136.49	18.0
130.05	0.3	133.12	10.0	136.75 to 136.83	Overlay
130.15	2.0	133.15	25.0	136.90 to 137.07	Overlay
130.51	1.0	133.21	4.0	137.09 to 137.26	Overlay
130.51	4.0	133.55	15.0	137.68	<1.0
130.63	25.0	133.58 to 133.63	Overlay	137.90	4.0
130.81	<1.0	133.65 to 133.83	Overlay	138.01 to 138.09	Overlay
130.83 to 131.01	Overlay	133.84	4.0	138.11 to 138.15	Overlay
131.25	9.0	133.84	24.0	138.17	<1.0
131.69	<1.0	134.85	6.0	138.17	<1.0
131.79	6.0	134.95	12.0	138.37 to 138.46	Overlay
131.80	36.0	134.96	24.0	138.58 to 138.68	Overlay
131.81	8.0	134.96	4.0	133.79	2.0
131.82	24.0	135.02	4.0	139.26 to 139.47	Overlay
132.02	<1.0	135.05	18.0	139.61	30.0
132.10	1.0	135.29 to 135.31	Overlay		
132.14	9.0	135.60	<1.0		
132.18	200.0				
132.30 to 132.40	Overlay				

Continued

TABLE B.2. PATCH LOCATION AND SIZE IN DISTRICT 1 - DATA SUMMARY FROM DETAILED INSPECTION BY CTR PERSONNEL, MAY 1979

Highway: IH30 East Bound Lane, CTR Project Nos. 101 to 105.

Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)	Location of Patch (mile post)	Size of Patch (ft^2)
139.64	9.0	147.62	6.0		
139.65	30.0	147.62	1.0		
139.72	0.5	147.99	4.0		
140.20	<1.0	147.99	4.0		
140.50	<1.0	148.01	180.0		
141.25 to 141.35	Overlay	148.15	12.0		
141.38 to 141.50	Overlay	148.45	6.0		
141.51 to 141.60	Overlay	148.65	12.0		
141.62 to 141.68	Overlay	149.49	20.0		
142.23	<1.0	149.51	20.0		
142.35	9.0	149.53	6.0		
142.42	9.0	150.10	12.0		
142.56	15.0	150.29	1.0		
142.81 to 143.02	Overlay	150.55	300.0		
143.85	20.0	151.30	4.0		
145.82	1.0	151.45	450.0		
146.25	4.0	152.30	18.0		
147.21	12.0	152.75	<1.0		
147.25	12.0				
147.32	30.0				
147.56	1.0				
147.59	<1.0				
147.62	4.0				

84 patches ≥ 1.0 ft^2

TABLE B.2. PATCH LOCATION AND SIZE IN DISTRICT 1 - DATA SUMMARY FROM DETAILED INSPECTION BY CTR PERSONNEL, MAY 1979

Highway: IH30 West Bound Lane, CTR Project Nos. 101 to 105.

Location of Patch (mile post)	Size of Patch (ft^2)
152.85	60.0
	66.0
	16.0
152.75	120.0
151.15	<1.0
	<1.0
150.85	12.0
150.45	1.0
150.33	10.0
150.05	8.0
149.94	24.0
149.85	48.0
149.60	24.0
145.45	10.0
145.35	15.0
145.34	12.0
145.33	2.0
	2.0
149.25	12.0
149.16	8.0
149.15	5.0
149.14	<1.0
149.13	4.0
	9.0
	30.0
148.65	<1.0
148.35	8.0
148.07	12.0
147.63	2.0
147.00	20.0
146.85	6.0
146.60	<1.0

Location of Patch (mile post)	Size of Patch (ft^2)
145.54	<1.0
145.09	4.0
145.08	12.0
144.60	20.0
143.26	2.3
143.26	2.3
143.26	2.3
143.12 to 143.05	Overlay
143.04 to 142.85	Overlay
142.30	8.0
142.22	60.0
142.06	84.0
141.96	25.0
141.85	9.0
	<1.0
	<1.0
	2.3
141.75	12.0
141.66 to 141.34	Overlay
141.39 to 141.16	Overlay
140.66 to 141.56	Overlay
140.27	18.0
139.50 to 139.42	Overlay
139.39 to 139.25	Overlay

Location of Patch (mile post)	Size of Patch (ft^2)
139.13	48.0
138.97	45.0
138.65	6.0
138.63 to 138.56	Overlay
138.54 to 138.36	Overlay
138.27	6.0
138.25 to 138.15	Overlay
138.03	6.0
137.82	4.0
137.25	54.0
137.16 to 137.05	Overlay
137.07 to 136.91	Overlay
136.76	20.0
136.67 to 136.61	Overlay
136.33	6.0
136.32	6.0
136.27	22.0
136.25 to 136.19	Overlay
136.18	4.0
136.04	8.0
136.03	20.0
136.02	12.0
135.96	15.0
135.94	6.0

Continued

APPENDIX C

RESULTS OF CRCP DIRECTIONAL TRAFFIC DISTRIBUTION ANALYSIS

TABLE C.1. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 4

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T: Traffic Applications in Millions

F: Failures Per Mile

i = EB, WB

	F		$(T_i/\Sigma T)x100$	
CTR	EB	WB	EB	WB
411	.4	.6	47.5	52.5
408	0	2.5	28.6	71.4
409	.2	0	53.7	46.3
404	0	0	50.0	50.0
403	0	0	50.0	50.0
402	0	0	50.0	50.0
407	4.6	6.1	46.4	53.6
405	.5	1.1	43.9	56.1
406	.6	.3	53.9	46.1

TABLE C.2. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 9

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T: Traffic Applications in Millions
F: Failures Per Mile
i = NB, SB

	F		$(T_i/\Sigma T) \times 100$	
CTR	NB	SB	NB	SB
906	2.4	5.1	41.1	58.9
903	0.0	0.0	50.0	50.0
901	0.0	0.0	50.0	50.0
902	0.0	0.0	50.0	50.0
910	0.0	0.0	50.0	50.0
909	0.0	1.0	36.8	63.2
908	0.0	0.0	50.0	50.0
907	19.0	0.0	87.4	12.6
905	5.0	1.2	65.6	34.4
904	6.8	18.1	47.8	52.2

TABLE C.3. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 10

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T: Traffic Applications in Millions

F: Failures Per Mile

i = EB, WB

	F		$(T_i/\Sigma T)x100$	
CTR	EB	WB	EB	WB
1006	8.5	6.5	49.3	50.7
1007	11.5	11.0	50.6	49.4
1001	11.5	4.5	61.8	38.2
1005	1.3	1.7	47.2	52.8
1004	18.4	18.8	49.7	50.3
1002	2.6	1.7	54.7	45.3
1003	9.7	3.9	61.4	38.6
1009	5.3	2.6	58.5	41.5
1010	10.8	9.1	52.2	47.8
1014	22.4	11.0	59.9	40.1
1008	16.5	1.7	75.4	24.6
1011	3.8	5.8	44.7	55.3
1012	2.7	3.9	45.6	54.4
1013	.6	0	41.8	58.2

TABLE C.4. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 13

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T: Traffic Applications in Millions
F: Failures Per Mile
i = EB, WB

	F		$(T_i/\Sigma T)\times100$	
CTR	EB	WB	EB	WB
1317	1.1	1.7	45.8	54.2
1320	0	3.2	26.3	73.7
1321	.4	1.4	40.4	59.6
1316	.8	1.3	45.6	54.4
1315	1.1	2.0	44	56
1313	1.1	7.1	29.9	70.1
1314	0	0	50	50
1311	0	1.1	36	64

TABLE C.5. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 17

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T:Traffic Applications in Millions

F:Failures Per Mile

i = NB, SB

	F		$(T_i / \Sigma T) \times 100$	
CTR	NB	SB	NB	SB
1711	.1	.6	42.8	57.2
1701	0.0	0.0	50.0	50.0
1702	.4	?		
1705	0.0	0.0	50.0	50.0
1704	.3	6.6	23.6	76.4
1703	.9	5.0	32.1	67.9
1707	.2	1.0	40.5	59.5
1710	2.8	5.3	42.2	57.8
1709	0.0	0.0	50.0	50.0
1708	1.7	4.9	37.8	62.2
1706	2.9	4.8	43.9	56.1

TABLE C.6. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 19

$$T = 2.37\,(F + 1)^{.497} - 1$$

where: T:Traffic Applications in Millions

F:Failures Per Mile

i = EB, WB

	F		$(T_i/\Sigma T) \times 100$	
CTR	EB	WB	EB	WB
1918	1	.9	63.2	36.8
1919	.7	.5	52.4	47.6
1914	.4	0	56.8	43.2
1910	0	0	50	50
1911	.9	1.7	30.3	69.7
1902	16.1	8.9	57.6	42.4
1909	3.8	1	64	36
1908	29.8	18.7	56	44
1906	20.6	15.1	54	46
1907	0	45	8.4	91.6
1904	7.2	4.1	57	43
1901	4	2.3	65.5	43.5

TABLE C.7. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 24

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T:Traffic Applications in Millions

F:Failures Per Mile

i = EB, WB

	F		$(T_i/\Sigma T) \times 100$	
CTR	EB	WB	EB	WB
2422	.5	0	58.1	41.9
2423	.7	0	60.4	39.6
2420	.4	.4	50	50
2415	0	0	50	50
2414	.1	.4	45.3	54.7
2412	0	0	50	50
2411	0	.2	46.1	53.9
2409	0	0	50	50
2410	.3	.6	46.1	53.9

TABLE C.8. ESTIMATED TRAFFIC DISTRIBUTIONS FOR DISTRICT 25

$$T = 2.37\ (F + 1)^{.497} - 1$$

where: T:Traffic Applications in Millions

F:Failures Per Mile

i = EB, WB

	F		$(T_i/\Sigma T)x100$	
CTR	EB	WB	EB	WB
2501	0	.3	44.6	55.4
2503	0	.8	38.7	61.3
2504	.7	.7	50.0	50.0
2502	.1	.1	50.0	50.0
2505	0	0	50.0	50.0

APPENDIX D

ANOVA - RELATIVE SIGNIFICANCE OF FACTORS AFFECTING CRCP DISTRESS

APPENDIX D. ANOVA - RELATIVE SIGNIFICANCE OF FACTORS AFFECTING CRCP DISTRESS

Description of Analysis - Anova using Multiple Linear Regression

Analysis of variance was performed to evaluate the significance of the effect of construction, environment, load and previous condition variables on present distress in the pavement. Data on the condition of 87 different sections of CRCP across the State of Texas encompassing a variety of environmental, construction and load conditions were used in the analysis (Refs 2 and 3). Four different distress manifestations were investigated in relation to seven construction factors, three environment factors, single factors representing the variation in age and traffic, and three different factors describing distress manifestations earlier in the pavement's life. These data are fully tabulated in Ref 2 and 3. A brief description of each different level of each factor is given along with the number of observations of the dependent variable taken at each level of these factors in both 1974 and 1978. A more complete description of the factors themselves is given in Chapter 5. The analysis was performed on three different sets of data for four distress manifestations as described in Table D.1. in order to confirm the consistency of the results over time. Owing to the high degree of intercorrelation between the factors (covariates) as seen in Appendix G it was decided to use multiple regression package computer programs (Ref 10) to calculate the statistics needed for the analysis of variance. For each distress manifestation, an estimate of the contribution of each factor to the total variance was obtained as follows:

$$\text{Variance in } y \text{ explained by factor } A = \text{Total variance in } y \text{ multiplied by } \Delta R_A^2$$

where

ΔR_A^2 = Change in R^2 for regression equation due to inclusion of factor A after all other variables have been included

TABLE D.1. DESCRIPTION OF DATA (OBSERVATIONS) ON DEPENDENT VARIABLES

Description of Data	Number of Observations			
	No. of Failures (x)	No. of Punchouts (y)	Percent Spalling (z)	Serviceability Index (SI)
Values of dependent variables taken from 1974 condition survey with corresponding values for "traffic" and "age" factors. Values of previous distress factors are taken at zero age for all sections.	87	84	87	87
Values of dependent variables are taken from 1978 condition survey with corresponding values for "traffic" and "age" factors. Values of previous distress factors are taken in 1974 for all sections.	67	67	59	none
Values of dependent variables are taken from both 1974 and 1978 condition surveys, with corresponging values for "traffic" and "age" factors. Values of previous distress factors are taken at zero age and in 1974, respectively for all sections.	154	Not Appicable	Not Applicable	Not Applicable

and

R^2 = the multiple correlation coefficient for the regression equation (Refs 8 and 10).

The significance of the contribution of each factor was tested using the F statistic which was calculated as follows (Refs 8 and 10).

$$F = \frac{\Delta R_A^2 / \text{ degrees of freedom for factor } A}{1 - R^2 \text{ with all variables in the equation/d of residual}}$$

and then compared with tabulated values of F (Ref 8) for given significance levels.

It should be emphasized that this approach was adopted because of the intercollinearity of factors arising from unequal numbers of observations in each cell (treatment combination) and unequal spacing of levels (values) of quantitative factors (covariates) (Appendix G). Multivariate analysis-of-variance programs (Ref 11), could also be used to confirm the results obtained using the procedure discussed above.

Results of Analysis - Significant Factors

The results of the analysis of variance (Refs 8 ch 4, 12 ch 18, and 13) for each of those of the three data sets which were analyzed for the four dependent variables are reproduced in full in Appendix E along with a summary of the models tested in each case. The significance levels of the F statistic calculated for each factor (covariate) are summarized in the following pages for all four variables. Tables D.2.a, b, c, and d summarize the results for the variable "Number of Failures," "Number of Punchouts," "Percent Severe Spalling," and "Serviceability Index," respectively.

Notes and Limitations on the Analysis

(1) The SPSS Standard Regression Procedure was used (Ref 10).

(2) Dummy variables were created to perform the regression on the qualitative variables (Ref 10 pp 375).

TABLE D.2. RESULTS OF ANOVA: HIERARCHY OF FACTORS AFFECTING CRCP DISTRESS

a. Factors Affecting "Number of Failures"

Priority	Factor Description*	Level of Significance (%)		
1	Previous number of failures (PZ)	Less	than	0.1%
2	Pavement age (X)			0.1%
3	Cumulative traffic (Y)	"	"	7.5%
4	Thorn Moisture Index (R)	"	"	8.0%
5	Subgrade Stabilizer Type (N)	"	"	9.0%
6	Subbase Stabilization Percent (J)	"	"	9.0%
7	Subgrade Clay Activity (U)	"	"	10.0%
8	Interaction of Y with J	"	"	0.1%
9	Subbase Stabilizer Type (K) with X	"	"	0.3%
10	Interaction of K with N	"	"	0.4%
11	K with Geographical Regional Factor (V)	"	"	1.0%
12	Interaction of J with N	"	"	1.5%
13	Interaction of J with V	"	"	3.0%
14	Concrete Aggregate Type (A) with K	"	"	3.0%
15	V with Previous Age (PX)	"	"	4.0%
16	Interaction of X with J	"	"	4.0%
17	Interaction of R with J	"	"	7.0%
18	Interaction of Y with K	"	"	8.5%
19	Subbase Thickness (G) with (R)	"	"	10.0%
20	Interaction of U with J	"	"	10.0%

*For notation see Table F2 of Appendix F.

TABLE D.2. RESULTS OF ANOVA: HIERARCHY OF FACTORS AFFECTING CRCP DISTRESS

b. Factors Affecting "Number of Punchouts"

Priority	Factor Description	Level of Significance (%)
1	Previous Number of Failures (PZ)	Less than 0.2%
2	Concrete Aggregate Type (A)	" " 0.5%
3	Subgrade Clay Activity (U)	" " 2.5%
4	Thorn Moisture Index (R)	" " 4.0%
5	Subbase Stabilizer Type (K)	" " 7.0%
6	Pavement Age (X)	" " 7.0%
7	Subgrade Stabilizer Type (N)	" " 1.0%
8	X with Subbase Stabilizer Percent (J)	" " 0.1%
9	X with Subbase Stabilizer Type (K)	" " 0.1%
10	J with Geographical Regional Factor (V)	" " 0.3%
11	Interaction of K with N	" " 0.3%
12	Previous Traffic (PY) with PZ	" " 0.5%
13	Interaction of R with X	" " 1.5%
14	X with Traffic (Y)	" " 2.0%
15	Interaction of J with N	" " 2.0%
16	Interaction of K with Y	" " 2.5%
17	Interaction of K with V	" " 2.5%
18	Interaction of R with Y	" " 2.5%
19	X with Subbase Thickness (G)	" " 3.0%
20	Interaction of J with Y	" " 7.0%

TABLE D.2. RESULTS OF ANOVA: HIERARCHY OF FACTORS AFFECTING CRCP DISTRESS

c. Factors Affecting "Percent Spalling"

Priority	Factor Description	Level of Significance (%)		
1	Previous Number of Failures (PZ)	Less	than	0.5%
2	Cumulated Traffic (Y)	"	"	5.0%
3	Subbase Stabilizer Percent (J)	"	"	7.0%
4	Geographical Regional Factor (V)	"	"	8.0%
5	Interaction of J with Subgrade Stabilizer Type (N)	"	"	0.6%
6	Interaction of J with Concrete Aggregate Type (A)	"	"	2.5%
7	Interaction of J with Subgrade Clay Activity (U)	"	"	3.5%
8	Interaction of Thorn Moisture Index (R) with A	"	"	3.5%
9	Interaction of Previous Traffic (PY) with PZ	"	"	3.5%
10	Interaction of R with V	"	"	4.0%
11	Interaction of R with N	"	"	7.0%
12	Interaction of J with V	"	"	10.0%
13	Interaction of J with PY	"	"	10.0%

No other factors showed a significant effect at the 10% level.

Notes: The results obtained using the 1978 data were considered more reliable than those obtained from the 1974 analysis owing to the larger data spread despite higher levels of significance. For notation see Appendix F, Table F.2.

TABLE D.2. RESULTS OF ANOVA: HIERARCHY OF FACTORS AFFECTING CRCP DISTRESS

d. Factors Affecting "Serviceability Index"

Priority	Factor Description	Level of Significance (%)	
1	Pavement Age (X)	Less than	0.1%
2	Subbase Stabilizer Percent (J)	" "	7.0%
3	Geographical Regional Factor (V)	" "	8.0%

Others not significant at 10% level of significance.

Notes 1. Size of sample of observations (data) is too small for any real conclusions to be drawn from these results. More data is needed, although 80% of the total variance was explained by the equation containing all the main effects.

2. Full details of analysis have been summarized in Appendix E Table E.4.

3. Interactions were not studied.

(3) The problem of possible curvilinearity for the covariates was treated by looking for linear, quadratic, cubic and quartic powers of each covariate (quantitative variable) in the analysis. It was assumed that the proportion of variance explained by these four powers combined would sufficiently represent the total variance attributable to the factor concerned. Justification for this can be seen in earlier work (Ref 2, 14 and 15). The quartic power was the highest that could be used to give a valid inference based on the number of observations available while still leaving sufficient degrees of freedom of error.

(4) The analysis was performed both with and without two factor interactions as pooling of levels was necessary in the latter case to leave sufficient degrees of freedom for a residual variance estimate. The drawback to the pooling of course, is that the inference space is reduced, hence the need for the analysis of the main effects alone.

(5) Lack-of-fit and pure error terms were pooled in the estimate of residual (unexplained) variance which was used in the significance tests. This was done because of the lack of replication for the different cells (treatment combinations) and the variation in the number of observations per cell. Standard F-distribution tables (Ref 16) were used in the analysis.

(6) Fixed factors were initially assumed in order to simplify the analysis.

(7) Other factors could be included in a more comprehensive analysis once a larger data base has been assembled. The SPSS MANOVA program should be used for analysis (Ref 11).

(8) The presence of dangerously high intercorrelations, of outliers, the homogeneity or otherwise of variance and the normality or otherwise of the distribution of the dependent variables were investigated before performing the analysis, since the least square techniques rest on related assumptions.

Comments on the Results of the Analysis

(1) The first distress manifestation examined was number of failures per mile (number of failures = number of punchouts plus number of patches). The analysis was performed for all three data sets (1974, 1978 and combined - see Table D.1). A hierarchical listing of the 20 most important factors affecting total failures, based on the results of all three analyses (Appendix E), is given in Table D.2. It is apparent that previous failures and pavement age highly significant factors, while traffic, subbase stabilizer percentage and moisture also play important roles. The significant interactions of these terms and others have also been listed. Of these, combinations of stabilizer type, subgrade stabilizer type,

geographical regional factor and subbase stabilizer percent are highly significant.

(2) The six factors which most affected punchouts along with the 18 important interactions have been listed in Table D.2b. Again, previous failures play a highly significant role along with concrete aggregate type, and subgrade clay activity. Interactions of the pavement age, subgrade stabilizer type, subbase stabilizer percent and type, geographical regional factor, previous traffic and previous failures are particularly important. It was not possible to perform analyses on the combined 1974 and 1978 data since different techniques were used for measuring punchouts in these two surveys.

(3) Again different spalling measuring techniques prohibited pooling the data so separate analyses on the 1974 and 1978 data were run. The results are summarized in Table D.2c from which it is clear that again, previous failures, subbase stabilizer, percent and traffic are highly significant, as are interactions of concrete aggregate type, subbase stabilizer percent, subgrade clay activity, moisture index and geographical regional factor.

(4) Insufficient data was available for the analysis of serviceability index, but preliminary results indicate that pavement age, subbase stabilizer percent and geographical factor are significant.

APPENDIX E

ANOVA TABLES FOR FACTORS AFFECTING CRCP DISTRESS

APPENDIX E. ANOVA TABLES FOR FACTORS AFFECTING CRCP DISTRESS

Nomenclature

See Table F.2 of Appendix F for an explanation of the symbols used in Tables E.1 to E.4 on pages to . Also,

R^2 = % of total variance explained by regression equation including all factors,

$1-R^2$ = Residual variance for regression equation with all factors,

ΔE^2_i = Contribution of factor ,i, to total variance explained by the regression equation after adjusting for all other factors,

dof_i = Degrees of freedom for factor ,i,

dof_{res} = Degrees of freedom for residual, and

$$F = \frac{\Delta R^2_i / dof_i}{1-R^2/dof_{res}}$$

Note: For main effects

$$\Delta R^2_i = R^2_{reg.}(\text{all}) - R^2_{reg.}(\text{all except factor i}) \quad ,$$

and thus

$$F_i = \frac{\Delta R^2_i / dof_i}{[1-R^2_{reg.}(\text{all})]/dof_{res.}(\text{all})} \quad ,$$

bur for interaction terms,

$$\Delta R^2_{ij} = R^2_{reg.}(\text{all} + \text{ij}) - R^2_{reg.}(\text{all}) \quad ,$$

and thus

$$F_{ij} = \frac{\Delta R^2_{ij} / dof_{ij}}{[1-R^2_{reg.}(\text{all} + \text{ij})]/dof_{res.}(\text{all} + \text{ij})}$$

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : FAILURES PER MILE

a. Data from 1974 Condition Survey.

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	2.76	5	64.66	41	45	0.70	Not sig. at 10%
	K	0.82	3	"	"	"	0.35	" " " "
	N	1.25	1	"	"	"	1.59	" " " "
	O	1.24	5	"	"	"	0.32	" " " "
	U	0.89	1	"	"	"	1.13	" " " "
	V	0.38	4	"	"	"	0.12	" " " "
	B	0.29	2	"	"	"	0.18	" " " "
	G	0.63	4	"	"	"	0.20	" " " "
	J	0.20	4	"	"	"	0.06	" " " "
	R	1.89	4	"	"	"	0.60	" " " "
	X	6.87	4	"	"	"	2.19	Sig. at <10%
	Y	5.09	4	"	"	"	1.62	Not sig. at 10%
	PX	-	-	-	-	-	-	-
	PY	-	-	-	-	-	-	-
	PZ	-	-	-	-	-	-	-
Up to 2 levels for each factor	A	0	1	32.92	12	74	0.00	Not sig. at 10%
	K	1.72	1	"	"	"	1.89	" " " "
	N	2.08	1	"	"	"	2.30	" " " "
	O	0.11	1	"	"	"	0.12	" " " "
	U	2.60	1	"	"	"	2.87	Sig. at <10%
	V	1.89	1	"	"	"	2.09	Not sig. at 10%
	B	0.07	1	"	"	"	0.08	" " " "
	G	0.33	1	"	"	"	0.36	" " " "
	J	0.43	1	"	"	"	0.48	" " " "
	R	1.08	1	"	"	"	1.19	" " " "
	X	7.33	1	"	"	"	8.09	Sig. at <0.6%

Continued

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : FAILURES PER MILE

a. Data from 1974 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 2 levels for each factor	Y	1.12	1	32.92	12	74	1.24	Not sig. at 10%
	PX	-	-	-	-	-	-	-
	PY	-	-	-	-	-	-	-
	PZ	-	-	-	-	-	-	-
	Interactions							
	AK	3.13	1	36.05	13	74	3.57	Sig. at < 8.0%
	KN	6.62	1	39.54	"	"	7.99	" " < 0.8%
	KV	5.30	1	38.30	"	"	6.36	" " < 1.5%
	KX	8.65	1	41.57	"	"	10.80	" " < 0.3%
	NJ	4.44	1	37.56	"	"	5.18	" " < 2.5%
	NX	4.33	1	37.25	"	"	5.03	" " < 3.0%
	UJ	2.91	1	35.83	"	"	3.31	" " < 9.0%
	UX	2.57	1	35.49	"	"	2.91	" " <10.0%
	VJ	4.83	1	37.75	"	"	5.66	" " < 2.0%
	VX	2.94	1	36.86	"	"	3.34	" " < 9.0%
	JX	8.72	1	41.64	"	"	10.91	" " < 0.3%
	JY	10.87	1	43.79	"	"	11.84	" " < 0.1%

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : FAILURES PER MILE

b. Data from 1978 Condition Survey

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	2.69	5	97.53	53	13	1.08	Not sig. at 10.0%
	K	0.55	3	"	"	"	0.37	" " " "
	N	0.00	1	"	"	"	0.00	" " " "
	O	0.53	5	"	"	"	0.22	" " " "
	U	0.31	1	"	"	"	0.63	" " " "
	V	0.44	4	"	"	"	0.22	" " " "
	B	0.38	2	"	"	"	0.39	" " " "
	G	0.96	4	"	"	"	0.48	" " " "
	J	0.59	4	"	"	"	0.30	" " " "
	R	0.52	4	"	"	"	0.26	" " " "
	X	2.11	4	"	"	"	1.06	" " " "
	Y	0.52	4	"	"	"	0.26	" " " "
	PX	1.98	4	"	"	"	1.00	" " " "
	PY	0.70	4	"	"	"	0.35	" " " "
	PZ	7.07	4	"	"	"	3.57	Sig. at <10.0%
Up to 2 levels for each factor	A	0.96	1	80.93	15	51	2.46	Not sig. at 10.0%
	K	0.08	1	"	"	"	0.19	" " " "
	N	0.00	1	"	"	"	0.00	" " " "
	O	0.35	1	"	"	"	0.91	" " " "
	U	0.15	1	"	"	"	0.38	" " " "
	V	0.59	1	"	"	"	1.52	" " " "
	B	0.00	1	"	"	"	0.26	" " " "
	G	0.22	1	"	"	"	0.55	" " " "
	J	0.68	1	"	"	"	1.74	" " " "
	R	0.07	1	"	"	"	0.19	" " " "

Continued

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : FAILURES PER MILE

b. Data from 1978 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 2 levels for each factor	X	5.03	1	80.93	15	51	12.92	Sig. at< 0.1%
	Y	0.45	1	"	"	"	1.15	Not sig. at 10.0%
	PX	1.15	1	"	"	"	2.95	Sig. at<10.0%
	PY	0.29	1	"	"	"	0.75	Not sig. at 10.0%
	PZ	27.90	1	"	"	"	71.70	Sig. at< 0.1%
	Interactions							
	NV	1.64	1	82.57	16	50	4.53	Sig. at< 5.0%
	UPZ	1.30	1	82.23	"	"	3.52	Sig. at< 8.0%
	JR	1.18	1	82.11	"	"	3.15	Sig. at< 9.0%
	JPX	1.21	1	82.14	"	"	3.26	Sig. at< 9.0%
	XPZ	3.39	1	84.32	"	"	10.37	Sig. at< 0.3%

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE*: FAILURES PER MILE

c. Data from 1974 & 1978 Condition Surveys.

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	1.32	5	64.00	53	100	0.68	Not sig. at 10.0%
	K	0.61	3	"	"	"	0.52	" " " "
	N	1.26	1	"	"	"	3.21	Sig. at < 9.0%
	O	1.46	5	"	"	"	0.75	Not sig. at 10.0%
	U	0.91	1	"	"	"	2.32	" " " "
	V	0.63	4	"	"	"	0.40	" " " "
	B	0.49	2	"	"	"	0.63	" " " "
	G	1.46	4	"	"	"	0.94	" " " "
	J	0.55	4	"	"	"	0.35	" " " "
	R	1.12	4	"	"	"	0.72	" " " "
	X	6.01	4	"	"	"	3.84	Sig. at < 0.8%
	Y	2.28	4	"	"	"	1.45	Not sig. at 10.0%
	PX	2.84	4	"	"	"	1.81	" " " "
	PY	0.86	4	"	"	"	0.55	" " " "
	PZ	6.92	4	"	"	"	4.42	Sig. at < 0.4%
Up to 2 levels for each factor	A	0.20	1	43.74	15	138	0.47	Not sig. at 10.0%
	K	0.53	1	"	"	"	1.28	" " " "
	N	1.00	1	"	"	"	2.41	" " " "
	O	0.04	1	"	"	"	0.09	" " " "
	U	0.98	1	"	"	"	2.38	" " " "
	V	0.55	1	"	"	"	1.32	" " " "
	B	0.07	1	"	"	"	0.16	" " " "
	G	0.27	1	"	"	"	0.65	" " " "
	J	1.25	1	"	"	"	3.01	sig. at < 9.0%
	R	1.35	1	"	"	"	3.27	" " < 8.0%

Continued

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : FAILURES PER MILE

c. Data from 1974 & 1978 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 2 levels for each factor	K	7.22	1	"	"	"	17.46	Sig. at < 0.1%
	Y	1.39	1	"	"	"	3.36	" " < 7.5%
	PX	0.80	1	"	"	"	1.91	Not sig. at 10.0%
	PY	0.15	1	"	"	"	0.36	" " " "
	PZ	13.61	1	"	"	"	32.89	Sig. at < 0.1%
	Interactions							
	KN	3.63	1	47.37	16	137	9.30	Sig. at < 0.4%
	KV	2.82	1	46.56	"	"	7.12	" " < 1.0%
	AK	1.85	1	45.59	"	"	4.58	" " < 3.0%
	KY	1.29	1	45.03	"	"	3.17	Sig. at < 8.5%
	NJ	2.43	1	46.17	"	"	6.09	" " < 1.5%
	UJ	1.20	1	44.94	"	"	2.93	" " <10.0%
	VJ	1.83	1	45.57	"	"	4.55	" " < 3.0%
	VPX	1.71	1	45.45	"	"	4.24	" " < 4.0%
	GR	1.13	1	44.87	"	"	2.78	" " <10.0%
	JR	1.50	1	45.24	"	"	3.69	" " < 7.0%
	JX	1.76	1	45.50	"	"	4.35	" " < 4.0%

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : NUMBER OF PUNCHOUTS

(See Refs 2 & 3 for D.V. data)

a. Data from 1974 Condition Survey

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	4.65	5	53.32	41	45	0.90	Not sig. at <10.0%
	K	0.70	3	"	"	"	0.22	" " " "
	N	1.62	1	"	"	"	1.56	" " " "
	O	1.69	5	"	"	"	0.33	" " " "
	U	1.08	1	"	"	"	1.08	" " " "
	V	0.15	4	"	"	"	0.03	" " " "
	B	0.82	2	"	"	"	0.04	" " " "
	G	1.55	4	"	"	"	0.37	" " " "
	J	1.31	4	"	"	"	0.32	" " " "
	R	1.91	4	"	"	"	0.46	" " " "
	X	3.26	4	"	"	"	0.79	" " " "
	Y	6.26	4	"	"	"	1.51	" " " "
	PX	-	-	-	-	-	-	-
	PY	-	-	-	-	-	-	-
	PZ	-	-	-	-	-	-	-
Up to 2 levels for each factor	A	1.04	1	28.83	12	74	1.08	Not sig. at 10.0%
	K	1.72	1	"	"	"	1.79	" " " "
	N	7.10	1	"	"	"	7.38	Sig. at < 0.9%
	O	0.76	1	"	"	"	0.79	Not sig. at 10.0%
	U	0.92	1	"	"	"	0.95	" " " "
	V	1.86	1	"	"	"	1.93	" " " "
	B	0.00	1	"	"	"	0.00	" " " "
	G	2.56	1	"	"	"	2.66	" " " "
	J	3.32	1	"	"	"	3.45	Sig. at < 7.0%

Continued

TABLE E.1. RESULTS OF ANOVA - DEPENDENT VARIABLE : NUMBER OF PUNCHOUTS

(See Refs 2 & 3 for D.V. data)

a. Data from 1974 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 2 levels for each factor	R	5.68	1	28.83	12	74	5.90	Sig. at < 2.5%
	X	8.18	1				8.51	" " < 0.5%
	Y	0.00	1				0.00	Not sig. at 10.0%
	PX	-	-	-	-	-	-	-
	PY	-	-	-	-	-	-	-
	PZ	-	-	-	-	-	-	-
	Interactions							
	KN	8.37	1	37.20	13	73	9.73	Sig. at < 0.3%
	KV	4.83	1	33.66	13	73	5.32	" " < 2.5%
	KJ	2.97	1	31.80	13	73	3.17	" " < 8.5%
	KX	14.54	1	43.37	13	73	18.74	" " < 0.1%
	KY	4.51	1	33.34	13	73	4.94	" " < 2.5%
	NV	3.13	1	32.19	13	73	3.36	" " < 8.0%
	NJ	5.21	1	34.04	13	73	5.77	" " < 2.0%
	UJ	2.76	1	31.59	13	73	2.94	" " <10.0%
	VG	3.14	1	31.97	13	73	3.36	" " < 8.0%
	VJ	8.95	1	37.78	13	73	10.50	" " < 0.3%
	GX	4.24	1	33.07	13	73	4.63	" " < 3.0%
	JX	13.15	1	41.98	13	73	16.55	" " < 0.1%
	JY	3.46	1	32.29	13	73	3.72	" " < 7.0%
	RX	6.14	1	34.97	13	73	6.90	" " < 1.5%
	RY	4.62	1	33.45	13	73	5.07	" " < 2.5%
	XY	5.02	1	33.85	13	73	5.54	" " < 2.0%

TABLE E.2. RESULTS OF ANOVA - DEPENDENT VARIABLE : NUMBER OF PUNCHOUTS

(See Ref 3 for D.V. data)

b. Data from 1978 Condition Survey

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	8.73	5	99.47	53	13	16.57	Sig. at < 0.5%
	K	1.50	3	"	"	"	4.73	" " < 7.0%
	N	0.00	1	"	"	"	0.09	Not sig. at <10.0%
	O	1.84	5	"	"	"	3.49	Sig. at <10.0%
	U	1.12	1	"	"	"	11.36	" " < 2.5%
	V	1.20	4	"	"	"	2.85	Not sig. at 10.0%
	B	0.80	2	"	"	"	3.81	Sig. at <10.0%
	G	1.15	4	"	"	"	2.72	Not sig. at 10.0%
	J	1.06	4	"	"	"	2.50	" " " "
	R	2.41	4	"	"	"	5.72	Sig. at < 4.0%
	X	1.91	4	"	"	"	4.53	" " < 7.0%
	Y	1.68	4	"	"	"	3.98	" " < 9.0%
	PX	1.55	4	"	"	"	3.67	" " <10.0%
	PY	1.53	4	"	"	"	3.62	" " <10.0%
	PZ	12.88	4	"	"	"	30.54	" " < 0.2%
Up to 2 levels for each level	A	0.74	1	17.68	15	51	0.44	Not sig. at 10.0%
	K	1.09	1	"	"	"	0.65	" " " "
	N	0.04	1	"	"	"	0.02	" " " "
	O	0.04	1	"	"	"	0.02	" " " "
	U	0.13	1	"	"	"	0.08	" " " "
	V	0.75	1	"	"	"	0.45	" " " "
	B	0.04	1	"	"	"	0.03	" " " "
	G	0.00	1	"	"	"	0.00	" " " "
	J	3.76	1	"	"	"	2.24	" " " "
	R	0.72	1	"	"	"	0.43	" " " "
	X	0.09	1	"	"	"	0.06	" " " "

Continued

TABLE E.2. RESULTS OF ANOVA - DEPENDENT VARIABLE : NUMBER OF PUNCHOUTS

(See Ref 3 for D.V. data)

b. Data from 1978 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 2 levels for each factor	Y	2.18	1	17.68	15	51	1.30	Not sig. at 10.0%
	PX	0.09	1	"	"	"	0.06	" " " "
	PY	0.43	1	"	"	"	0.25	" " " "
	PZ	6.65	1	"	"	"	3.96	Sig. at < 6.0%
	<u>Interactions</u>							
	PYPZ	13.01	1	30.69	16	50	9.01	Sig. at < 0.5%

All other two factor interactions not significant at 10%

TABLE E.3. RESULTS OF ANOVA - DEPENDENT VARIABLE : PERCENT SPALLING

(See Refs 2 & 3 for D.V. data)

b. Data from 1974 Condition Survey

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	2.14	5	62.20	41	45	0.51	Not sig. at 10.0%
	K	2.23	3	"	"	"	0.84	" " " "
	N	0.59	1	"	"	"	0.70	" " " "
	O	5.87	5	"	"	"	1.40	" " " "
	U	0.16	1	"	"	"	0.19	" " " "
	V	7.89	4	"	"	"	2.35	Sig. at < 8.0%
	B	0.08	2	"	"	"	0.05	Not sig. at 10.0%
	G	1.96	4	"	"	"	0.58	" " " "
	J	8.15	4	"	"	"	2.43	Sig. at < 7.0%
	R	2.61	4	"	"	"	0.78	Not sig. at 10.0%
	X	5.86	4	"	"	"	1.74	" " " "
	Y	9.24	4	"	"	"	2.75	Sig. at < 5.0%
	PX	-	-	-	-	-	-	-
	PY	-	-	-	-	-	-	-
	PZ	-	-	-	-	-	-	-
Up to 2 levels for each factor	A	0.83	1	21.20	12	74	0.78	Not sig. at 10.0%
	K	0.27	1	"	"	"	0.25	" " " "
	N	1.40	1	"	"	"	1.32	" " " "
	O	1.44	1	"	"	"	1.36	" " " "
	U	0.70	1	"	"	"	0.66	" " " "
	V	0.46	1	"	"	"	0.43	" " " "
	B	0.10	1	"	"	"	0.10	" " " "
	G	3.35	1	"	"	"	3.14	Sig. at < 9.0%
	J	2.64	1	"	"	"	2.48	Not sig. at 10.0%
	R	0.20	1	"	"	"	0.19	" " " "
	X	1.24	1	"	"	"	1.17	" " " "
	Y	0.08	1	"	"	"	0.07	" " " "

Continued

TABLE E.3. RESULTS OF ANOVA - DEPENDENT VARIABLE : PERCENT SPALLING

(See Refs 2 & 3 for D.V. data)

b. Data from 1974 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eqn	dof Residual	F Calc'd.	Level of Significance
	Interactions							
Up to 2 levels for each factor	AG	3.50	1	24.70	13	73	3.39	Sig. at < 7.5%
	KG	4.53	1	25.73	"	"	4.45	" " < 5.0%
	KJ	3.86	1	25.06	"	"	3.76	" " < 6.0%
	NG	4.90	1	26.10	"	"	4.84	" " < 4.0%

TABLE E.3. RESULTS OF ANOVA - DEPENDENT VARIABLE : PERCENT SPALLING

(See Refs 2 & 3 for D.V. data)

b. Data from 1978 Condition Survey

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor		Not enough observations of Z available to provide sufficient degrees of freedom for residuals at this many levels of each factor.						
Up to 2 levels for each factor	A	0.02	1	35.17	15	43	0.01	Not sig. at 10.0%
	K	1.48	1	"	"	"	0.93	" " " "
	N	0.02	1	"	"	"	0.02	" " " "
	O	1.40	1	"	"	"	0.88	" " " "
	U	0.06	1	"	"	"	0.04	" " " "
	V	0.19	1	"	"	"	0.12	" " " "
	B	0.09	1	"	"	"	0.06	" " " "
	G	1.15	1	"	"	"	0.73	" " " "
	J	2.73	1	"	"	"	1.73	" " " "
	R	1.54	1	"	"	"	0.98	" " " "
	X	0.00	1	"	"	"	0.00	" " " "

Continued

TABLE E.3. RESULTS OF ANOVA - DEPENDENT VARIABLES : PERCENT SPALLING

(See Refs 2 & 3 for D.V. data)

b. Data from 1978 Condition Survey (Continued)

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 2 levels for each factor	Y	0.00	1	35.17	15	43	0.00	Not sig. at 10.0%
	PX	0.02	1	"	"	"	0.01	" " " "
	PY	0.16	1	"	"	"	0.10	" " " "
	PZ	14.13	1	"	"	"	8.94	Sig. at < 0.5%
	Interactions							
	AJ	8.09	1	43.26	16	42	5.71	Sig. at < 2.5%
	AR	7.61	1	42.78	"	"	5.32	" " < 3.0%
	NJ	11.60	1	46.77	"	"	8.71	" " < 0.6%
	NR	5.34	1	40.51	"	"	3.59	" " < 7.0%
	UR	7.26	1	42.43	"	"	5.05	" " < 3.5%
	VJ	4.37	1	39.54	"	"	2.89	" " <10.0%
	VR	7.11	1	42.28	"	"	4.93	" " < 4.0%
	JPY	4.44	1	39.61	"	"	2.94	" " <10.0%
	PYPZ	7.26	1	42.43	"	"	5.05	" " < 3.5%

All other two factor interactions not significant at 10%

TABLE E.4. RESULTS OF ANOVA - DEPENDENT VARIABLE SI

Data from 1974 Condition Survey

Precision of Analysis	Factor or Covariate	ΔR^2 Factor (%)	dof Factor	R^2 Equation (%)	dof eq'n	dof Residual	F Calc'd.	Level of Significance
Up to 5 levels for each factor	A	3.69	5	79.88	41	45	1.65	Not sig. at 10.0%
	K	1.86	3	"	"	"	1.38	" " " "
	N	0.30	1	"	"	"	0.67	" " " "
	O	2.16	5	"	"	"	0.97	" " " "
	U	0.51	1	"	"	"	1.15	" " " "
	V	4.13	4	"	"	"	2.31	Sig. at < 8.0%
	B	0.44	2	"	"	"	0.49	Not sig. at 10.0%
	G	2.28	4	"	"	"	1.27	" " " "
	J	4.26	4	"	"	"	2.38	Sig. at < 7.0%
	R	3.21	4	"	"	"	1.79	Not sig. at 10.0%
	X	10.64	4	"	"	"	5.95	Sig. at < 0.1%
	Y	2.52	4	"	"	"	1.41	Not sig. at 10.0%
	PX	-	-	-	-	-	-	-
	PY	-	-	-	-	-	-	-
	PZ	-	-	-	-	-	-	-
Up to 2 levels for each factor	Insufficient data available at the time of this analysis to perform this regression.							

APPENDIX F

SUMMARY OF DATA USED IN ANOVA AND DISTRESS PREDICTION MODEL ANALYSIS

APPENDIX F. SUMMARY OF DATA USED IN ANOVA AND DISTRESS PREDICTION MODEL ANALYSIS

TABLE OF CONTENTS

INTRODUCTION

Nature and Extent of Comprehensive Data from 1974, 1978 Surveys (Table F1)

Measurements of 4 pavement performance parameters (punchouts, failures, spalling, and serviceability index) and 17 pavement characteristics (including environmental, construction, traffic, age and distress factors) were taken in two separate condition surveys in 1974 and 1978. The information was collected for a series of CRCP sections at locations scattered throughout Texas as summarized in Table F1 and References 2 and 3. The number of sections for which characteristic data were available and which were rated in each district in both surveys is also given in Table F1.

Additional Data From 1980 Survey (Table F1)

Also included in Table F1 is a list of the anticipated dates on which each of the above pavement sections is to be rated during 1980. This condition survey is to be concluded jointly by the CTR at the University of Texas at Austin, and the Texas SDHPT. Once available, these data will be incorporated into the total data bank.

Summary of Coordinated Data from 1974, 1978 Surveys (Tables F2, F3, F4)

A summary of the values of all the measured parameters for those pavement sections which were "condition surveyed" in both 1974 and 1978 is included as Table F2 (Notation), Table F3 (Description of Levels used for Qualitative Factors) and Table F4 (Summary of Data). Only those measurements which reflect meaningful continuity between surveys are included here. The number of these pavement sections, broken down by district, is indicated in Table F1. It should be noted that the CTR section numbers used in Table F4 were originally allocated in 1974. Some of these were changed after the 1978 survey. These changes have not been incorporated into Table F4.

TABLE F1. NATURE AND EXTENT OF COORDINATED CRCP CONDITION SURVEY DATA

Texas SDHPT District No.	No. of Sections Rated 1974	No. of Sections Rated 1980	Anticipated Dates for 1980 survey
1	6	5	June 16 to 20
3	11	4	
4	7	6	
9	4	2	
10	13	13	
13	14	13	June 23 to July 3
17	7	5	June 23 to July 3
19	12	10	June 16 to 20
20	9	0	July 7 to 11
25	3	3	
Total	86	61	

TABLE F2. NOTATION USED IN SUMMARY OF COORDINATED DATA

Symbol	Explanation	Factor Type*
No.	CFTR Section Location Number	(not applicable)
A	Concrete Aggregate Type (8 levels)	qualitative
B	Number of Longitudinal Bars	quantitative
C	Transverse Bar Spacing (in.)	quantitative
D	Concrete Mix Type (2 levels)	qualitative
E	Concrete Paving Type (2 levels)	qualitative
F	Concrete Vibration Type (3 levels)	qualitative
G	Subbase Thickness (in.)	quantitative
H	Subbase Surface Type (6 levels)	qualitative
I	Subbase Aggregate Type (7 levels)	qualitative
J	Subbase Stabilizer Content (percent)	quantitative
K	Subbase Stabilizer Type (3 levels)	qualitative
L	Subbase Mixing Type (3 levels)	qualitative
M	Subgrade Stabilization Depth (in.)	quantitative
N	Subgrade Stabilizer Type (3 levels)	qualitative
O	Shoulder Layer Surfacing Type (5 levels)	qualitative
P	Shoulder Layer Base Material Type (5 levels)	qualitative
Q	Shoulder Layer Stabilizer Type (3 levels)	qualitative
R	Thornwaite Moisture Index	quantitative
S	Average Annual No. of Freeze-Thaw Cycles	quantitative
T	Amount of Solar Radiation(Langleys per day)	quantitative
U	Subgrade Clay Content (percent)	quantitative
V	Texas Geographic and Topographic Regional Factor (10 levels)	qualitative
W	Texas SDHPT Temperature Constant	quantitative
X	Age of Pavement Section (months)	quantitative
Y	Accumulated Traffic (millions of 18KESALS)	quantitative
Z	Failures/mile (punchouts + patches)	quantitative
SI	Serviceability Index	quantitative

TABLE F2. NOTATION USED IN SUMMARY OF COORDINATED DATA (Continued)

Symbol	Explanation	Factor Type*
PX	Age on Date of Previous Survey (months)	quantitative
PY	Traffic on Date of Previous Survey	quantitative
PZ	No. of Failures on Date of Previous Survey	quantitative
PSI	SI on Date of Previous Survey	quantitative

*Dummy values of "0" or "1" are used in the appropriate column of Table F4 to indicate the absence or presence, respectively, of each level of the qualitative factors. These levels are described in Table F3. Actual values are used for the quantitative factors or covariates.

TABLE F3. DESCRIPTION OF LEVELS USED FOR QUALITATIVE FACTORS

Factor	Description of Levels
A	Siliceous River Gravel (SRG)
	Limestone (L)
	Limestone River Gravel (LRG)
	SRG + LRG
	SRG + L
	SRG + LRG + Slag
	LRG + Slag
	SRG + Slag
D	Central Mix or other
E	Slipform Paver or other
F	Internal Vibration
	Pan Vibration
	Both
H	2 Course Surface Layer
	Surface Treatment
	Asphalt
	None
	Water
I	Processed Material
	Natural Soil
	Pit Run Gravel
	Limestone
	Sand
	Shell Material
	Sandstone
K	Asphalt
	Cement
	Lime
L	Road Mixer
	Central Mixer
	None
N	Asphalt
	Cement
	Lime
O	One Course Surface Treatment
	Two Course Surface Treatment
	Asphalt Concrete
	Cement Concrete
	Sod

TABLE F3. DESCRIPTION OF LEVELS USED FOR QUALITATIVE FACTORS (Cont.)

Factor	Description of Levels
P	Flexible Material Roadbed Treatment Foundation Course Shell Material Existing Material
Q	Asphalt Cement Lime
V	1: Trans-Pecos Region 2: High Plains Region 3: Low Rolling Plains Region 4: Edwards Plateau Region 5: Southern Region 6: Lower Valley Region 7: South Central Region 8: North Central Region 9: East Texas Region 10: Upper Coast Region

TABLE F4. SUMMARY OF COORDINATED CRCP CONDITION SURVEY DATA

(Only those measurements which reflect meaningful continuity between surveys are included here).

```
****************************************************************
* CFHR    A        B    C   DE   F    G    H        I    J    K    L  *
****************************************************************
* CFHR M N      O       P     Q    R    S    T    U    V        W     *
****************************************************************
* CFHR  X   Y              Z           SI                             *
****************************************************************
* CFHR  PX  PY             PZ          PSI                            *
****************************************************************

*   101 01000000   39  24  00  010  6001000  1000000  5.5  010  100 *
*   101 6000  01000  00001  010  16  55  425  83 0000000100  21     *
*   101 120  2.536        2.91       2.9                            *
*   101                                                             *
*   102 00000010   39  24  00  010  6001000  1000000  6.0  010  100 *
*   102 6000  01000  10000  000  17  55  426  83 0000000100  21     *
*   102 105  2.195        1.21       2.8                            *
*   102                                                             *
*   103 00000010   39  24  00  010  6001000  1000000  6.0  010  100 *
*   103 6000  01000  00001  010  18  55  427  36 0000000100  21     *
*   103 104  2.184        1.02       3.1                            *
*   103                                                             *
*   104 00000010   39  24  00  010  6001000  1000000  6.0  010  100 *
*   104 6000  01000  00001  010  19  55  428  40 0000000100  21     *
*   104 101  1.950        .87        3.2                            *
*   104                                                             *
*   105 01000000   39  30  11  001  6001000  0001000  2.0  010  100 *
*   105 6001  01000  10000  010  10  70  430 100 0000000100  21     *
*   105  81  .930         .78        3.4                            *
*   105                                                             *
*   109 10000000   39  36  11  100  6000100  0001000  0.0  000  100 *
*   109 0000  01000  10000  000  10  55  430  88 0000000100  21     *
*   109  34  1.106        .00        *                              *
*   109                                                             *
*   301 00100000   39  24  00  100  4000100  0000001  4.0  010  010 *
*   301 6000  00100  00100  000  -8  70  456  31 0000000100  22     *
*   301 116  .987         .28        2.8                            *
*   301                                                             *
*   302 00100000   39  24  00  100  4000010  0000100  6.0  010  100 *
*   302 6000  00100  00100  000  -8  70  456  18 0000000100  22     *
*   302 112  .848         .08        3.1                            *
*   302                                                             *
*   303 00100000   39  30  00  100  4001000  0000001  4.0  010  010 *
*   303 6000  00000  00100  000  -8  70  456  52 0000000100  22     *
*   303  77  1.704        2.96       2.7                            *
*   303                                                             *
*   306 00100000   39  30  11  100  4000010  0000001  5.0  010  010 *
*   306 0000  00000  00100  000 -10  70  458  73 0000000100  22     *
*   306  66  1.000        .51        3.1                            *
*   306                                                             *
*   307 00100000   39  30  10  100  4001000  0000001  4.0  010  010 *
*   307 6000  00000  00001  001  -6  70  452  40 0000000100  22     *
*   307  64  .493         .00        2.7                            *
*   307                                                             *
****************************************************************
```

```
*****************************************************************
* CFHR    A         B  C   DE   F    G    H       I      J   K   L *
*****************************************************************
* CFHR M N      O      P    Q    R    S     T    U     V      W     *
*****************************************************************
* CFHR  X    Y              Z          SI                           *
*****************************************************************
* CFHR  PX  PY             PZ          PSI                          *
*****************************************************************

*   309 00100000    39  30  00  100  4000010  0010000  4.0  100  100 *
*   309 0000  00000  10000  100 -15  70  460   0 0000000100  22      *
*   309  55   .804           .00        2.9                          *
*   309                                                              *
*   310 00100000    39  30  01  100  4000010  0010000  4.0  100  100 *
*   310 0000  00000  10000  100 -15  70  460   0 0000000100  22      *
*   310  55   .080           .00        3.3                          *
*   310                                                              *
*   311 0010000     39  30  11  001  4000010  0010000  5.0  100  100 *
*   311 0000  00000  00100  100  -9  70  455  39 0000000100  22      *
*   311  43   .692           .14        3.6                          *
*   311                                                              *
*   313 00100000    39  30  11  001  4000010  0001000  5.0  100  100 *
*   313 6000  00000  00100  000  -3  70  450  10 0000000100  22      *
*   313  20   .380          0.0         3.4                          *
*   313                                                              *
*   314 00100000    39  30  11  001  4001000  0000001  4.0  010  010 *
*   314 0000  01000  00100  000  -6  70  452  37 0000000100  22      *
*   314  18   .343           .00        3.2                          *
*   314                                                              *
*   315 00100000    39  36  11  100  4001000  0000001  4.0  010  100 *
*   315 0000  00000  00100  000 -11  70  458  77 0000000100  22      *
*   315   8   .173           .00        3.7                          *
*   315                                                              *
*   402 10000000    39  24  00  001  6000010  1000000  2.5  001  100 *
*   402 6001  00010  10000  001 -18 100  475 100 0100000000   9      *
*   402 114  4.364           .00        2.5                          *
*   402                                                              *
*   403 10000000    39  24  10  100  6001000  1000000  2.0  010  010 *
*   403 6001  00010  10000  010 -18 100  475 100 0100000000   9      *
*   403 101  4.447           .00        3.0                          *
*   403                                                              *
*   404 10000000    39  24  10  100  6001000  1000000  2.0  010  010 *
*   404 6001  00100  10000  010 -19 100  475 100 0100000000   9      *
*   404  92  3.008           .00        2.8                          *
*   404                                                              *
*   405 10000000    39  30  11  001  4000100  1000000  0.0  000  000 *
*   405 6001  00100  00001  100 -15 100  475  98 0100000000   9      *
*   405  89  1.471          1.14        3.5                          *
*   405                                                              *
*   406 10000000    39  30  00  001  6000100  0100000  2.5  100  100 *
*   406 6001  00100  00001  100 -18 100  475 100 0100000000   9      *
*   406  88  2.057          1.28        3.1                          *
*   406                                                              *
*****************************************************************
```

```
*********************************************************************
* CFHR    A        B    C    DF    F    G    H      I      J     K    L *
*********************************************************************
* CFHR M N      O      P      Q    R    S    T     U      V      W     *
*********************************************************************
* CFHR  X   Y               Z          SI                              *
*********************************************************************
* CFHR  PX  PY              PZ         PSI                             *
*********************************************************************

*   408 10000000    39  30  11  100  6001000  1000000  2.0  010  010 *
*   408 6001  00100  00001  010 -20 100  475 100 0100000000   9      *
*   408  65  1.325          .00        3.3                           *
*   408                                                              *
*   410 10000000    39  36  11  100  6000100  1000000  2.0  001  010 *
*   410 4001  10000  00001  001 -20 100  475 100 0100000000   9      *
*   410  22   .408          .14        3.6                           *
*   410                                                              *
*   901 10000000    39  24  00  100  5000010  0010000  0.0  000  000 *
*   901 5001  00100  10000  000   8  50  430  85 0000000100  28      *
*   901 170  3.283        18.13        2.8                           *
*   901                                                              *
*   904 10000000    39  24  00  100  6000010  0010000  2.5  001  100 *
*   904 6001  00100  00100  000   8  50  430  81 0000000100  28      *
*   904 112  2.153        22.36        2.7                           *
*   904                                                              *
*   907 10000000    39  24  00  010  6000001  0001000  2.5  001  100 *
*   907 6001  00100  10000  000   8  50  430  20 0000000100  28      *
*   907  98  1.850         1.90        *                             *
*   907                                                              *
*   908 10000000    39  24  00  100  4000010  0010000  2.5  001  100 *
*   908 6001  00100  10000  000   8  50  430 100 0000000100  28      *
*   908  91  1.164         2.28        2.6                           *
*   908                                                              *
* 1001 00010000    39  24  00  100 10001000  1000000  0.0  000  000 *
* 1001 0000  01000  10000  000  10  50  425  38 0000000010  24      *
* 1001 132  4.197         3.06        3.2                           *
* 1001                                                              *
* 1002 00001000    39  24  00  100  4001000  1000000  0.0  000  000 *
* 1002 0000  01000  00001  010  11  50  425   0 0000000010  24      *
* 1002 130  3.331          .45        3.3                           *
* 1002                                                              *
* 1003 00010000    39  24  00  100  0000000  0000000  0.0  000  000 *
* 1003 0000  01000  00001  010  12  50  425   0 0000000010  24      *
* 1003 125  3.550         2.23        3.2                           *
* 1003                                                              *
* 1004 00010000    39  24  00  100  6001000  1000000  3.0  010  010 *
* 1004 0000  01000  00001  010  12  50  425  38 0000000010  24      *
* 1004 125  3.520         3.62        3.0                           *
* 1004                                                              *
* 1005 00000000    39  24  00  100  6001000  1000000  4.0  010  010 *
* 1005 0000  01000  10000  000  13  50  425   0 0000000010  24      *
* 1005 116  3.850          .93        3.0                           *
* 1005                                                              *
*********************************************************************
```

```
****************************************************************
* CFHR   A        B  C   DE   F   G   H        I      J    K   L *
****************************************************************
* CFHR M N      O      P     Q    R    S     T     U      V    W   *
****************************************************************
* CFHR  X   Y               Z          SI                           *
****************************************************************
* CFHR  PX  PY             PZ          PSI                          *
****************************************************************

* 1006 00010000    39  24  00  100  6001000  1000000  4.0  010  010 *
* 1006 0000   01000  10000  000  14  50  424 100 0000000010  24     *
* 1006 105  2.860         3.86        3.1                           *
* 1006                                                              *
* 1007 00010000    30  24  00  100  6001000  1000000  3.0  010  010 *
* 1007 0000   01000  10000  000  14  50  424  47 0000000010  24     *
* 1007 105  2.840         6.65        3.1                           *
* 1007                                                              *
* 1008 00000100    39  24  00  001  6001000  1000000  3.0  010  010 *
* 1008 0000   01000  00001  010  15  50  424   0 0000000010  24     *
* 1008 104  2.034         2.69        3.5                           *
* 1008                                                              *
* 1009 01000000    39  24  01  100  6001000  1000000  3.0  010  010 *
* 1009 0000   01000  00001  010  16  50  424   0 0000000010  24     *
* 1009 100  2.610          .66        3.4                           *
* 1009                                                              *
* 1010 00010000    39  24  00  100  6001000  1000000  3.0  010  010 *
* 1010 0000   01000  00001  010  16  50  424   0 0000000010  24     *
* 1010  97  2.444         5.26        3.1                           *
* 1010                                                              *
* 1011 00000100    39  24  01  100  6001000  1000000  3.0  010  010 *
* 1011 0000   01000  00001  010  17  50  422   0 0000000010  24     *
* 1011  93  1.994          .88        3.4                           *
* 1011                                                              *
* 1012 00000100    39  30  01  100  6001000  1000000  3.0  010  010 *
* 1012 0000   01000  00001  010  18  50  422   2 0000000010  20     *
* 1012  84  1.940         1.33        3.4                           *
* 1012                                                              *
* 1014 00000100    39  24  00  100  6001000  1000000  3.0  010  010 *
* 1014 0000   01000  00001  010  20  50  422   0 0000000010  24     *
* 1014  99  2.070         5.68        3.2                           *
* 1014                                                              *
* 1301 10000000    39  24  00  100  6001000  0100000  4.0  010  100 *
* 1301 8001   01000  00001  010  -8  20  425  80 0000001000  33     *
* 1301 119  1.334         1.12        3.1                           *
* 1301                                                              *
* 1302 10000000    39  24  00  100  6001000  0100000  6.0  010  100 *
* 1302 0000   01000  00001  010  -6  20  425  80 0000001000  33     *
* 1302  90  1.141          .87        3.2                           *
* 1302                                                              *
* 1303 10000000    39  30  10  010  6001000  0100000  5.0  010  100 *
* 1303 6001   01000  00001  010  -8  20  425  25 0000001000  33     *
* 1303  67   .460          .83        3.2                           *
* 1303                                                              *
****************************************************************
```

```
*****************************************************************************
* CFHR    A         B    C    DE    F    G    H         I        J    K    L *
*****************************************************************************
* CFHR M N     O      P     Q    R    S    T    U     V      W              *
*****************************************************************************
* CFHR   X   Y                 Z          SI                                *
*****************************************************************************
* CFHR   PX   PY              PZ          PSI                               *
*****************************************************************************

* 1304 10000000    39   30   10   010   6001000  0100000  4.5  010  100 *
* 1304 6001  01000  00001  010 -10   20   425   96 0000001000  33        *
* 1304  61   .687          .83          *                                 *
* 1304                                                                    *
* 1305 10000000    39   30   11   001   6001000  0100000  4.5  010  100 *
* 1305 6000  01000  00001  010 -10   20   425   25 0000001000  33        *
* 1305  57   .441          .00       3.1                                  *
* 1305                                                                    *
* 1307 10000000    30   30   11   001   6001000  0100000  4.5  010  100 *
* 1307 6000  01000  00001  010 -12   20   425   25 0000001000  33        *
* 1307  81   .026          .37       3.4                                  *
* 1307                                                                    *
* 1308 10000000    39   30   00   010   6001000  0000001  4.4  010  010 *
* 1308 0000  01000  00001  010 -12   20   425   97 0000001000  33        *
* 1308  57   .621          .16       3.2                                  *
* 1308                                                                    *
* 1309 10000000    39   30   00   010   6001000  1000000  7.0  010  010 *
* 1309 6001  01000  10000  000  -4   20   425   77 0000001000  33        *
* 1309  56   .809         1.13       2.9                                  *
* 1309                                                                    *
* 1310 10000000    30   30   11   100   6001000  0000001  4.5  010  010 *
* 1310 7001  01000  00001  010 -14   20   425   25 0000001000  33        *
* 1310  47   .527          .08       3.6                                  *
* 1310                                                                    *
* 1311 10000000    39   30   11   001   4000100  1000000  4.7  010  001 *
* 1311 7001  00100  11100  000 -16   20   425   61 0000001000  33        *
* 1311  30   .358          .30       3.5                                  *
* 1311                                                                    *
* 1312 10000000    39   36   11   101   6001000  0100000  5.5  010  010 *
* 1312 6001  00000  00001  010 -20   20   425   57 0000001000  33        *
* 1312  26   .343          .24       3.2                                  *
* 1312                                                                    *
* 1313 10000000    39   30   11   001   6001000  0100000  6.0  010  010 *
* 1313 6001  01000  00001  010 -10   20   425   51 0000001000  33        *
* 1313  25   .372          .40       3.9                                  *
* 1313                                                                    *
* 1314 10000000    39   36   11   001   4000100  1000000  4.4  100  001 *
* 1314 6001  00000  00001  100 -18   20   425   44 0000001000  33        *
* 1314  24   .312          .30          *                                 *
* 1314                                                                    *
* 1315 10000000    39   30   11   001   4000100  1000000  4.4  100  001 *
* 1315 6001  10000  00001  100  -6   20   425   93 0000001000  33        *
* 1315   9   .141          .04       3.7                                  *
* 1315                                                                    *
*****************************************************************************
```

```
*****************************************************************************
* CFHR    A        B   C   DE   F    G   H        I       J     K     L   *
*****************************************************************************
* CFHR M N      O      P     Q    R    S     T      U      V      W        *
*****************************************************************************
* CFHR  X   Y              7          SI                                   *
*****************************************************************************
* CFHR  PX  PY             PZ         PSI                                  *
*****************************************************************************

* 1702 01000000    39  24   00  010  4000010  0000001  6.0  100  001 *
* 1702 6001  10000  00000  100  92  43  425  92 0000000100  30       *
* 1702 125  2.891         1.58       3.4                             *
* 1702                                                               *
* 1703 10000000    39  24   10  001  4000010  1000000  4.5  100  001 *
* 1703 0000  00100  00000  100   6  45  425  50 0000000100  30       *
* 1703  79  1.800         1.43       3.4                             *
* 1703                                                               *
* 1704 10000000    39  24   10  010  4000010  1000000  5.0  100  001 *
* 1704 6001  01000  00100  100   7  44  425  69 0000000100  30       *
* 1704  78  1.181         0.09       3.4                             *
* 1704                                                               *
* 1705 10000000    39  30   11  100  4000010  1000000  5.0  100  001 *
* 1705 6001  01000  10000  001   3  50  425 100 0000000100  30       *
* 1705  66  1.790         1.14       3.6                             *
* 1705                                                               *
* 1706 10000000    39  36   11  100  4000010  1000000  4.5  100  001 *
* 1706 6001  00100  00001  100   5  46  425   8 0000000100  30       *
* 1706  56  1.344          .45       4.0                             *
* 1706                                                               *
* 1707 10000000    39  30   11  100  4000010  1000000  4.5  100  001 *
* 1707 6001  00100  00001  100   6  48  425  60 0000000100  30       *
* 1707  36   .908          .37       3.9                             *
* 1707                                                               *
* 1709 10000000    39  30   11  100  4000010  1000000  4.5  100  001 *
* 1709 6001  00100  00001  100   4  46  425  58 0000000100  30       *
* 1709  34   .891         1.09       3.6                             *
* 1709                                                               *
* 1901 10000000    39  24   01  100  6010000  0100000  6.0  100  100 *
* 1901 6000  00100  01000  010  30  60  420  11 0000000010  25       *
* 1901 114  3.817          .50       3.4                             *
* 1901                                                               *
* 1902 10000000    39  24   01  100  6010000  0100000  4.0  010  010 *
* 1902 6000  00100  00001  010  26  60  420  25 0000000010  25       *
* 1902 107  1.978         2.96       3.3                             *
* 1902                                                               *
* 1904 00000010    40  10   00  001  6010000  0100000  6.0  100  100 *
* 1904 6000  00100  00001  010  20  60  420  40 0000000010  25       *
* 1904  91  1.876          .54       3.3                             *
* 1904                                                               *
* 1905 00001000    40  30   00  001  6010000  0100000  6.0  010  100 *
* 1905 6000  00100  00001  010  24  60  420   6 0000000010  25       *
* 1905  90  2.879         5.59       3.5                             *
* 1905                                                               *
*****************************************************************************
```

```
*****************************************************************
* CFHR    A        B   C   DE   F   G   H       I      J    K    L  *
*****************************************************************
* CFHR M N      O      P    Q    R    S    T    U     V       W     *
*****************************************************************
* CFHR  X  Y               Z         SI                             *
*****************************************************************
* CFHR  PX  PY             PZ        PSI                            *
*****************************************************************

* 1906 10000000    40  30  00  001  6010000  0100000  6.0  010  100 *
* 1906 6000  00100  00001  010  25  60  420    0 0000000010  25     *
* 1906  89  2.885          6.77        3.4                          *
* 1906                                                              *
* 1907 00000001    39  30  00  001  6001000  0100000  6.0  010  100 *
* 190712000  00100  00001  010  24  60  420    0 0000000010  25     *
* 1907  83  3.295           .57        3.1                          *
* 1907                                                              *
* 1908 10000000    39  30  00  001  6010000  0100000  4.0  010  100 *
* 1908 6000  00100  00100  010  28  60  420   72 0000000010  25     *
* 1908  80  1.832          1.12        3.3                          *
* 1908                                                              *
* 1909 10000000    39  30  00  001  6001000  0100000  4.0  010  100 *
* 1909 8001  00100  01000  010  26  60  420   86 0000000010  25     *
* 1909  77  1.519          1.92        3.4                          *
* 1909                                                              *
* 1910 00000001    39  30  00  001  6001000  0100000  4.5  010  100 *
* 1910 8011  00100  01000  010  21  60  420   40 1020000010  25     *
* 1910  44   .698           .46        3.5                          *
* 1910                                                              *
* 1912 00000001    46  36  11  100  7000100  0100000  4.5  010  100 *
* 1912 8001  00100  00001  100  21  60  420   40 0000000010  25     *
* 1912  44  1.089           .07        3.9                          *
* 1912                                                              *
* 1913 10000000    46  36  11  001  7000100  0100000  5.2  010  100 *
* 1913 6001  00001  10000  000  25  60  420   63 0000000010  25     *
* 1913  35   .877           .15        3.9                          *
* 1913                                                              *
* 1914 00000001    46  30  11  001  6000100  0100000  5.2  010  100 *
* 1914 8001  00001  00001  100  24  60  420   78 0000000010  25     *
* 1914  31   .744           .43        3.8                          *
* 1914                                                              *
* 2002 10000000    39  24  00  100  6100000  0000010  0.0  000  000 *
* 2002 0000  10000  10000  100  26  25  415  100 0000000001  32     *
* 2002 133  3.574           .00        3.4                          *
* 2002                                                              *
* 2003 10000000    39  24  00  100  6100000  0100000  4.0  010  100 *
* 2003 8001  10000  10000  000  26  25  415   78 0000000001  32     *
* 2003 131   .153           .12        3.2                          *
* 2003                                                              *
* 2004 10000000    39  24  00  001  6000010  0000010  0.0  000  000 *
* 2004 6001  10000  10000  100  26  25  415   62 0000000001  32     *
* 2004 130  2.449          8.40        3.0                          *
* 2004                                                              *
*****************************************************************
```

```
*******************************************************************
* CFHR   A          B   C   DE   F    G    H        I     J    K    L   *
*******************************************************************
* CFHR M N       O        P       Q    R    S     T     U     V      W   *
*******************************************************************
* CFHR  X   Y              Z          SI                               *
*******************************************************************
* CFHR  PX  PY             PZ         PSI                              *
*******************************************************************

* 2009 01000000    39  24  01  100  6000010  0000010  7.0  010  010 *
* 2009 6001  10000  00001  010  26  25  415  42 0000000001  32      *
* 2009 113  2.220        3.46       3.4                             *
* 2009                                                              *
* 2011 01000000    39  24  00  100  4000010  0000010  7.0  010  000 *
* 2011 6001  10000  10000  010  26  25  415  56 0000000001  32      *
* 2011 102  1.327        3.13       2.5                             *
* 2011                                                              *
* 2014 10000000    39  24  00  100  5001000  0010000  7.0  010  100 *
* 2014 0000  10000  10000  010  20  25  415   0 0000000001  32      *
* 2014  91  2.095        2.01       2.6                             *
* 2014                                                              *
* 2015 10000000    39  24  01  100  4000010  0000100  5.0  010  100 *
* 2015 6001  10000  10000  010  26  25  415  41 0000000001  32      *
* 2015  82   .491        1.59       2.9                             *
* 2015                                                              *
* 2017 10000000    39  30  01  010  4000010  1000000  6.0  010  010 *
* 2017 6001  10000  10000  010  26  25  415  55 0000000001  32      *
* 2017  57   .304         .00       3.1                             *
* 2017                                                              *
* 2019 10000000    46  30  00  001  6000010  1000000  8.0  010  010 *
* 2019 6001  10000  00010  010  26  25  415  37 0000000001  32      *
* 2019  35  1.091         .26       2.9                             *
* 2019                                                              *
* 2501 10000000    39  30  11  001  4000010  1000000  5.0  100  001 *
* 2501 0000  10000  10000  100 -10  80  460   0 0000000100  19      *
* 2501  71  1.222         .03       3.9                             *
* 2501                                                              *
* 2502 10000000    39  30  11  001  4000010  1000000  5.0  100  001 *
* 250215000  10000  10000  100  -8  80  460   0 0000000100  19      *
* 2502  48   .833         .00       4.0                             *
* 2502                                                              *
* 2503 10000000    39  36  11  001  4000010  1000000  6.5  100  001 *
* 2503 0000  10000  10000  100  -6  80  460   0 0000000100  19      *
* 2503  11   .218         .00       3.6                             *
* 2503                                                              *
*  101 01000000    39  24  00  010  6001000  1000000  5.5  010  100 *
*  101 6000  01000  00001  010  16  55  425  83 0000000100  21      *
*  101 171  9,466        3,8        *                               *
*  101 120  2.536        2.91       2.9                             *
*  102 00000010    39  24  00  010  6001000  1000000  6.0  010  100 *
*  102 6000  01000  10000  000  17  55  426  83 0000000100  21      *
*  102 156  8,658        1,21       *                               *
*  102 105  2.195        1.21       2.8                             *
*******************************************************************
```

```
****************************************************************
* CFHR    A          B  C   DE   F   G    H        I     J   K   L *
****************************************************************
* CFHR M N    O      P     Q    R    S     T     U     V      W    *
****************************************************************
* CFHR  X   Y                 Z        SI                          *
****************************************************************
* CFHR  PX  PY                PZ       PSI                         *
****************************************************************

*   103 00000010   39  24  00  010  6001000  1000000  6.0  010  100 *
*   103 6000  01000  00001  010  18  55  427  36 0000000100  21     *
*   103 155  8.635         1.20       3.4                           *
*   103 104  2.184         1.02       3.1                           *
*   104 00000010   39  24  00  010  6001000  1000000  6.0  010  100 *
*   104 6000  01000  00001  010  19  55  428  40 0000000100  21     *
*   104 152  7.893         1.15       3.6                           *
*   104 101  1.950          .87       3.2                           *
*   105 01000000   39  30  11  001  6001000  0001000  2.0  010  100 *
*   105 6001  01000  10000  010  10  70  430 100 0000000100  21     *
*   105 132  5.294         4.40       3.7                           *
*   105  81   .930          .78       3.4                           *
*   301 00100000   39  24  20  100  4000100  0000001  4.0  010  010 *
*   301 6400  00100  00100  000  -8  70  456  31 0000000100  22     *
*   301 168  3.501          .37       3.5                           *
*   301 116   .987          .28       2.8                           *
*   307 00100000   39  30  10  100  4001000  0000001  4.0  010  010 *
*   307 6000  00000  00001  001  -6  70  452  40 0000000100  22     *
*   307 116  1.784          .80       3.0                           *
*   307  64   .493          .00       2.7                           *
*   310 00100000   39  30  01  100  4000010  0010000  4.0  100  100 *
*   310 0000  00000  10000  100 -15  70  460   0 0000000100  22     *
*   310 107   .539          .00       3.8                           *
*   310  55   .080          .00       3.3                           *
*   314 00100000   39  30  11  001  4001000  0000001  4.0  010  010 *
*   314 0000  01000  00100  000  -6  70  452  37 0000000100  22     *
*   314  70  2.715          .62       3.4                           *
*   314  18   .303          .00       3.2                           *
*   402 10000000   39  24  00  001  6000010  1000000  2.5  001  100 *
*   402 6001  00010  10000  001 -18 100  475 100 0100000000   9     *
*   402 166 13.022          .00       2.7                           *
*   402 114  4.364          0.0       2.5                           *
*   403 10000000   39  24  10  100  6001000  1000000  2.0  010  010 *
*   403 6001  00010  10000  010 -18 100  475 100 0100000000   9     *
*   403 153 13.374          .00       3.2                           *
*   403 101  4.447          0.0       3.0                           *
*   404 10000000   39  24  10  100  6001000  1000000  2.0  010  010 *
*   404 6001  00100  10000  010 -19 100  475 100 0100000000   9     *
*   404 144  9.866          .00       3.1                           *
*   404  92  3.008          0.0       2.8                           *
*   406 10000000   39  30  00  001  6000100  0100000  2.5  100  100 *
*   406 6001  00100  00001  100 -18 100  475 100 0100000000   9     *
*   406 140  6.095         6.32       3.1                           *
*   406  88  2.057         1.28       3.1                           *
****************************************************************
```

```
**********************************************************************
* CFHR    A         B   C   DE   F    G    H         I    J    K   L *
**********************************************************************
* CFHR M N     O       P     Q    R    S      T      U      V     W  *
**********************************************************************
* CFHR  X   Y                 Z             SI                       *
**********************************************************************
* CFHR  PX  PY                PZ            PSI                      *
**********************************************************************

*    408 10000000    39  30  11  100  6001000  1000000  2.0  010  010 *
*    408 6001   00100  00001  010 -20 100  475 100 0100000000    9    *
*    408 117  4.449          .11        3.5                           *
*    408  65  1.325          0.0        3.3                           *
*    410 10000000    39  36  11  100  6000100  1000000  2.0  001  010 *
*    410 0001   10000  00001  001 -20 100  475 100 0100000000    9    *
*    410  74  2.714          .48        3.6                           *
*    410  22   .498          .14        3.6                           *
*    907 10000000    39  24  00  010  6000001  0001000  2.5  001  100 *
*    907 6001   00100  10000  000   8  50  430  20 0000000100  28     *
*    907 148  9.740         3.61        *                             *
*    907  98  1.850         1.99        *                             *
*    908 10000000    39  24  00  100  4000010  0010000  2.5  001  100 *
*    908 6001   00100  10000  000   8  50  430 100 0000000100  28     *
*    908 141  8.471         8.65        2.4                           *
*    908  91  1.164         2.28        2.6                           *
*   1001 00010000    39  24  00  100 10001000  1000000  0.0  000  000 *
*   1001 0000   01000  10000  000  10  50  425  38 0000000010  24     *
*   1001 182  9.331         8.15        *                             *
*   1001 132  4.197         3.06        3.2                           *
*   1002 00001000    39  24  00  100  4001000  1000000  0.0  000  000 *
*   1002 0000   01000  00001  010  11  50  425   0 0000000010  24     *
*   1002 180  9.571         2.12        *                             *
*   1002 130  3.331          .45        3.3                           *
*   1003 00010000    39  24  00  100  0000000  0000000  0.0  000  000 *
*   1003 0000   01000  00001  010  12  50  425   0 0000000010  24     *
*   1003 175  9.803         6.93        *                             *
*   1003 125  3.550         2.23        3.2                           *
*   1004 00010000    39  24  00  100  6001000  1000000  3.0  010  010 *
*   1004 0000   01000  00001  010  12  50  425  38 0000000010  24     *
*   1004 175  9.273        18.66        *                             *
*   1004 125  3.520         3.62        3.0                           *
*   1005 00000000    39  24  00  100  6001000  1000000  4.0  010  010 *
*   1005 0000   01000  10000  000  13  50  425   0 0000000010  24     *
*   1005 166  7.965         1.54        *                             *
*   1005 116  3.850          .93        3.0                           *
*   1006 00010000    39  24  00  100  6001000  1000000  4.0  010  010 *
*   1006 0000   01000  10000  000  14  50  424 100 0000000010  24     *
*   1006 155  9.653         7.34        *                             *
*   1006 105  2.860         3.86        3.1                           *
*   1007 00010000    39  24  00  100  6001000  1000000  3.0  010  010 *
*   1007 0000   01000  10000  000  14  50  424  47 0000000010  24     *
*   1007 155  9.465        11.39        *                             *
*   1007 105  2.840         6.65        3.1                           *
**********************************************************************
```

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*****************************************************************
* CFHR    A        B    C    DE   F    G    H        I     J    K    L  *
*****************************************************************
* CFHR M N      O       P       Q    R    S     T      U      V      W      *
*****************************************************************
* CFHR  X   Y                 Z         SI                                 *
*****************************************************************
* CFHR  PX  PY                PZ        PSI                                *
*****************************************************************

* 1008 00000100   39  24  00  001  6001000  1000000  3.0  010  010 *
* 1008 0000  01000  00001  010  15  50  424   0 0000000010  24     *
* 1008 154  6,410          9,01       3,7                          *
* 1008 104  2.334          2.69       3.5                          *
* 1009 01000000   39  24  01  100  6001000  1000000  3.0  010  010 *
* 1009 0000  01000  00001  010  16  50  424   0 0000000010  24     *
* 1009 150  9,158          4.05       *                            *
* 1009 100  2.610           .66       3.4                          *
* 1010 00010000   39  24  00  100  6001000  1000000  3.0  010  010 *
* 1010 0000  01000  00001  010  16  50  424   0 0000000010  24     *
* 1010 147  8,226         10,16       *                            *
* 1010  97  2.444          5.26       3.1                          *
* 1011 00000100   39  24  01  100  6001000  1000000  3.0  010  010 *
* 1011 0000  01000  00001  010  17  50  422   0 0000000010  24     *
* 1011 143  6.768          4.75       3,7                          *
* 1011  93  1.994           .88       3.4                          *
* 1012 00000100   39  30  01  100  6001000  1000000  3.0  010  010 *
* 1012 0000  01000  00001  010  18  50  422   2 0000000010  24     *
* 1012 130  8,549          3,29       3,8                          *
* 1012  84  1.940          1.33       3.4                          *
* 1014 00000100   39  24  00  100  6001000  1000000  3.0  010  010 *
* 1014 0000  01000  00001  010  20  50  422   0 0000000010  24     *
* 1014 149  7.888         17.04       *                            *
* 1014  99  2.070          5.68       3.2                          *
* 1301 10000000   39  24  00  100  6001000  0100000  4.0  010  100 *
* 1301 8001  01000  00001  010  -8  20  425  80 0000001000  33     *
* 1301 173  3,270          7,33       3,2                          *
* 1301 119  1.334          1.12       3.1                          *
* 1302 10000000   39  24  00  100  6001000  0100000  6.0  010  100 *
* 1302 0000  01000  00001  010  -6  20  425  80 0000001000  33     *
* 1302 144  3,217          8,33       3,3                          *
* 1302  90  1.141           .871      3.2                          *
* 1303 10000000   39  30  10  010  6001000  0100000  5.0  010  100 *
* 1303 6001  01000  00001  010  -8  20  425  25 0000001000  33     *
* 1303 121  2,709          2,10       *                            *
* 1303  67   .460           .83       3.2                          *
* 1304 10000000   39  30  10  010  6001000  0100000  4.5  010  100 *
* 1304 6001  01000  00001  010 -10  20  425  96 0000001000  33     *
* 1304 115  2,112          2,18       *                            *
* 1304  61   .687           .83       *                            *
* 1305 10000000   39  30  11  001  6001000  0100000  4.5  010  100 *
* 1305 6000  01000  00001  010 -10  20  425  25 0000001000  33     *
* 1305 111  2,257           .35       3,0                          *
* 1305  57   .441          0.0        3.1                          *
*****************************************************************
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*************************************************************************
* CFHR    A          B   C    DE    F    G    H          I        J    K    L  *
*************************************************************************
* CFHR M N      O       P      Q    R    S       T       U       V        W      *
*************************************************************************
* CFHR  X   Y                 Z           SI                                    *
*************************************************************************
* CFHR  PX  PY                P7          PSI                                   *
*************************************************************************

* 1307 10000000    39  30  11  001  6001000  0100000  4.5  010  100 *
* 1307 6000  01000  00001  010 -12  20  425  25 0000001000  33      *
* 1307 135  2.406          .37       *                              *
* 1307  81   .020          .37      3.4                             *
* 1308 10000000    39  30  00  010  6001000  0000001  4.4  010  010 *
* 1308 0000  01000  00001  010 -12  20  425  97 0000001000  33      *
* 1308 111  2.125          .57      3.1                             *
* 1308  57   .621          .16      3.2                             *
* 1309 10000000    39  30  00  010  6001000  1000000  7.0  010  010 *
* 1309 6001  01000  10000  000  -4  20  425  77 0000001000  33      *
* 1309 112  4.089        3.88       3.4                             *
* 1309  56   .809        1.13       2.9                             *
* 1310 10000000    39  30  11  100  6001000  0000001  4.5  010  010 *
* 1310 7001  01000  00001  010 -14  20  425  25 0000001000  33      *
* 1310 101  1.955        3.92       3.3                             *
* 1310  47   .527          .08      3.4                             *
* 1311 10000000    39  30  11  001  4000100  1000000  4.7  010  001 *
* 1311 7001  00100  10000  000 -16  20  425  61 0000001000  33      *
* 1311  84  1.775        1.43       3.7                             *
* 1311  30   .358          .34      3.5                             *
* 1312 10000000    39  36  11  001  6001000  0100000  5.5  010  010 *
* 1312 6001  00000  00001  010 -20  20  425  57 0000001000  33      *
* 1312  80  1.632        1.37       3.1                             *
* 1312  26   .343          .24      3.2                             *
* 1314 10000000    39  36  11  001  4000100  1000000  4.4  100  001 *
* 1314 6001  00000  00001  100 -18  20  425  44 0000001000  33      *
* 1314  78  1.627        1.07       3.7                             *
* 1314  24   .312         0.0       *                               *
* 1315 10000000    39  30  11  001  4000100  1000000  4.4  100  001 *
* 1315 6001  10000  00001  100  -6  20  425  93 0000001000  33      *
* 1315  63  2.272          .19      3.7                             *
* 1315   9   .141          .04      3.7                             *
* 1703 10000000    39  24  10  001  4000010  1000000  4.5  100  001 *
* 1703 0000  00100  00000  100   6  45  425  50 0000000100  30      *
* 1703 132  9.051        3.47       3.3                             *
* 1703  79  1.800        1.43       3.4                             *
* 1705 10000000    39  30  11  100  4000010  1000000  5.0  100  001 *
* 1705 6001  01000  10000  001   3  50  425 100 0000000100  30      *
* 1705 119  8.581        4.12       3.6                             *
* 1705  66  1.790        1.14       3.6                             *
* 1706 10000000    39  36  11  100  4000010  1000000  4.5  100  001 *
* 1706 6001  00100  00001  100   5  46  425   8 0000000100  30      *
* 1706 109  7.712          .64      4.1                             *
* 1706  56  1.344          .45      4.0                             *
*************************************************************************
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***************************************************************
* CFHR    A        B   C   DE   F   G   H       I     J    K    L  *
***************************************************************
* CFHR M N     O      P     Q    R    S    T    U    V     W       *
***************************************************************
* CFHR  X   Y               Z         SI                            *
***************************************************************
* CFHR  PX  PY              PZ        PSI                           *
***************************************************************

* 1707 10000000    39  30  11  100  4000010  1000000  4.5  100  001 *
* 1707 6001  00100  00001  100   6  48  425  60 0000000100  30      *
* 1707  89  6,416          3,28       3,7                           *
* 1707  36   .908           .37       3.9                           *
* 1709 10000000    39  30  11  100  4000010  1000000  4.5  100  001 *
* 1709 6001  00100  00001  100   4  46  425  58 0000000100  30      *
* 1709  87  7,066          4,15       3,9                           *
* 1709  34   .891          1.09       4.0                           *
* 1901 10000000    39  24  01  100  6010000  0100000  6.0  100  100 *
* 1901 6000  00100  01000  010  30  60  420  11 0000000010  25      *
* 1901 165 10,644          3,11       3,5                           *
* 1901 114  3.817           .50       3.4                           *
* 1902 10000000    39  24  01  100  6010000  0100000  4.0  010  010 *
* 1902 6000  00100  00001  010  26  60  420  25 0000000010  25      *
* 1902 158  9,373         11,22       3,4                           *
* 1902 107  1.978          2.96       3.3                           *
* 1904 00000010    40  10  00  001  6010000  0100000  6.0  100  100 *
* 1904 6000  00100  00001  010  20  60  420  40 0000000010  25      *
* 1904 142  7,785           ,54       3,3                           *
* 1904  91  1.876           .54       3.3                           *
* 1905 00001000    40  30  00  001  6010000  0100000  6.0  010  100 *
* 1905 6000  00100  00001  010  24  60  420   6 0000000010  25      *
* 1905 142  8,503         11,19       3,6                           *
* 1905  90  2.879          5.59       2.9                           *
* 1906 10000000    40  30  00  001  6010000  0100000  6.0  010  100 *
* 1906 6000  00100  00001  010  25  60  420   0 0000000010  25      *
* 1906 141  8,620         21,29       3,4                           *
* 1906  89  2.885          6.77       3.4                           *
* 1907 00000001    39  30  00  001  6001000  0100000  6.0  010  100 *
* 19071200   00100  00001  010  24  60  420   0 0000000010  25      *
* 1907 140 10,086          2,02       3,3                           *
* 1907  83  3.295           .57       3.1                           *
* 1910 00000001    39  30  00  001  6001000  0100000  4.5  010  100 *
* 1910 8011  00100  01000  010  21  60  420  40 0000000010  25      *
* 1910 128  4,643          3,38       3,5                           *
* 1910  44   .698           .46       3.5                           *
* 1912 00000001    46  36  11  100  7000100  0100000  4.5  010  100 *
* 1912 8001  00100  00001  100  21  60  420  40 0000000010  25      *
* 1912  95  5,947           ,58       3,9                           *
* 1912  44  1.089           .07       3.9                           *
* 1913 10000000    46  36  11  001  7000100  0100000  5.2  010  100 *
* 1913 6001  00001  10000  000  25  60  420  63 0000000010  25      *
* 1913  86  5,162           ,61       4,2                           *
* 1913  35   .877           .15       3.9                           *
***************************************************************
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*************************************************************************
* CFHR    A        B    C   DF   F    G    H       I       J     K    L  *
*************************************************************************
* CFHR M N     O       P     Q    R    S    T     U      V       W       *
*************************************************************************
* CFHR  X    Y                Z           SI                             *
*************************************************************************
* CFHR  PX   PY              PZ           PSI                            *
*************************************************************************

* 1914 00000001    46   30   11   001   6000100   0100000   5.2   010   100 *
* 1914 8001   00001   00001  100   24   60   420   78 0000000010   25       *
* 1914   82  5.135             .94         4.2                               *
* 1914   31   .744             .43         3.8                               *
* 2501 10000000    39   30   11   001   4000010   1000000   5.0   100   001 *
* 2501 0000   10000   10000  100 -10   80   460    0 0000000100   19        *
* 2501  122  3.641             .13         4.3                               *
* 2501   71  1.222             .03         3.9                               *
* 2502 10000000    39   30   11   001   4000010   1000000   5.0   100   001 *
* 250215000   10000   10000  100   -8   80   460    0 0000000100   19       *
* 2502   99  3.018             .08         4.3                               *
* 2502   48   .833             0.0         4.0                               *
* 2503 10000000    39   36   11   001   4000010   1000000   6.5   100   001 *
* 2503 0000   10000   10000  100   -6   80   460    0 0000000100   19       *
* 2503   62  2.285             .35         3.7                               *
* 2503   11   .218             0.0         3.6                               *
*************************************************************************
```

APPENDIX G

CORRELATION MATRIX FOR DATA USED IN ANOVA AND DISTRESS PREDICTION MODEL ANALYSIS

CORRELATION MATRIX

VARIABLE NUMBER	1	2	3	4	5	6	7	8	9	.
1	1.	-.283	-.373	-.266	.213	-. 16	.133	. 32	-. 21	-. 13
2		1.	-. 86	-. 61	. 62	-. 16	-.155	-. 65	.234	-. 5
3			1.	-. 81	. 67	-.321	-.2 6	.289	. 44	.154
4				1.	-.211	.132	-. 12	-. 61	-. 49	-. 23
5					1.	. 42	-. 13	-. 53	. 96	. 15
6						1.	-.533	-.243	-.197	-.112
7							1.	-.155	-.126	-. 72
8								1.	-. 53	-. 3
9									1.	-. 24
1.										1.

VARIABLE NUMBER	11	12	13	14	15	16	17	18	19	20
1	-. 17	-.173	.513	-.373	-.17	.347	.199	-.235	-. 73	-.141
2	.3 6	. 14	. 55	.3 1	-. 36	.1 1	. 5	.132	. 3	. 9
3	-. 56	.58	-.3 4	-.283	.26	-.141	-.153	-.217	-.189	-.117
4	-. 4	-. 78	-.217	.156	. 4	. 15	-.1 9	.143	-.1 1	.1
5	-. 63	-. 4	.173	-.212	. 21	-. 91	.75	-.5 1	-.327	-.19
6	-.159	-.3 9	-. 39	-. 92	.164	-. 11	-.277	. 81	-. 12	.123
7	-.1 2	-.198	. 93	.138	-.169	-. 13	.221	-. 21	. 7	. 13
8	-. 43	-. 83	-. 2	-. 83	. 41	-. 18	. 31	-.121	.	-. 92
9	-. 35	-. 67	. 9	. 22	. 75	. 5	-. 45	-. 69	-. 46	-. 1
1	-. 2	-. 38	. 12	. 25	-. 25	-. 58	. 35	-. 7	-. 5	-. 96
11	1.	-. 54	.1	.2 4	-.2 1	. 81	.179	. 79	. 42	-.123
12		1.	-.153	-.141	. 19	. 57	. 35	-.133	-.149	-. 73
13			1.	-.175	-. 95	.548	.112	-.251	-. 91	-.13
14				1.	-.161	-.217	.213	.272	.272	. 4
15					1.	. 78	-.947	. 52	-. 86	. 7
16						1.	-.132	-. 87	-. 77	-. 95
17							1.	-.129	. 96	-.117
18								1.	.461	.755
19									1.	.375
20										1.

VARIABLE NUMBER	21	22	23	24	25	26	27	28	29	30
1	-.181	-.126	.833	-.276	-.318	-.26	.131	-.229	.185	. 7
2	-. 1	.174	-.236	.977	-. 73	-. 6	.175	. 47	-.141	-. 6
3	-.137	-.129	-.311	-.184	.852	-. 79	-. 53	-.277	-.187	.154
4	-. 15	. 64	-.211	-. 6	-. 69	.978	-.173	.191	. 12	-. 56
5	-.241	-.43	-. 8	. 46	-. 47	-.2 6	.823	-.166	-. 79	-. 94
6	.116	-. 65	-.129	.179	-.274	.137	. 37	.863	-.528	-.224
7	. 27	-. 49	.231	-.153	-.176	-. 21	. 39	-.513	.5 6	-.144
8	-. 57	.1 4	. 81	-. 64	.211	-. 6	-. 57	-.21	-.141	.92
9	-. 14	-. 82	-. 13	.194	-. 33	-. 48	. 53	-.17	-.119	-. 43
10	-. 5	.115	-. 19	-. 29	.22	-. 28	. 21	-. 97	-. 65	-. 28
11	-. 71	.288	. 49	.26	-. 48	-. 39	-. 17	-.138	-. 93	-. 39
12	-.127	-. 91	-.154	. 16	.335	-. 76	-. 77	-.267	-.18	-. 75
13	-.217	-. 92	.385	. 28	-.259	-.212	.159	-.2 3	. 1	. 59
14	.21	.325	-.255	.296	-.242	.181	-. 5	. 23	.148	-. 37
15	-. 19	-. 27	-. 62	-. 32	.221	. 39	. 27	.19	-.136	. 1
16	-.146	. 22	.324	. 98	-.141	. 17	-.172	-. 52	-. 44	. 55
17	-. 3	-. 11	. 83	-. 4	-.13	-.1 9	. 29	-.333	.183	. 53
18	.485	.313	.136	.161	-. 13	.175	-. 56	.43	.186	. 71
19	.681	.133	.133	. 14	-.155	-. 97	-.136	.139	.124	.313
20	.63	-.386	.138	. 59	-. 6	.153	. 71	.4 7	.18	-. 56
21	1.	-.23	-. 34	. 21	-.111	. 3	-.122	.295	.137	-. 3
22		1.	. 76	.142	-. 9	. 24	-.135	.313		.181
23			1.	-.23	-.265	-.217	.147	-.147	.34	.174
24				1.	-. 72	-. 59	.157	. 85	-.138	-. 38
25					1.	-. 67	-. 55	-.236	-.159	.133
26						1.	-.17	.211	. 8	-. 55
27							1.	-. 23	. 71	-. 72
28								1.	-.456	-.193
29									1.	-. 5
30										1.

VARIABLE NUMBER	31	32	33	34	35	36	37	38	39	[illegible]
1	-. 2	-. 3	-.	-.158	.434	-.396	-.224	.214	-.126	-.247
2	.266	-. 7	.27	. 57	.11	.324	. 58	.167	.123	.113
3	-. 37	.182	-. 56	.483	-.259	-.249	-. 17	-.193	-.242	-.184
4	-. 43	-. 28	-. 4	-. 68	-.185	.2 5	.131	. 92	. 62	.135
5	. 31	-. 3	-. 67	-. 95	-. 42	-.193	-.337	-.333	-.4 7	-.469
6	-.172	-.111	-.159	-.272	-.1 7	-. 65	.199	. 13	-.121	. 96
7	-.11	-. 71	-.1 2	-.174	. 57	. 79	-.125	-. 31	.111	-. 39
8	-. 46	-. 3	-. 42	-. 73	. 98	-. 64	-. 11	. 45	. 23	-. 29
9	.873	-. 24	-. 34	-. 59	.149	.	-.112	. 14	-. 64	-. 4
1	-. 21	.988	-. 2	-. 33	. 4	-. 7	-.122	-. 51	. 9	-. 99
11	-. 3	-. 19	.994	-. 48	.153	.213	-.1 7	.127	.194	. 54
12	-. 58	-. 38	-. 54	.879	-.126	-. 99	-. 92	-. 23	-. 93	-.126
13	.161	-. 6	. 91	-.121	.852	-.247	-.168	.359	-.2 5	-.253
14	. 34	. 7	.2 2	-. 57	-.13	.94	.142	-. 91	.387	.247
15	. 55	-.	-.2	. 1	. 23	-.18	.671	.122	-.447	. 4
16	. 49	-. 63	. 88	. 4	.529	-.148	. 27	.823	-.165	-. 32
17	-. 16	. 22	.177	. 4	-. 13	.217	-.7 4	-.193	.42	-.133
18	. 49	-. 1	. 31	. 26	.117	.32	.718	.39	.618	.971
19	-. 2	-. 56	. 43	-.116	. 67	.33	.244	.133	.5 3	.498
2	. 71	-. 95	-.122	. 15	. 33	.113	.593	.234	.593	.925
21	. 31	-. 49	-. 7	-.1 6	-.126	.3 8	.3 7	. 49	.434	.333
22	-. 33	.122	.294	. 15	.117	.287	.166	.21	.3 7	.169
23	. 46	-. 33	. 69	-.134	.553	-.292	.115	.432	.22	. 54
24	.237	-. 29	.229	. 59	. 87	.33	.383	.183	.14	.151
25	-. 46	.256	-. 49	.637	-.221	-.244	.139	-.114	-. 74	-. 18
26	-. 42	-. 27	-. 39	-. 67	-.181	.212	.15	.1 7	. 82	.171
27	. 67	. 5	-. 21	-. 85	. 15	-. 38	-. 31	-.217	-. 29	-.1 8
28	-.148	-. 96	-.137	-.235	-.119	. 57	.435	.141	.151	.44
29	-.1	-. 64	-. 92	-.158	. 79	.131	. 14	. 41	.236	.162
3	-. 42	-. 27	-. 39	-. 67	.129	-. 27	.14	.147	.119	. 59
31	1.	-. 21	-. 3	-. 51	.241	. 24	. 69	. 61	. 48	. 44
32		1.	-. 19	-. 33	-. 11	-. 21	.3 4	-. 53	. 8	-. 23
33			1.	-. 47	.144	.215	-.115	.137	.199	. 5
34				1.	-. 83	-. 42	. 33	. 46	. 49	. 13
35					1.	-.2	.134	.581	. 76	. 78
36						1.	.154	-.117	.439	.313
37							1.	.374	.21	.7 2
38								1.	.22	.367
39									1.	.733
4°										1.

VARIABLE NUMBER	41	42	43	44	45
1	-.177	.471	-.245	-.287	-.359
2	-. 11	. 79	.341	.357	.235
3	-.139	-.168	-. 4	-.111	-.291
4	-. 16	-.19	-. 7	.153	.2 3
5	-.242	. 93	-. 3	-.116	-.15
6	.1	. 27	-.281	-.171	-.159
7	. 36	. 49	. 54	. 47	.271
8	-. 58	. 62	. 75	. 37	-.1 5
9	-. 16	. 45	. 73	. 73	. 44
10	-. 5	-. 12	. 55	. 35	-. 21
11	-. 71	. 35	.152	.227	. 74
12	-.128	-.174	.165	. 7	-.117
13	-.217	.89	. 13	-. 72	-.224
14	.21	-.23	.75	.839	.924
15	-. 21	.129	-.276	-.239	-.356
16	-.145	.728	-. 92	-. 36	-.293
17	-.	-.179	.391	.325	.435
18	.486	-.171	. 17	.119	.214
19	.682	-. 56	. 95	.121	.295
20	.631	-.128	-.12	-. 7	. 59
21	1.	-.188	-. 3	. 6	.233
22	-.23	-. 79	.195	.269	.215
23	-. 28	.4 3	-.217	-.235	-.283
24	. 2	. 53	.325	.354	.234
25	-.112	-.229	-. 1	-. 87	-.249
26	. 3	-.186	-. 1	.16	.193
27	-.123	. 15	-.	-. 54	-. 12
28	.288	-.1 6	-.234	-. 96	-. 55
29	.15	-. 6	. 15	. 17	.251
30	-. 32	.177	. 93	. 6	-. 53
31	. 29	. 91	. 91	. 67	. 54
32	-. 49	-. 41	. 45	. 25	-. 32
33	-. 71	. 72	.156	.231	. 74
34	-.1 7	-.17	.233	. 98	-. 52
35	-.12	.9 7	. 25	-. 48	-.229
36	.3 7	-.283	.655	.796	.882
37	.3 6	. 38	-.227	-.126	-.121
38	. 5	.948	-. 6	. 53	-.197
39	.437	-.244	.266	.314	.443
40	.535	-.159	-. 3	.1 1	.198
41	1.	-.196	-. 8	. 59	.235
42		1.	-. 3	-.147	-.334
43			1.	.913	.714
44				1.	.79
45					1.

SUB PROBLEM CARD

SUBPRO 19 - 1.32 1.32 - . 4 YES YES YES

APPENDIX H

COMPUTER PRINTOUT FROM STEPWISE REGRESSION ANALYSIS FOR DISTRESS PREDICTION MODEL DEVELOPMENT

DESCRIPTION OF VARIABLES

TABLE H.1. DESCRIPTION OF VARIABLES USED IN STEPWISE REGRESSION ANALYSIS (Ref 29)

Variable Number	Description
1	Concrete Aggregate - Siliceous River Gravel (SRG)
2	" " - Limestone (L)
3	" " - Limestone River Gravel (LRG)
4	" " - LRG + Slag
5	Slip Form Paver or other
6	Subbase Aggregate - Processed Material
7	" " - Natural Soil
8	" " - Pit Run Gravel
9	" " - Limestone
10	" " - Sand
11	" " - Shell Material
12	" " - Sandstone
13	Subgrade Stabilizer Type
14	Thornwaite Moisture Index
15	Average Annual No. of Freeze-Thaw Cycles
16	Subgrade Clay Content (percent)
17	Texas SDHPT Temperature Constant
18	Age of Pavement Section (months)
19	Failures Per Mile (punchouts + patches)
20	Age on Date of Previous Survey (months)
21	Failures per mile on Date of Previous Survey
22	Change in Age Since Date of Previous Survey
23	Interaction of No. 18 and No. 1
24	" " 18 " " 2
25	" " 18 " " 3
26	" " 18 " " 4
27	" " 18 " " 5
28	" " 18 " " 6
29	" " 18 " " 7

Continued

TABLE H.1. DESCRIPTION OF VARIABLES USED IN STEPWISE REGRESSION ANALYSIS (Ref 29)(Continued)

Variable Number	Description
30	Interaction of No. 18 and No. 8
31	" " " 18 " " 9
32	" " " 18 " " 10
33	" " " 18 " " 11
34	" " " 18 " " 12
35	" " " 18 " " 13
36	" " " 18 " " 14
37	" " " 18 " " 15
38	" " " 18 " " 16
39	" " " 18 " " 17
40	" " " 18 " " 18
41	" " " 22 " " 21
42	" " " 13 " " 16
43	" " " 14 " " 42
44	" " " 14 " " 16
45	" " " 14 " " 15

COMPUTER PRINTOUT EXCERPTS

(Reference 29)

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STEP 1 - STEPWISE REGRESSION,    VERSION OF NOVEMBER [illegible], 19[illegible]

CENTER FOR HIGHWAY RESEARCH, THE UNIVERSITY OF TEXAS AT AUSTIN
STEP 1 IS BASED ON BMD 2R

REGRESSION OF MACHADO'S DATA WITH LAST 31 VARIABLES TRAFFIC

PROBLEM CODE                      MACHAD
NUMBER OF CASES                    147
NUMBER OF ORIGINAL VARIABLES        21
NUMBER OF VARIABLES ADDED           24
TOTAL NUMBER OF VARIABLES           45
NUMBER OF SUB-PROBLEMS               1


PROBLEM CARD
PROBLM   MACHAD  147   21   34   24-  -     1  -  YES YES YES

TRANSGENERATION CARD(S)
TRNGEN 2212 16   2 .
TRNGEN 2313 18    1.
TRNGEN 2413 18    2.
TRNGEN 2513 18    3.
TRNGEN 2613 18    4.
TRNGEN 2713 18    5.
TRNGEN 2813 18    6.
TRNGEN 2913 18    7.
TRNGEN 3013 18    8.
TRNGEN 3113 18    9.
TRNGEN 3213 18   1 .
TRNGEN 3313 18   11.
TRNGEN 3413 18   12.
TRNGEN 3513 18   13.
TRNGEN 3613 18   14.
TRNGEN 3713 18   15.
TRNGEN 3813 18   16.
TRNGEN 3913 18   17.
TRNGEN 4013 18   16.
TRNGEN 4113 22   21.
TRNGEN 4213 13   16.
TRNGEN 4313 14   42.
TRNGEN 4413 14   16.
TRNGEN 4513 14   15.

VARIABLE FORMAT CARD(S)
(5X,3F1. ,3X,F1. ,13X,F1. ,[illegible]X,[illegible]F1. /[illegible]X,F1. ,2 X,F3. ,X,F3. ,[illegible]X,F3. ,13X
,F3. /5X,F3. ,1 X,F[illegible] ,2/5X,F3. ,1 X,F1[illegible])

LISTING OF DATA AS READ FROM INPUT FILE

  .          1.    E+     .          .        .              1.     E+     .            .              .        .
  .          .            .         1.[illegible]  [illegible]  3.5   E+ 1   [illegible].3  E+ 1  2.[illegible]  [illegible]+ 2  1.[illegible]  [illegible]+  [illegible].91  [illegible]+   - .
- .

  .          .            .         1.   [illegible]+.  .              1.     E+     .            .              .        .
  .          .            .         1.7   E+[illegible]1  3.5.  E+.1   8.3    E+ 1   2.1   [illegible]+ 2  1. 5  E+ 2   .21   E+   - .
- .
```

VARIABLE	MEAN	STANDARD DEVIATION
1	5.1 2 4 816E- 1	4.99 9 59 36E- 1
2	6.12244897[illegible]E- 2	2.4 5611671[illegible]E- 1
3	1. 2 4 8163[illegible]E- 1	3. 37368[illegible]64E- 1
4	5.44217687 7 E- 2	2.[illegible]236 56 E- 1
5	4.35374149[illegible]E- 1	4.[illegible] 5769[illegible]E- 1
6	4.7619 47619[illegible]E- 1	3. 14 [illegible]234[illegible]E- 1
7	2.721 8843 4[illegible]E- 1	4.45557157 [illegible]E- 1
8	6.12244897[illegible]E- 2	2.4 5611671[illegible]E- 1
9	4. 8163265[illegible]E- 1	1.3384 945[illegible]E- 1
10	1.36 544217[illegible]E- 1	1.15 4[illegible]2218[illegible]E- 1
11	2.721 8843 4[illegible]E- 1	1.63253[illegible]72[illegible]E- 1
12	9.5238 [illegible]E- 2	2.94 47 9449[illegible]E- 1
13	4.4897959[illegible] 4[illegible]E- 1	4.99 9 59 36E- 1
14	[illegible].3[illegible]9[illegible]7[illegible]E+	[illegible].7 53 945231E+ 1
15	5.[illegible]4[illegible]8[illegible]714[illegible]E+ 1	2.2[illegible]39847445E+ 1
16	4.748[illegible]E+ 1	3.62[illegible]9617697E+ 1
17	[illegible].4[illegible]E+ 1	6.6229 17298[illegible]E+ 1
18	9.[illegible]653 6[illegible]E+ 1	4.24415[illegible]619[illegible]E+ 1
19	2.7 931[illegible]72[illegible]E+	4.16[illegible]39139 E+
20	3.[illegible]993[illegible]97[illegible]E+ 1	4.353124[illegible]81 E+ 1
21	5.34217687 7E- 1	1.[illegible]7 [illegible]4212285E+
22	6.7[illegible]39446E+ 1	3. 1[illegible]1 9637 E+ 1
23	4.[illegible]6598638[illegible]E+ 1	5.4[illegible]237 77[illegible]E+ 1
24	7.44217687 7E+	[illegible].99[illegible]84895E+ 1
25	7.4[illegible]979[illegible]E+	2.6 [illegible]21[illegible]581E+ 1
26	6.[illegible]37[illegible]E+	[illegible].3[illegible]317446[illegible]E+ 1
27	3.28843[illegible]3741[illegible]E+ 1	4.5459[illegible]487[illegible]E+ 1
28	4.9[illegible]63[illegible]E+ 1	[illegible].93227237 E+ 1
29	2.6721 884[illegible]E+ 1	4.84 939[illegible]199[illegible]E+ 1
30	5.884353741[illegible]E+	2.51223 8213[illegible]E+ 1
31	3.4897959[illegible]45E+	1.945467769[illegible]E+
32	1.3197278[illegible]E+	1.1411353632[illegible]E+ 1
33	3.2[illegible]17 59 7[illegible]E+	1.9521 3176[illegible]E+ 1
34	7.78231[illegible]9[illegible]E+	2.7387 747 E+ 1
35	3.945[illegible]23[illegible]E+ 1	5.14[illegible]236[illegible]76[illegible]E+ 1
36	7.2587 748[illegible] E+ 2	1.8769183584E+ 3
37	5.275 2 4 [illegible]25E+ 3	3.273341465 E+ 3
38	4.6 5[illegible] 34 E+ 3	4.41972 6398[illegible]E+ 3
39	2.[illegible]5416326[illegible]E+ 4	1.19438859 E+ 4
40	1.1719761[illegible] 5E+ 4	8.4[illegible]63[illegible]8664E+ 3
41	2.7384 [illegible]16[illegible]E+ 1	6.44956491875E+ 1
42	3.117687 748E+ [illegible]	7.94 4245 74E+ 1
43	1.2 2 4 9163E+ 1	1. 63[illegible]4961965E+ 3
44	1.19312925175E+ 2	1.1535 4665[illegible]E+ 2
45	2.1644897959E+ 2	3.783591946E+ 2

COVARIANCE MATRIX

VARIABLE NUMBER	1	2	3	4	5	6	7	8	9	1[illegible]
1	.249	-. 34	-. 57	-.[illegible]3	. 53	-. 4	.[illegible]41	.	-. 2	-. 1
2		. 58	-. [illegible]	-.[illegible] 3	. 7	-. 2	-. [illegible]7	-. [illegible]	. 11	-. [illegible]
3			. 92	-.[illegible]6	. 1	-. 49	-. 23	. 21	. 3	. 5
4				.[illegible]52	-. 24	. 15	-.[illegible] 1	-.[illegible] 3	-. 2	-. 1
5					.246	. 1	-. 3	-. [illegible]5	. 1	. [illegible]
6						.2[illegible]1	-.13	-.[illegible]29	-. 2	-. 7
7							.2[illegible]	-. [illegible]7	-. 11	-. 4
8								. 3[illegible]	-. 3	-. [illegible]
9									. 39	-. [illegible]
1[illegible]										. [illegible]4

VARIABLE NUMBER	11	12	13	14	15	16	17	18	19	
1	-. 1	-. 5	.128	-1.171	-1.336	6.23	5.24	-4.979	-.131	-3. 4
2	. 12	. 1	. 7	1.234	-.198	.861	. 77	1.35	. 3	. 59
3	-. 3	. 52	-. 45	-1.464	1.8 5	-1.556	-3. 8	-2.739	-.239	-1.574
4	-. 1	-. 5	-. 25	.722	.2 9	.124	-1.636	1.43	-. 95	.334
5	-. 5	-. 1	. 43	-1.798	.237	-1.65	1.635	-1 .574	-.677	-4.127
6	-. 13	-. 46	-. 1	-.783	1.377	-.197	-9.131	1.721	-. 25	2.7 2
7	-. 7	-. 26	. 21	1. 49	-1.727	-.2 8	6.544	-.393	. 14	.255
8	-. 2	-. 6	-.	-.342	.227	-.153	.489	-.219	.1	-.972
9	-. 1	-. 4	. 9	. 76	.345	.364	-.61	-.582	-. 35	-. 39
1	-.	-. 1	. 1	. 5	-. 68	-.246	.275	-. 36	-. 26	-.438
11	. 27	-. 3	. 9	.567	-.751	.48	1.922	.544	. 28	-.477
12		. 97	-. 13	-.7 9	.13	.611	.593	-1.72	-.179	-.997
13			.249	-1.487	-1. 34	9.525	3.692	-5.323	-.19	-3.735
14				29 .8 6	-52.385	-134.157	245. 3	197. 84	19.3 9	29.954
15					523.219	64.5 4	-1437.559	5 .593	-8.197	59.4
16						1316.936	-314.3	-127.1 5	-11.687	-1 .573
17							4395.293	-36 .527	26.546	-377.3 9
18								19 1.283	84.917	14 .153
19									17.334	62.132
2										19 3.925

VARIABLE NUMBER	21	22	23	24	25	26	27	28	29	30
1	-.115	-1.893	22.597	-4.125	-4.133	-3.797	3.434	-6.944	4.463	.379
2	-. 3	1.161	-3. 8	7. 34	-.459	-.422	1.919	.675	-1.647	-.363
3	-. 53	-1.184	-5.137	-.765	6.735	-.7 3	-.728	-5. 51	-3.745	1.175
4	-. 4	.436	-2.738	-.4 8	-.4 8	6.516	-1.8 2	3.5 1	.131	-.111
5	-.152	-6.447	-.225	.683	-.615	-3.	18.695	-4.941	-1.9 5	-1.175
6	. 67	-.981	-3.525	.137	-3.571	2. 13	.843	25.929	-12.811	-2.511
7	. 15	-.653	5.598	-2. 39	-2. 41	-.279	.799	-13.469	19.727	-1.512
8	-. 17	.754	1. 64	-.459	1.322	-.422	-.523	-5. 31	-1.647	5.352
9	-. 4	-.493	-.136	1.153	-.169	-.291	.477	-1.	-. 95	-.1 1
10	-. 7	.4 2	-.1	-.1	.666	-. 4	.111	-.573	-.15	-. 41
11	-. 15	1.40	.432	1.269	-. 4	-.187	-.117	-.347	-.732	-.161
12	-. 48	-.721	-2.627	.141	4.1 1	-.556	-1. 3	-4.71	-2.562	-.754
13	-.138	-1.397	1 .447	.427	-3.367	-3. 94	1.354	-6. 67	. 3	.36
14	4.548	167.13	-236.297	151. 7	-1 7.3 9	9 .5 9	-38.531	23.297	122.33	-15.637
15	-.358	-18.734	-76.79	-21.869	131.736	25.699	23.134	261. 34	-15 .167	3.646
16	-6.717	23.57	635.315	1 5.922	-132.895	18.213	-235.54	-113.8	-76.967	1 .
17	-.232	-22.716	299.955	-8.296	-123.98	-21 .443	33.2 3	-1321.279	585.469	96.518
18	26.139	4 1. 25	452.314	2 4.815	-13.857	217.13	-127.143	1 92.532	381.348	75.535
19	3.6 3	16.656	3 . 42	1.782	-15.845	-11.944	-34.3 5	34.535	25. 72	53.18
20	34.361	-5 8.657	377.1 9	76.791	-6.682	195.914	141.657	65.59	79 .9 9	-61.357
21	1.615	-8.921	-7.339	.789	-3.684	.126	-7.1	22.469	3.449	-.353
22		9 9.692	125.214	128. 26	-7.175	21.316	-253.3	27. 42	.439	176.74
23			2951.992	-374.4 3	-374.743	-344.286	354.7 3	-478.915	395. 93	237.441
24				895.769	-55.816	-51.09	227.975	153.126	-2 .225	-44.
25					677.574	-51.327	-66. 17	-369.724	-2 .4	38.789
26						856.626	-226.537	37 .197	1 .7 9	-4 .545
27							2 33.541	-67.563	156. 84	-33. 37
28								3591.877	-1322.694	-231.27
29									2343.518	-158.
30										531.

VARIABLE NUMBER	31	32	33	34	35	36	37	38	39	40
1	-. 18	-.171	-. 3	-2.153	11.144	-371.38	-365.744	471.956	-745.358	-1 36.359
2	1.244	-. 81	1.272	.376	1.355	146.186	45.821	177.813	351.132	339. 47
3	-.222	.532	-.314	4. 16	-4. 54	-141.987	-16.954	-249.951	-871.4 1	-47 .34
4	-.191	-. 72	-.173	-.426	-2.162	87.391	97.91	93. 37	166. 75	361. 3
5	.299	-. 17	-.651	-1.288	-1. 77	-18 .587	-548.255	-732.284	-24 1.88	-1955. 1
6	-1.673	-.633	-1.559	-3.731	-2.76	-61.397	327.134	28.445	-719.55	4 5.335
7	-.956	-.362	-.891	-2.132	1.3	66.583	-134.834	-61.284	585.1 1	-148.459
8	-.215	-. 81	-.2	-.48	1. 88	-29. 61	-9.9 5	47.594	64.146	-55.453
9	3.37	-. 54	-.134	-.32	1.522	.155	-9. 15	12.181	-151.368	-9 .837
10	-. 48	1.711	-. 45	-.1 7	. 21	-1.478	-4.521	-26.255	12.3 6	-28.572
11	-. 96	-. 36	3.135	-.213	1.282	65.236	-62.672	91.751	375.298	74.741
12	-.335	-.127	-.312	7. 89	-1.914	-54.755	-88.565	-29.344	-322.896	-312.735
13	1.566	-. 35	.891	-1.648	21.89	-231.291	-274.92	791.7 3	-1213.272	-1 93.2 7
14	11.294	1.397	67.7 7	-26.834	-114.489	3 85.343	2355.699	-683 .853	791 7.251	35542. 9
15	24.549	-1.926	-89.8	6.347	26.899	-77 7.451	5 296.313	12316.111	*1 35.362	1 413.492
16	34.611	-26.258	62.473	4 .229	987.374	*6865.17	3244.887	*2312.914	*1 8 .794	*4796.514
17	-2 .755	16.482	229.624	72.573	-45.212	26945.188	*26 4.792	*644 .573	*9586.525	*446 .927
18	4 .596	-.443	69.369	3 .184	255.947	25484.373	998 .2 5	7321 .218	*1542.351	*6965.526
19	-.174	-2.646	3.474	-13.27	14.391	2579.947	333 .234	2483.4 1	24925.616	17481.518
20	6 .161	-42.512	-1 4.745	16.122	74.626	5263.622	83351.135	45213. 40	*1752.134	*3997.755
21	.754	-.71	-1.749	-3.687	-8.237	733.5	1276.725	269.145	6533.131	5727. 77
22	-19.565	42. 68	174.114	12.062	181.32	1622 .75	16439. 21	27987.173	*979 .217	42977.751
23	48.161	-2 .378	73.324	-199.87	1546.6 5	*9781.265	2 469.583	*3757. 82	*154 .124	7 332.454
24	138.131	-9.889	134.354	48.7 7	134.372	16524.558	8113.237	24237.389	49597. 81	36153.531
25	-23.434	76. 2	-24.388	453.996	-275.918	*1899.3 5	11785.224	*3168. 86	*2683.2 4	-3662.81
26	-24. 46	-9. 93	-22.4 6	-53.623	-271.867	11642. 82	14335.131	13876.852	28485.189	42271.595
27	59.393	2.359	-2 .2 4	-1 6.614	36.389	-3217.638	-4629.867	*1729.3 2	*5462.481	*1591.929
28	-172.745	-65.327	-16 .955	-385.224	-367.191	6381. 76	8922 .935	37397.375	*639 .28	*2139.245
29	-93.890	-35.5 6	-87.494	-2 9.376	197.934	11871.546	8173.453	8973.288	*9656.965	66116.2
30	-2 .676	-7.819	-19.265	-46.1 6	242.991	-1263.947	3279.4	16281.123	35394.848	14575.322
31	378.484	-4.637	-11.425	-27.345	241.453	889.742	4382.497	5285.773	1 958.852	7 38. 76
32		13 .219	-4.321	-1 .341	-6.373	-454.431	156.343	-2684.983	1 29.337	-2173.547
33			384.984	-25.479	145.295	79 9.9 3	-7379.519	11877.755	45253. 11	9943.122
34				75 .948	-117.147	-4159.371	2957.135	5533.717	15769.673	3 93.194
35					2647.346	*5323.557	22491.922	*2165.1 1	45511.785	33984.76
36						*4822.524	*2539.557	*94 8.965	*1933.295	*1977.235
37							*8 37.933	*6 96.563	* 7 9.415	*6875.519
38								*3926.998	*5586.847	*9351.716
39									*1942.522	*1218.748
40										*7641.21

VARIABLE NUMBER	41	42	43	44	45
1	-5.718	9.258	-132.347	-156.749	-175.14
2	-.173	.749	88.383	39.96	55.257
3	-2.714	-3.0 3	-1.235	-39.231	-86.484
4	-.229	-1.7 3	-.659	43. 38	45.263
5	-7.75	1.81	-16.132	-57.2 6	-73.15
6	3.241	.538	-149.591	-39.979	-82.373
7	1. 43	.963	27.70	24.38	118.3 2
8	-.9 7	.585	19.314	1 .296	-24.85
9	-.2 2	.357	15.336	16.8 9	8.5 2
10	-.775	-.746	7.137	4.681	-2.349
11	-.75	.242	28.154	43. 33	11.878
12	-2.437	-2. 17	52. 25	7.415	-33.865
13	-6.851	17.297	6.663	-41.837	-1 9.23
14	23 .965	-154.996	136 1.514	15549.139	15429.129
15	-3 .531	116. 2	-67 5.913	-6354. 5	-819 .591
16	-338.762	1 4 .279	-3548.147	-.5 .214	* 4 5.794
17	-. 75	-362.7 5	28 54.866	77 11.518	292 3.623
18	1329.284	-254.466	661. 82	5866. 82	8392. 34
19	183.1 7	-9.255	41 .964	584. 2	1159.9 8
20	1776.919	-22 .64	-5589.419	-5777.416	2532. 17
21	81.914	-9.430	-7.335	89.1 4	289.951
22	-447.634	-33.706	625 .5	5447.498	536 . 17
23	-98.2 3	863.569	*2543.623	*4835.482	*5 26.163
24	38.499	62.675	1 477.799	1132 .737	6867.362
25	-188.627	-233.807	-4 .153	-262 .717	-5342.134
26	5.455	-214.831	-82.826	5443.527	5562.2 8
27	-362.885	26.343	-21.847	-2854.375	-54 . 3
28	1113.351	-25 .474	*4906.327	-5694.983	-32 5.9 9
29	468.955	-11.457	776.251	831.423	119 1.496
30	-52.145	175.6 1	2488.893	1745.845	-13 8.587
31	36. 47	7 . 43	1685.257	151 . 85	1 33.984
32	-36.387	-19.799	582.74	329.7 7	-352.131
33	-89.655	24.763	3258.372	5275.592	1419.434
34	-188.26	-14 .19	6797.594	31 9.575	-1383.271
35	-397.288	1635.152	1389.634	-2870.671	*1552.987
36	372 5.862	* 918.024	*4236.475	*3965.341	* 213.141
37	64691.921	4889.161	*176 . 89	* 374.931	*819 .749
38	14123.641	95379.779	*1217.341	*3866.843	*1388.493
39	*4 95.815	*3817.414	*7619.761	*2687.568	*3763.235
40	* 633.322	*276 .444	*391 .468	*8651.554	*3543.1 8
41	4159.689	-471.994	-37 .377	4442.626	14817.975
42		1552.695	-335 .798	-6718.754	*2865.876
43			*135 .5.1	* 51.98	*3589.854
44				*3743.1 7	* 221.612
45					*81 .181

STEP NUMBER 6
VARIABLE ENTERED 4

MULTIPLE R .8195
R SQUARED .671
STD. ERROR FOR RESIDUALS 2.4357

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	6	17 .1898	283.365	47.765
RESIDUAL	14	83 .5464	5.9325	

VARIABLES IN EQUATION

INTERCEPT = -3.8 5673197- 1

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
8	-5.84 1421E+	2.2364458E+	6.8191E+
2	-3.5551998E-02	9.35 9229E-03	1.4455E+ 1
3	9.8765275E- 2	2.17635 1E- 2	2. 594E+ 1
39	4.9347741E- 5	1.814 351E- 5	7. 752E+
4	1.3 61965E- 4	5.78344 9E- 5	5.1 95+
41	4.6 61 19E- 2	4. 58 283E-03	1.2895E+ 2

VARIABLES NOT IN EQUATION

VARIABLE	PARTIAL CORR.	TOLERANCE	F TO ENTER
1	8.2194591E- 2	3.2522E- 1	9.4546E- 1
2	-3.5144561E- 2	9.5118E- 1	1.719 E- 1
3	-8.9 7 2473E- 2	7.9533E- 1	1.1116E+
4	-1.4473267E- 1	9.6 81E- 1	3.1878E+
5	-1.3 88 9 E- 2	6.9133E- 1	2.418 E- 2
6	1. 1631937E- 2	8.3853E- 1	1.4365E- 2
7	2.614321 E- 2	9. 493E- 1	5.3 67E- 2
9	-7.2783353E- 3	9.8971E- 1	7.3643E- 3
1	-6.4579924E- 2	9.9337E- 1	5.9395E- 1
11	2.7 3 5365E- 2	8.5341E- 1	1. 153E- 1
12	-3.4256195E- 2	9.6273E- 1	1.633 E- 1
13	9.195227 E- 2	8.4219E- 1	1.1951E+
14	2.3 88326E- 2	7.2993E- 1	7.414 E+ 2
15	3.243 194E- 2	3.59 9E- 1	1.4634E- 1
16	-6.1737268E- 3	9. 694E- 1	5.3326E- 3
17	1.6726951E- 2	2.4485E- 1	3.39 2E- 2
18	-4.3652335E- 2	4.3829E- 2	2.6535E- 1
21	-6. 371442E- 2	8.694 E- 4	5. 947 - 1
22	-4.3651335E- 2	9.6795E- 1	2.6538E- 1
23	1. 6241 9E- 1	8.6264E- 1	1.5363E+
24	-4.33931 7E- 2	9.3169E- 1	2.6229E- 1
25	-1.3157326E- 1	9. 624E- 1	2.4489E+
26	-1.5489133E- 1	5.4662E- 1	3.4169E+
27	1.219 15 E- 2	9.3334E- 1	2. 623E- 2
28	-1.9142147E- 2	6.6538E- 1	4.576 - 2
29	5.613 935E- 2	8.5963E- 1	4.3933E- 1
31	-8.4513369E- 3	9.9111E- 1	9.3277E- 3
32	-7.0285375E- 2	9.3793E- 1	7.3 12E- 1
33	2.3954155E- 3	8.4795E- 1	7.991 E- 2
34	-5.27 417E- 2	9.6453E- 1	3.9712E- 1
35	9.51723 5E- 2	8.9279E- 1	1.27 E+
36	2.4813548E- 3	6.7493E- 1	8.562 - 4
37	2.479239 1E- 3	1.9729E- 1	9.744E- 4
39	-2.613331 E- 2	7.8541E- 1	9.4998E- 2
42	8.3398 973E- 2	8.4694E- 1	9.7355E- 1
43	-2.4569377E- 2	7.9433E- 1	8.4644E- 2
44	-9. 65 657E- 2	7.9477E- 1	9.1 E- 1
45	4.397 437E- 2	5.7674E- 1	2.69 4 - 1

SUMMARY TABLE

STEP NUMBER	VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	MULTIPLE RSQ	INCREASE IN RSQ	F VALUE TO ENTER OR REMOVE	NUMBER OF INDEPENDENT VARIABLES INCLUDED
1	41		.[illegible]	.465	.465	1.[illegible]	1
2	7		.7621	.58[illegible]	.1[illegible]	3.9781 [illegible]	[illegible]
3	8		.7849	.6161	. 353	1.313 684[illegible]	3
4	39		.7981	.6372	. 211	8.2628 221+	4
5	2		.8127	.6599	. 227	9.4 143 41+	5
6	4		.8[illegible]	.671[illegible]	. 12	5.[illegible] 87022+	6
7	26		.8244	.6797	. 7[illegible]	3.4157[illegible]	7
8	25		.8287	.6867	. 7	3. 7[illegible]	8

INDEX-PLOT CARD
IDXPLT19221926

APPENDIX I

PROGRAM AND DATA USED IN DEVELOPMENT OF DISCRIMINANT FUNCTION

PROGRAM INPUT AND DATA

```
RUN NAME         DISCRIMINANT ANALYSIS OF OVERLAYED SECTIONS
VARIABLE LIST    FAILURE,MINORSP,SEVERES,PUMPING,OVERLAY
INPUT FORMAT     FIXED(4X,F5.1,5X,F5.1,5X,F5.1,5X,F5.1,5X,F5.1)
N OF CASES       233
VAR LABELS       FAILURE, NUMBER OF FAILURES PER MILE
VAR LABELS       MINORSP,PERCENT OF MINOR SPALLING
VAR LABELS       SEVERES,PERCENT OF SEVERE SPALLING
VAR LABELS       PUMPING,PERCENT OF PUMPING
VAR LABELS       OVERLAY,HAS HIGHWAY BEEN OVERLAYED?
VALUE LABELS     OVERLAY(1.0)YES(2.0)NO
DISCRIMINANT     GROUPS=OVERLAY(1.0,2.0)/VARIABLES=FAILURE,MINORSP,
                 SEVERES,PUMPING/
                 ANALYSIS=FAILURE,MINORSP,SEVERES,PUMPING/
                 METHOD=DIRECT
OPTIONS          6,7
STATISTICS       1,2,7
READ INPUT DATA
     26.0        50.0        5.0        11.0        1.0
     28.3        50.0        1.0         9.0        1.0
      8.3        50.0        4.0         0.5        1.0
     20.5        50.0        0.0        11.0        1.0
      7.5        20.0        2.0        10.0        1.0
     36.5        20.0        2.0        10.5        1.0
     50.0         5.0       12.0         4.5        1.0
     49.4        20.0       10.0         2.0        1.0
     12.5        20.0        5.0        10.0        1.0
     12.5        20.0        1.0        24.0        1.0
      8.0        20.0        3.0        17.0        1.0
     13.1         5.0        0.0        12.0        1.0
      5.9         5.0        9.0         0.0        1.0
      0.4         5.0        8.0         0.0        1.0
     45.7         5.0       12.0         0.0        1.0
      3.0         5.0       17.0         0.0        1.0
     16.3         5.0       12.0         0.0        1.0
      2.9         5.0        5.0         0.0        1.0
      7.5         0.0        0.0         0.0        1.0
     11.8        36.0       13.0        10.0        1.0
      0.0        33.2        0.7         0.0        2.0
      2.0        42.6        0.5         0.0        2.0
      7.0        38.4        0.0         0.0        2.0
      4.0        34.7        0.2         0.0        2.0
     10.0        28.0        0.3         0.0        2.0
      4.0        30.3        0.0         0.0        2.0
      2.0        43.7        1.4         0.0        2.0
      2.0        53.0        0.2         0.0        2.0
      4.0        25.4        0.9         1.4        2.0
      3.0        55.3        0.3         0.0        2.0
      0.0        17.1        0.0        38.4        2.0
      1.0        17.4        0.4        18.4        2.0
      0.0        16.2        0.0         6.0        2.0
      0.0         7.1        2.2         1.6        2.0
      0.0         5.3        2.4         0.6        2.0
      1.0         7.7        0.5         8.8        2.0
      0.0         1.6        0.2         0.0        2.0
      0.0        14.8        0.2         0.0        2.0
      1.0        24.8        0.0         3.0        2.0
      1.0        17.6        0.0         1.3        2.0
      3.0         7.3        0.0         5.8        2.0
      2.0        10.1        0.1        11.8        2.0
      0.0        37.8        0.0         3.6        2.0
      2.0         0.0        0.0         2.6        2.0
```

0.0	35.4	0.0	7.5	2.0
1.0	12.0	0.1	2.6	2.0
0.0	6.8	0.3	0.0	2.0
2.0	18.0	0.3	8.3	2.0
1.0	18.8	0.3	2.4	2.0
0.0	12.9	0.6	0.2	2.0
0.0	42.2	0.0	0.0	2.0
0.0	27.8	0.0	2.0	2.0
0.0	28.2	0.0	10.2	2.0
0.0	17.8	0.0	0.2	2.0
1.0	20.2	0.0	0.0	2.0
0.0	13.2	0.0	2.6	2.0
0.0	27.1	0.1	1.4	2.0
0.0	17.6	0.0	5.3	2.0
0.0	31.0	0.6	0.0	2.0
0.0	11.3	0.0	0.0	2.0
0.0	50.5	0.0	0.4	2.0
0.0	29.5	0.0	1.0	2.0
0.0	7.2	0.5	0.0	2.0
0.0	13.5	0.3	0.0	2.0
1.0	27.6	0.0	0.0	2.0
0.0	25.9	0.1	0.0	2.0
19.0	19.1	0.0	0.0	2.0
0.0	35.0	0.1	0.0	2.0
1.0	14.3	0.0	0.0	2.0
1.0	21.7	0.8	0.0	2.0
1.0	20.2	0.2	0.0	2.0
0.0	14.2	1.2	0.0	2.0
0.0	25.5	0.2	0.0	2.0
0.0	14.4	0.1	3.0	2.0
10.0	13.8	0.7	4.0	2.0
3.0	15.7	0.9	4.2	2.0
1.0	14.8	0.3	0.0	2.0
3.0	18.3	0.0	0.0	2.0
0.0	21.7	0.0	0.0	2.0
0.0	8.8	0.0	3.8	2.0
1.0	7.3	0.0	3.6	2.0
0.0	11.6	0.1	2.0	2.0
0.0	22.7	0.0	2.4	2.0
2.0	24.5	0.1	1.5	2.0
22.0	9.4	0.7	1.6	2.0
2.0	68.2	0.9	12.4	2.0
3.0	55.0	1.6	19.2	2.0
0.0	8.3	0.0	1.0	2.0
4.0	26.6	1.0	4.2	2.0
0.0	16.5	0.0	0.0	2.0
6.0	19.5	0.2	1.0	2.0
0.0	20.5	0.2	0.4	2.0
0.0	51.1	0.0	0.2	2.0
0.0	11.0	0.1	4.4	2.0
2.0	13.1	0.3	4.4	2.0
1.0	16.4	0.0	2.8	2.0
3.0	11.9	0.4	1.0	2.0
0.0	8.4	0.3	2.2	2.0
23.0	26.4	0.4	4.0	1.0
0.0	14.0	0.0	0.2	2.0
6.0	13.3	0.1	1.2	2.0
0.0	1.7	0.5	0.0	2.0
3.0	6.7	0.6	4.2	2.0
3.0	3.7	0.8	2.4	2.0
13.0	4.1	1.2	7.4	2.0
7.0	5.5	12.8	1.0	2.0

5.0	32.6	10.9	2.4	2.0
4.0	7.1	2.9	1.2	2.0
10.0	21.8	12.5	0.4	2.0
2.0	25.8	1.7	8.2	2.0
24.0	16.6	3.4	1.8	2.0
0.0	19.3	6.4	6.6	2.0
7.0	7.1	6.0	17.8	2.0
0.0	18.9	0.9	0.6	2.0
0.0	19.9	1.2	8.2	2.0
0.0	19.4	2.0	0.0	2.0
1.0	6.9	1.4	0.0	2.0
0.0	25.7	9.9	0.8	2.0
0.0	11.7	0.3	0.8	2.0
0.0	10.0	0.3	0.5	2.0
0.0	35.8	8.3	0.4	2.0
0.0	14.0	8.2	1.2	2.0
0.0	31.9	4.9	1.4	2.0
0.0	5.4	2.6	4.0	2.0
0.0	43.4	1.1	1.8	2.0
1.0	21.3	1.1	3.0	2.0
4.0	22.1	5.9	3.8	2.0
1.0	11.1	0.9	6.8	2.0
2.0	10.9	3.9	2.8	2.0
2.0	16.6	16.3	3.0	2.0
2.0	35.4	7.9	0.4	2.0
0.0	45.3	13.1	5.6	2.0
0.0	21.1	7.0	0.0	2.0
0.0	39.7	13.4	0.4	2.0
0.0	13.4	1.2	0.0	2.0
0.0	21.5	11.2	3.2	2.0
0.0	11.4	0.0	1.8	2.0
0.0	15.6	0.2	0.6	2.0
0.0	7.7	0.0	2.4	2.0
0.0	9.9	0.1	7.2	2.0
5.0	9.9	0.8	17.0	2.0
2.0	7.1	3.3	9.0	2.0
0.0	10.7	0.0	1.0	2.0
0.0	10.7	0.1	1.6	2.0
1.0	14.9	0.2	3.6	2.0
1.0	16.3	0.1	2.6	2.0
0.0	5.5	0.0	0.4	2.0
6.0	20.7	0.2	1.8	2.0
1.0	13.9	5.0	0.6	2.0
1.0	10.4	0.9	1.0	2.0
9.0	18.0	0.7	4.0	2.0
35.0	12.9	22.7	23.2	1.0
3.0	12.8	2.4	1.0	2.0
3.0	37.6	1.6	17.0	2.0
0.0	33.0	0.0	0.4	2.0
17.0	41.8	1.5	23.2	2.0
1.0	5.1	33.9	3.0	2.0
1.0	4.6	24.6	10.2	2.0
3.0	35.2	0.6	31.0	2.0
2.0	10.0	0.1	1.8	2.0
2.0	19.6	0.1	0.4	2.0
0.0	12.5	0.3	0.6	2.0
1.0	5.9	0.1	1.4	2.0
0.0	16.4	2.7	3.6	2.0
17.0	18.7	13.4	14.6	2.0
0.0	4.1	1.9	0.5	2.0
0.0	36.4	0.3	1.4	2.0
0.0	17.2	0.5	0.0	2.0

20.0	29.9	0.5	11.8	2.0
22.0	37.6	11.2	13.0	2.0
0.0	10.9	42.7	1.0	2.0
0.0	19.1	11.0	1.8	2.0
1.0	26.1	0.1	12.2	2.0
0.0	11.4	0.0	1.2	2.0
1.0	5.1	0.1	0.0	2.0
0.0	10.5	0.4	0.0	2.0
2.0	6.7	0.1	1.8	2.0
0.0	15.1	5.3	0.0	2.0
0.0	5.5	1.9	0.0	2.0
0.0	8.5	2.7	0.0	2.0
0.0	8.9	10.6	1.0	2.0
1.0	6.7	1.3	0.6	2.0
0.0	9.4	3.2	0.0	2.0
0.0	13.0	5.5	0.0	2.0
0.0	22.0	2.4	0.8	2.0
0.0	4.2	1.5	0.0	2.0
1.0	11.5	14.7	0.4	2.0
5.0	29.9	14.3	0.0	2.0
0.0	28.3	14.7	0.0	2.0
0.0	12.1	5.0	0.0	2.0
2.0	4.0	0.5	0.4	2.0
13.0	31.2	0.1	6.2	2.0
0.0	2.8	27.5	0.5	2.0
0.0	5.6	30.3	0.0	2.0
0.0	16.9	10.0	0.0	2.0
0.0	12.5	21.2	2.0	2.0
8.0	29.5	0.1	11.8	2.0
0.0	2.2	0.1	0.0	2.0
0.0	23.3	0.0	12.0	2.0
1.0	13.0	0.1	12.0	2.0
1.0	39.9	0.9	0.0	2.0
0.0	63.6	0.4	0.4	2.0
1.0	25.1	0.2	5.6	2.0
0.0	28.4	0.0	15.0	2.0
0.0	23.5	0.1	1.2	2.0
1.0	20.8	0.5	8.6	2.0
0.0	13.0	0.1	3.4	2.0
0.0	5.4	0.3	3.5	2.0
0.0	30.3	0.2	1.3	2.0
3.0	29.3	0.1	0.2	2.0
0.0	44.6	0.8	0.0	2.0
0.0	44.5	0.0	0.0	2.0
0.0	17.8	0.0	27.0	2.0
0.0	34.4	0.8	18.0	2.0
2.0	12.3	0.0	6.7	2.0
2.0	8.8	0.1	6.8	2.0
0.0	9.3	0.0	0.5	2.0
0.0	12.6	0.2	0.2	2.0
1.0	14.4	0.0	0.4	2.0
0.0	18.3	0.1	0.0	2.0
0.0	18.3	0.0	6.0	2.0
19.0	52.0	8.9	1.2	1.0
0.0	62.6	0.5	0.6	1.0
16.0	62.2	1.6	9.6	1.0
6.0	49.1	0.7	1.0	1.0
16.0	45.7	2.4	2.4	1.0
19.0	35.6	1.8	1.8	1.0
7.0	67.8	1.5	3.2	1.0
6.0	55.8	0.8	2.4	1.0
0.0	58.2	0.3	0.4	1.0

1.0	49.2	1.4	6.8	1.0
3.0	54.3	0.1	0.6	1.0
15.0	64.3	4.6	8.4	1.0

FINISH

PROGRAM OUTPUT

```
                                                                    14 AUG 79    15.27.49.     PAGE    1
      ****************************************
      *           COMPUTATION CENTER          *
      *     UNIVERSITY OF TEXAS AT AUSTIN     *
      * SOCIAL SCIENCES COMPUTING LABORATORY *
      ****************************************

      S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

      CDC 6000/CYBER 70 VERSION 7.0  -  INSTALLED 1 JULY 79


                RUN NAME        DISCRIMINANT ANALYSIS OF OVERLAYED SECTIONS
                VARIABLE LIST   FAILURE,MINORSP,SEVERES,PUMPING,OVERLAY
                INPUT FORMAT    FIXED(4X,F5.1,5X,F5.1,5X,F5.1,5X,F5.1,5X,F5.1)


               ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

               VARIABLE  FORMAT  RECORD    COLUMNS

               FAILURE    F 5. 1       1      5-   9
               MINORSP    F 5. 1       1     15-  19
               SEVERES    F 5. 1       1     25-  29
               PUMPING    F 5. 1       1     35-  39
               OVERLAY    F 5. 1       1     45-  49

THE INPUT FORMAT PROVIDES FOR    5 VARIABLES.    5 WILL BE READ
IT PROVIDES FOR  1 RECORDS (*CARDS*) PER CASE.  A MAXIMUM OF    49 *COLUMNS* ARE USED ON A RECORD.

                N OF CASES      233
                VAR LABELS      FAILURE, NUMBER OF FAILURES PER MILE
                VAR LABELS      MINORSP,PERCENT OF MINOR SPALLING
                VAR LABELS      SEVERES,PERCENT OF SEVERE SPALLING
                VAR LABELS      PUMPING,PERCENT OF PUMPING
                VAR LABELS      OVERLAY,HAS HIGHWAY BEEN OVERLAYED?
                VALUE LABELS    OVERLAY(1,0)YES(2,0)NO
                DISCRIMINANT    GROUPS=OVERLAY(1.0,2.0)/VARIABLES=FAILURE,MINORSP,
                                SEVERES,PUMPING/
                                ANALYSIS=FAILURE,MINORSP,SEVERES,PUMPING/
                                METHOD=DIRECT
                OPTIONS         6,7
                STATISTICS      1,2,7
                READ INPUT DATA

          00046400 CM NEEDED FOR DISCRIMINANT


          OPTION - 1
          IGNORE MISSING VALUE INDICATORS

          OPTION - 5
          PRINT CLASSIFICATION RESULTS TABLE

          OPTION - 6
          PRINT DISCRIMINANT SCORES AND CLASSIFICATION INFORMATION

          OPTION - 7
          PRINT A SINGLE PLOT OF CASES
```

FILE NONAME (CREATION DATE = 14 AUG 79)

GROUP COUNTS

	GROUP 1	GROUP 2	TOTAL
NUMBER	34.	199.	233.

MEANS

	GROUP 1	GROUP 2	TOTAL
FAILURE	15.56176	2.01508	3.99185
MINORSP	32.12059	19.52613	21.36395
SEVERES	4.96176	2.70573	3.06910
PUMPING	5.79706	3.43216	3.77725

STANDARD DEVIATIONS

	GROUP 1	GROUP 2	TOTAL
FAILURE	14.08451	4.20735	8.14212
MINORSP	22.38782	12.76086	15.16950
SEVERES	5.61659	6.11439	6.08347
PUMPING	6.54974	5.73588	5.90600

FILE NONAME (CREATION DATE = 14 AUG 79)

- D I S C R I M I N A N T   A N A L Y S I S -

ANALYSIS NUMBER 1

SOLUTION METHOD - DIRECT.

PRIOR PROBABILITIES - EQUAL

GROUP 1	GROUP 2
.50000	.50000

NUMBER REMOVED	EIGENVALUE	CANONICAL CORRELATION	PERCENT OF TRACE	WILKS LAMBDA	CHI-SQUARE	D.F.	SIGNIFICANCE
0	.67259	.63413	100.0	.59784	117.79124	4	.000

1 FUNCTIONS WILL BE USED IN REMAINING ANALYSES

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	1
FAILURE	-1.12886
MINORSP	-.48805
SEVERES	-.12809
PUMPING	.03504

CENTROIDS OF GROUPS IN REDUCED SPACE

GROUP 1	-1.97556
GROUP 2	.33753

CASE SUBFIL	CASE SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	1		1		1	3,969	,046	,999	2	,001	-3,968
	2		1		1	5,036	,025	1,000			-4,220
	3		1		1	,176	,675	,846	2	,154	-1,556
	4		1		1	1,279	,258	,995	2	,005	-3,107
	5		1	***	2	,521	,470	,732	1	,268	-,384
	6		1		1	5,889	,015	1,000			-4,402
	7		1		1	16,392	,000	1,000			-6,024
	8		1		1	19,568	,000	1,000			-6,399
	9		1		1	,703	,402	,676	2	,324	-1,137
	10		1		1	1,001	,317	,589	2	,411	-,975
	11		1	***	2	,592	,442	,710	1	,290	-,432
	12		1	***	2	,930	,335	,609	1	,391	-,627
	13		1	***	2	,046	,830	,898	1	,102	,122
	14		1	***	2	,322	,571	,982	1	,018	,905
	15		1		1	12,105	,001	1,000			-5,455
	16		1	***	2	,001	,977	,939	1	,061	,367
	17		1		1	,356	,551	,785	2	,215	-1,379
	18		1	***	2	,078	,780	,965	1	,035	,617
	19		1	***	2	,010	,922	,920	1	,080	,239
	20		1		1	,069	,793	,888	2	,112	-1,713
	21		2		2	,020	,888	,913	1	,087	,197
	22		2		2	,513	,474	,735	1	,265	-,379
	23		2	***	1	1,099	,294	,562	2	,438	-,927
	24		2		2	,538	,463	,727	1	,273	-,396
	25		2	***	1	,924	,336	,611	2	,389	-1,014
	26		2		2	,346	,557	,788	1	,212	-,250
	27		2		2	,592	,442	,710	1	,290	-,432
	28		2		2	1,092	,296	,564	1	,436	-,707
	29		2		2	,193	,660	,840	1	,160	-,102
	30		2	***	1	1,110	,292	,559	2	,441	-,922
	31		2		2	,383	,536	,984	1	,016	,957
	32		2		2	,119	,731	,970	1	,030	,682
	33		2		2	,208	,649	,977	1	,023	,793
	34		2		2	,461	,497	,986	1	,014	1,017
	35		2		2	,529	,467	,987	1	,013	1,065
	36		2		2	,357	,550	,983	1	,017	,935
	37		2		2	,785	,376	,991	1	,009	1,224
	38		2		2	,213	,645	,977	1	,023	,799
	39		2		2	,021	,982	,939	1	,061	,360
	40		2		2	,060	,807	,962	1	,038	,582
	41		2		2	,106	,745	,969	1	,031	,663
	42		2		2	,166	,684	,974	1	,026	,745
	43		2		2	,064	,800	,890	1	,110	,084
	44		2		2	,462	,497	,986	1	,014	1,017
	45		2		2	,023	,878	,911	1	,089	,185
	46		2		2	,185	,667	,975	1	,025	,768
	47		2		2	,514	,474	,987	1	,013	1,054
	48		2		2	,016	,898	,951	1	,049	,466
	49		2		2	,043	,837	,959	1	,041	,544
	50		2		2	,266	,606	,980	1	,020	,853
	51		2		2	,173	,677	,847	1	,153	-,079
	52		2		2	,003	,951	,943	1	,057	,396
	53		2		2	,009	,925	,948	1	,052	,432
	54		2		2	,137	,711	,972	1	,028	,707

CASE SUBFIL	SEQNUM	MISSING VALUES	ACTUAL GROUP	HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	55		2	2	.023	.878	.954	1	.046	.490
	56		2	2	.283	.595	.980	1	.020	.870
	57		2	2	.006	.940	.945	1	.055	.413
	58		2	2	.165	.684	.974	1	.026	.744
	59		2	2	.005	.946	.925	1	.075	.272
	60		2	2	.334	.563	.982	1	.018	.915
	61		2	2	.464	.496	.750	1	.250	-.343
	62		2	2	.000	.999	.935	1	.065	.336
	63		2	2	.490	.484	.987	1	.013	1.037
	64		2	2	.251	.616	.979	1	.021	.839
	65		2	2	.007	.932	.923	1	.077	.252
	66		2	2	.011	.915	.949	1	.051	.044
	67		2	*** 1	.000	.995	.935	2	.065	-1.970
	68		2	2	.035	.852	.904	1	.096	.151
	69		2	2	.117	.732	.970	1	.030	.680
	70		2	2	.008	.929	.947	1	.053	.426
	71		2	2	.022	.882	.953	1	.047	.486
	72		2	2	.212	.645	.977	1	.023	.798
	73		2	2	.015	.903	.951	1	.049	.459
	74		2	2	.244	.621	.978	1	.022	.831
	75		2	2	.773	.379	.655	1	.345	-.542
	76		2	2	.001	.978	.939	1	.061	.365
	77		2	2	.103	.748	.968	1	.032	.658
	78		2	2	.004	.950	.926	1	.074	.274
	79		2	2	.059	.808	.962	1	.038	.581
	80		2	2	.464	.496	.986	1	.014	1.018
	81		2	2	.347	.556	.983	1	.017	.927
	82		2	2	.334	.563	.982	1	.018	.916
	83		2	2	.051	.822	.961	1	.039	.563
	84		2	2	.014	.907	.917	1	.083	.220
	85		2	*** 1	.010	.918	.948	2	.052	-2.078
	86		2	*** 1	.704	.402	.676	2	.324	-1.137
	87		2	*** 1	1.326	.250	.503	2	.497	-.820
	88		2	2	.463	.496	.986	1	.014	1.018
	89		2	2	.215	.643	.832	1	.168	-.126
	90		2	2	.169	.681	.974	1	.026	.748
	91		2	2	.266	.606	.815	1	.185	-.178
	92		2	2	.079	.779	.965	1	.035	.618
	93		2	2	.492	.483	.741	1	.259	-.364
	94		2	2	.374	.541	.984	1	.016	.949
	95		2	2	.069	.793	.964	1	.036	.600
	96		2	2	.085	.770	.966	1	.034	.629
	97		2	2	.020	.888	.953	1	.047	.478
	98		2	2	.460	.498	.986	1	.014	1.016
	99		1	1	.590	.443	.988	2	.012	-2.743-
	100		2	2	.242	.623	.978	1	.022	.830
	101		2	2	.098	.754	.876	1	.124	.024
	102		2	2	.769	.381	.991	1	.009	1.214
	103		2	2	.104	.747	.968	1	.032	.661
	104		2	2	.164	.686	.974	1	.026	.742
	105		2	2	.946	.331	.605	1	.395	-.635
	106		2	2	.205	.651	.836	1	.164	-.115
	107		2	2	1.003	.317	.589	1	.411	-.664
	108		2	2	.012	.914	.949	1	.051	.446

CASE SUBFIL	CASE SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	109		2	***	1	.851	.356	.632	2	.368	-1.853
	110		2		2	.023	.880	.911	1	.089	.187
	111		2	***	1	.002	.587	.985	2	.015	-2.639
	112		2		2	.054	.816	.961	1	.039	.571
	113		2		2	.073	.787	.886	1	.114	.067
	114		2		2	.102	.750	.968	1	.032	.657
	115		2		2	.078	.780	.965	1	.035	.616
	116		2		2	.077	.781	.965	1	.035	.615
	117		2		2	.306	.580	.981	1	.019	.891
	118		2		2	.006	.939	.924	1	.076	.261
	119		2		2	.318	.573	.982	1	.018	.901
	120		2		2	.380	.537	.984	1	.016	.954
	121		2		2	.138	.710	.860	1	.140	-.030
	122		2		2	.113	.737	.969	1	.031	.674
	123		2		2	.030	.862	.907	1	.093	.164
	124		2		2	.548	.459	.988	1	.012	1.078
	125		2		2	.217	.641	.832	1	.168	-.128
	126		2		2	.013	.910	.950	1	.050	.451
	127		2		2	.175	.676	.847	1	.153	-.081
	128		2		2	.219	.640	.977	1	.023	.806
	129		2		2	.060	.800	.963	1	.037	.591
	130		2		2	.030	.862	.907	1	.093	.164
	131		2		2	.395	.530	.772	1	.228	-.291
	132		2		2	.550	.458	.723	1	.277	-.404
	133		2		2	.015	.901	.951	1	.049	.462
	134		2		2	.358	.550	.784	1	.216	-.260
	135		2		2	.237	.627	.978	1	.022	.824
	136		2		2	.002	.962	.942	1	.058	.385
	137		2		2	.343	.558	.983	1	.017	.923
	138		2		2	.193	.661	.976	1	.024	.777
	139		2		2	.501	.479	.987	1	.013	1.045
	140		2		2	.408	.587	.985	1	.015	1.001
	141		2		2	.000	.988	.938	1	.062	.352
	142		2		2	.180	.672	.975	1	.025	.762
	143		2		2	.364	.546	.983	1	.017	.941
	144		2		2	.366	.545	.983	1	.017	.942
	145		2		2	.116	.733	.970	1	.030	.678
	146		2		2	.085	.770	.966	1	.034	.629
	147		2		2	.588	.443	.988	1	.012	1.184
	148		2		2	.302	.581	.803	1	.197	-.212
	149		2		2	.068	.795	.964	1	.036	.598
	150		2		2	.208	.648	.977	1	.023	.794
	151		2		2	.767	.381	.657	1	.343	-.538
	152		1		1	5.399	.020	1.000			-4.299 —
	153		2		2	.005	.942	.945	1	.055	.410
	154		2		2	.378	.539	.778	1	.222	-.277
	155		2		2	.014	.906	.917	1	.083	.220
	156		2	***	1	.115	.734	.970	2	.030	-2.315
	157		2		2	.000	.998	.934	1	.066	.325
	158		2		2	.053	.818	.961	1	.039	.567
	159		2		2	.189	.664	.841	1	.159	-.097
	160		2		2	.123	.726	.970	1	.030	.689
	161		2		2	.001	.973	.940	1	.060	.371
	162		2		2	.280	.591	.980	1	.020	.874

CASE SUBFIL	CASE SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	163		2		2	,384	,536	,984	1	,016	,957
	164		2		2	,146	,703	,972	1	,028	,719
	165		2	***	1	,014	,906	,917	2	,083	-1,058
	166		2		2	,601	,438	,989	1	,011	1,113
	167		2		2	,052	,820	,896	1	,104	,110
	168		2		2	,143	,705	,972	1	,028	,716
	169		2	***	1	,177	,674	,975	2	,025	-2,396
	170		2	***	1	1,321	,250	,995	2	,005	-3,125
	171		2		2	,061	,806	,891	1	,109	,091
	172		2		2	,015	,904	,950	1	,050	,458
	173		2		2	,001	,973	,940	1	,060	,371
	174		2		2	,338	,561	,982	1	,018	,919
	175		2		2	,405	,524	,984	1	,016	,974
	176		2		2	,355	,551	,983	1	,017	,933
	177		2		2	,209	,647	,977	1	,023	,795
	178		2		2	,123	,726	,970	1	,030	,689
	179		2		2	,528	,467	,987	1	,013	1,065
	180		2		2	,378	,539	,984	1	,016	,952
	181		2		2	,204	,651	,976	1	,024	,789
	182		2		2	,319	,572	,982	1	,018	,903
	183		2		2	,332	,565	,982	1	,018	,913
	184		2		2	,172	,678	,974	1	,026	,752
	185		2		2	,036	,849	,958	1	,042	,529
	186		2		2	,603	,437	,989	1	,011	1,114
	187		2		2	,021	,885	,953	1	,047	,483
	188		2		2	,992	,319	,592	1	,408	-,659
	189		2		2	,067	,795	,889	1	,111	,078
	190		2		2	,206	,650	,976	1	,024	,791
	191		2		2	,279	,598	,980	1	,020	,865
	192		2	***	1	,233	,629	,826	2	,174	-1,492
	193		2		2	,097	,755	,968	1	,032	,649
	194		2		2	,027	,870	,955	1	,045	,501
	195		2		2	,040	,841	,958	1	,042	,538
	196		2		2	,018	,894	,952	1	,048	,470
	197		2		2	1,100	,294	,562	1	,438	-,711
	198		2		2	,755	,385	,991	1	,009	1,206
	199		2		2	,069	,793	,964	1	,036	,601
	200		2		2	,206	,650	,976	1	,024	,791
	201		2		2	,249	,618	,821	1	,179	-,161
	202		2		2	1,233	,267	,527	1	,473	-,773
	203		2		2	,001	,980	,939	1	,061	,362
	204		2		2	,014	,907	,950	1	,050	,454
	205		2		2	,036	,849	,958	1	,042	,528
	206		2		2	,031	,861	,956	1	,044	,512
	207		2		2	,293	,588	,981	1	,019	,879
	208		2		2	,612	,434	,989	1	,011	1,120
	209		2		2	,001	,976	,931	1	,069	,308
	210		2		2	,175	,676	,847	1	,153	-,080
	211		2		2	,259	,611	,817	1	,183	-,172
	212		2		2	,240	,624	,824	1	,176	-,153
	213		2		2	,280	,597	,980	1	,020	,866
	214		2		2	,006	,941	,924	1	,076	,263
	215		2		2	,095	,758	,967	1	,033	,646
	216		2		2	,176	,675	,975	1	,025	,757

CASE SUBFIL	CASE SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	217		2		2	,016	,519	,985	1	,015	,983
	218		2		2	,208	,594	,980	1	,020	,871
	219		2		2	,117	,732	,970	1	,030	,679
	220		2		2	,123	,726	,968	1	,032	,665
	221		2		2	,151	,698	,973	1	,027	,726
	222		1		1	1,092	,222	,996	2	,004	-3,197
	223		1	***	2	1,104	,281	,545	1	,455	-,741
	224		1		1	,883	,347	,992	2	,008	-2,915
	225		1		1	,697	,404	,678	2	,322	-1,182
	226		1		1	,218	,642	,977	2	,023	-2,443
	227		1		1	,302	,582	,981	2	,019	-2,523
	228		1		1	,008	,927	,921	2	,079	-1,843
	229		1		1	,392	,531	,773	2	,227	-1,352
	230		1	***	2	,873	,350	,626	1	,374	-,597
	231		1	***	2	,589	,443	,711	1	,289	-,432
	232		1	***	2	,686	,421	,693	1	,307	-,466
	233		1		1	,874	,352	,992	2	,008	-2,912

PREDICTION RESULTS -

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2
GROUP 1	1	34	22. 64.7 PCT	12. 35.3 PCT
GROUP 2	2	199	14. 7.0 PCT	185. 93.0 PCT

88.8 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 140.685 SIGNIFICANCE = 0

APPENDIX J

EXAMPLE CALCULATION OF DISCRIMINANT SCORE

APPENDIX J. EXAMPLE CALCULATION OF DISCRIMINANT SCORE

Table J.1 presents a summary of the calculations performed to obtain the "zeta" values for several CRCP sections along a principal highway in the State of Texas.

The table consists of 7 columns; the first column is the CTR number given to the section, the second column is the length of the project(miles), columns 3 to 6 give the amount of distress for each of several distress manifestations, and the last column gives the "zeta" values. For more detail in the equations used, please refer to Appendix I.

It should be noted that the smaller the zeta value the worse the condition of the pavement. If the value is positive, we interpretate it as indicating a pavement in good condition.

In addition to the ranking for each CTR section, a weighted average is given for the sections.

TABLE J.1. EXAMPLE CALCULATION OF DISCRIMINANT SCORE

CFTR#	LENGTH	F/M	%MS	%SS	%P	Z
1006FB	5.2	8.5	52.3	3.9	1.4	-0.85
WB		6.2	71.5	2.3	6.0	-1.10
1007EB	4.8	11.5	69.3	1.5	1.5	-1.77
WB		11.0	84.8	5.0	2.6	-1.98
1001EB	4.0	11.5	67.7	5.7	8.6	-1.75
WB		4.5	43.5	3.7	7.6	0.03
1005EB	8.2	1.3	60.0	1.0	1.9	-0.05
WB		1.7	64.7	1.0	0.2	-0.27
1004EB	8.0	18.4	56.1	6.9	5.2	-2.39
WB		18.8	61.9	8.2	8.6	-2.63
	30.2					-1.27

F/M - failures per mile

%MS - percent minor spalling

%SS - severe spalling

%P - pumping

Note: Highway: IH20 - Dist 10
Van Zandt Co.
(From Kaufman C/L East to Smith C/L)

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