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Preliminary Analysis of BPR Data

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Contents

Abstract vii

Executive Summary ix

Introduction 1

Analysis 4

Summary remarks 19

Conclusions 20

References 21

Appendix A: List of Variables in BPR Data

Appendix B: Scatter Plots for Variables Used in Analysis

Appendix C: Print-Out of Database Used for Analysis

Abstract

During the period of 1954 through 1956, the bureau of Public Roads (BPR) collected asphalt cement samples from 210 construction projects in 26 states. Field performance from 34 of the 210 projects were obtained in 1967 by Materials Research and Development (MR&D). This paper describes a preliminary analysis of this data in the attempt of relating properties of the asphalt cements to field performance.

Two analysis techniques were used, including:

- Simple regression
- Discriminate analysis and multivariate general linear modeling

No trends or simple correlations were found between the pavement performance variables measured (transverse cracking, rutting) and the asphalt binder and mix properties selected for this analysis. From discriminate analysis and general linear modeling, a relationship was found between transverse cracking and void content, recovered penetration of the binder at 77°F, and the ring and ball softening point of the asphalt. For rutting, no single variable was found to be significant but eight significant two-factor interactions were found with void content in six of the eight. However, discriminate functions could not be developed due to a lack of projects with good performance.

Executive Summary

This paper describes a preliminary analysis of data from a Bureau of Public Works (BPR) study of asphalt cements. The Bureau collected asphalt cement samples from 210 projects in 26 states during the period from 1954 to 1956. Properties of the asphalt cements included in the analysis were penetration at 77°F, softening point, viscosity at 140°F and 275°F and stiffness modulus at 20°F and 140°F. Other variables selected for the analysis were void content, bitumen index(asphalt content corrected for aggregate surface area), average daily traffic and truck traffic, yearly minimum and maximum temperature, and number of days per year over 89°F.

Materials Research and Development (MR&D) surveyed 53 of the 210 projects in 1967. Of these, 34 projects were still in service as constructed and each of these were constructed with 85-100 pen asphalt. Performance measurements consisted of ratings from 0 to 3 (good to bad) for transverse cracking, polygon cracking (alligator cracking), and rutting. Because almost all projects had high polygon cracking, it was dropped from the analysis.

Data were analyzed using the SYSTAT and SYGRAPH statistical packages. The following analysis techniques were used:

- Simple regression
- Discriminate analysis and general linear modeling

Using the regression approach, no simple correlations were found between the pavement performance variables (transverse cracking, rutting) and the asphalt (and asphalt mix) properties selected for this analysis. In addition to there being no quantitative correlations, no trends were visible between the performance variables and the selected asphalt (and asphalt mix) properties.

From the discriminate analysis and general linear modeling, a relationship was found between the transverse cracking of asphalt pavements and the void content of the mix (as obtained from the recovered cores), the penetration of asphalt at 77°F (recovered), and the Ring and Ball softening point of the asphalt. For rutting, no single variable was found to be significant although void content appeared in six of the eight significant interactions. Discriminant functions could not be developed however. Only two projects had no transverse cracking and no projects had zero rutting and there was not an adequate distribution to discriminate between good and poor performance.

Based on the results of the preliminary analysis, further and more detailed analysis does not appear to be warranted. Even if trends could be established and a discriminant function developed, there would still be a question as to its usefulness. Most of the properties measured during this (BPR) study have been shown, by SHRP researchers, to be incapable of accurately characterizing asphalt/asphalt mixture behavior. As such, further studies of the BPR data would not be useful for the SHRP program.

Introduction

This paper describes a preliminary analysis of data taken from Bureau of Public Roads (BPR) study of asphalts. Originally, BPR had collected asphalts from 210 projects in 26 states--a total of 323 asphalt samples from 105 refineries. Out of these, 146 samples were 85-100 penetration grade asphalts. Nearly all of the producers supplying any grade of asphalt for this study included one or more samples in the 85-100 pen range. This group was considered the most representative of all asphalt cements then produced and used in the United States. The 210 projects in 26 states using these asphalts were constructed during 1954-56. These projects were subsequently field surveyed by Materials Research and Development Inc. (MR&D) in 1967.

MR&D surveyed 53 of the 210 projects. Of these, 50 were constructed with 85-100 pen. grade asphalts. When the pavement surveys were done in 1967, 34 of these 50 projects were in service as constructed. These were categorized as survivors, and the remaining projects that had been resurfaced were categorized as non-survivors. Only the survivor sections were included in this analysis since condition information could not be collected for the overlaid pavements.

Data on original asphalts, laboratory-aged asphalts and recovered asphalts for these projects was available . Field performance data was also available as a result of the 1967 survey. A complete list of variables stored in the database, i.e., the asphalt properties, mix properties, environmental conditions, traffic data and the field performance data, is included as Appendix A. Properties of the original asphalts can be found in the paper, "Properties of Highway Asphalts, Part I, 85-100 Penetration Grade" (Welborn and Halstead, 1959).

Scope of Analysis

For this preliminary analysis, it was decided to analyze the relationship between select recovered asphalt properties and field performance. A hierarchy of pavement distress types measured in the study is presented in Figure 1. The three performance variables (dependent variables) selected for this analysis were:

- Transverse Cracking, Y_1
- Polygon Cracking, Y_2
- Rutting, Y_3

Transverse cracking is assumed to be a measure of non-load related thermal cracking. However, from Figure 1, it is clear that this assumption is not absolutely true. There was no attempt to distinguish between load-related and non-load related transverse cracks. For a description of distress types, refer to "Changes in fundamental properties of asphalt during service in pavements" (Vallerga, White & Rostler, 1970). Polygon cracking (commonly known as alligator cracking) is assumed to measure load-related cracking. The polygon cracking data showed almost no spread, with all sections showing high polygon cracking (i.e., nearly all values were 3.0). Therefore, polygon cracking, as a variable, was dropped from further analysis. Rutting is the other predominant distress concern in A-003A. The other variables (independent variables) selected for this study were:

- Project Number, X_1
- Recovered penetration, 77°F, dmm; X_2
- Recovered softening point, °F; X_3
- Recovered capillary viscosity, 140°F, Poises; X_4
- Recovered capillary viscosity, 275°F, Centistokes; X_5
- Void Content, %; X_6
- Bitumen Index, %; X_7
- Recovered stiffness modulus @ 20°F, 10 secs.; X_8
- Recovered stiffness modulus @ 140°F, 10 secs.; X_9
- Average Daily Traffic, vpd; X_{11}
- Average Daily Truck Traffic, vpd; X_{12}
- Maximum Yearly Temperature, °F; X_{13}
- Minimum Yearly Temperature, °F; X_{14}
- Number of days per year over 89°F, days; X_{15}
- Thickness of the uppermost layer (wearing course), inches; X_{16}

This last variable (X_{16}) was dropped from the analysis because of numerous missing values.

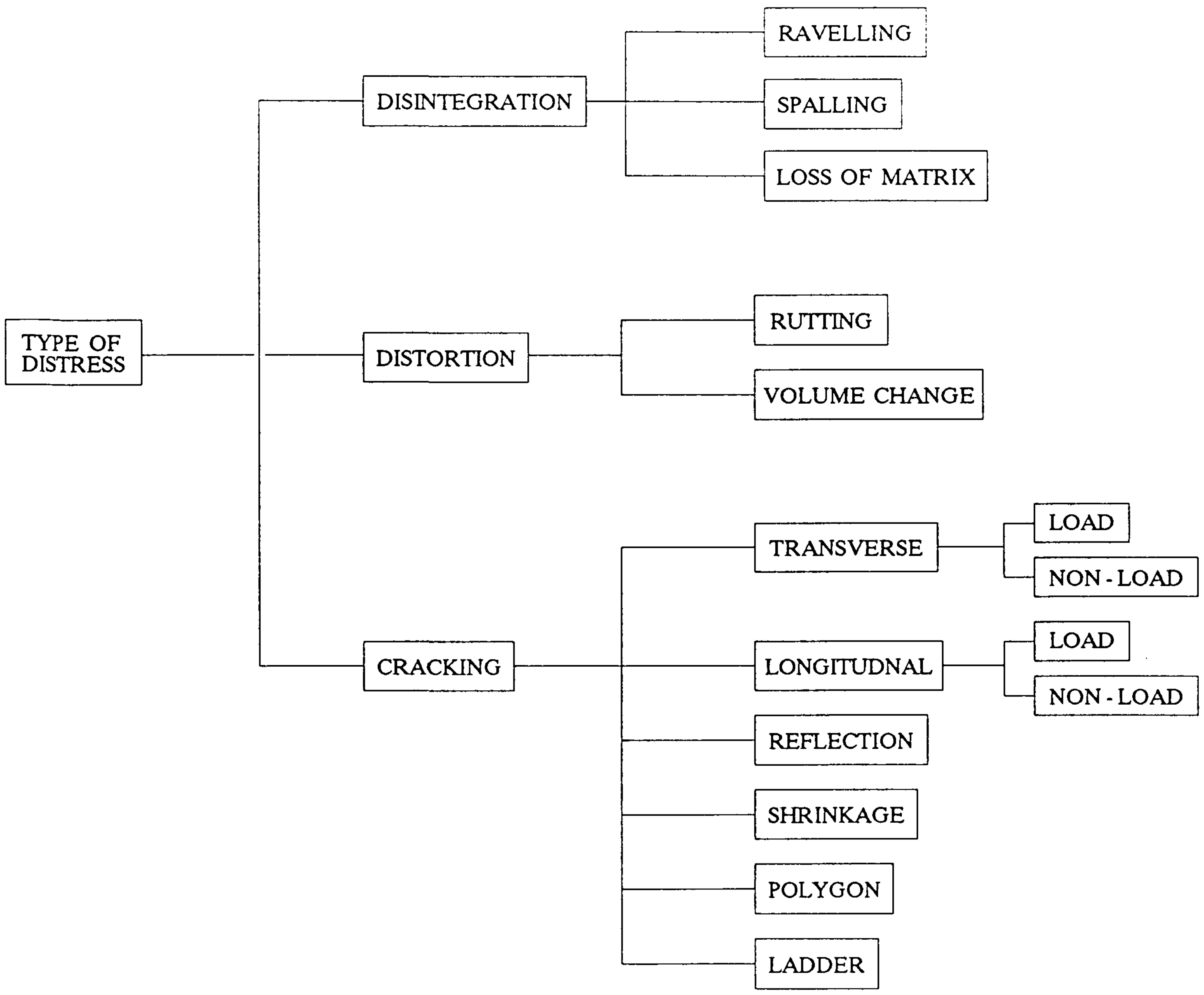

Figure 1. Hierarchy of pavement distress types used for 1967 condition survey.

Analysis

The data were analyzed using:

- Simple regression approach
- Discriminant analysis and multivariate general linear modeling

The simple regression approach was the preferred method of analysis. The discriminant analysis was intended as a "fall back" method of analysis, in the event that no simple relationships could be established.

Statistical Software Used

The SYSTAT and SYGRAPH statistical packages were used (on an IBM-PC) for this analysis.

Simple Regression Approach (Univariate Linear Model)

It was initially planned that simple regression relationships such as those developed in the A-003A Literature Review (Finn et. al., 1990, and Finn & Durrani, 1990) should be investigated. However, scatter plots (see Appendix B) showed a large scatter in the data and no "healthy" trends were noted. It is assumed that the large scatter in the data can be attributed to the wide range of environmental and loading conditions. Based on this assumption, each project was treated individually in terms of either the asphalt properties or the pavement performance, or both. The simple regression model was modified as follows:

$$\text{CATEGORY } X_1 = n$$

$$\text{MODEL } Y_i = \beta_0 + \beta X_i$$

where: X_1 = Project number
Y_i = Pavement performance parameter (dependent variable)
X_i = Asphalt property ($i = 2, \dots 5, 8, \dots 10$)
β_0, β = beta coefficients
n = total number of projects

Such a model has n-1 degrees of freedom in X, and 1 degree of freedom in X_i. As expected, this model provided a high coefficient of correlation (R^2). However, despite the high R^2, the p-value for the continuous variable (X_i) were very high. This suggests a non-significant relationship between the dependent variable (pavement performance parameter) and the continuous variable. In other words, if all the projects showed similar trends, i.e., similar slopes, it would result in lower p-values.

Another problem with this approach was the missing data in each project. An overview of the database is shown in Figure 2. Overall, 34 projects were included in the analysis. Each project had 6 observations. For six core extracted asphalt properties, there should have been six corresponding distress measurements. This was not so for all cases, as is shown in Figure 2. For example, in Figure 2, for Project No. 2 ($X_1 = 2$) and asphalt property X_3, only one observation is available and, hence, there is no variance. The observation is dropped when the model is regressed. Again, in the case of two observations per cell, there is but one possible regression line. This analysis was curtailed due to the problems indicated above and other problems which were encountered.

In short, no simple correlations were found between the pavement performance variables (transverse cracking, rutting) and the asphalt (and asphalt mix) properties selected for this analysis. In addition to there being no quantitative correlations, no trends were apparent between the performance variables and the selected asphalt (and asphalt mix) properties.

Discriminant Analysis and Multivariate General Linear Modeling

Data Manipulation

For this analysis, the data used were the average observations for each project level; hence, each project was treated as one data point. All analyses explained hereafter use one observation (average of reported values) per project, hence a total of 34 observations. Separate databases were

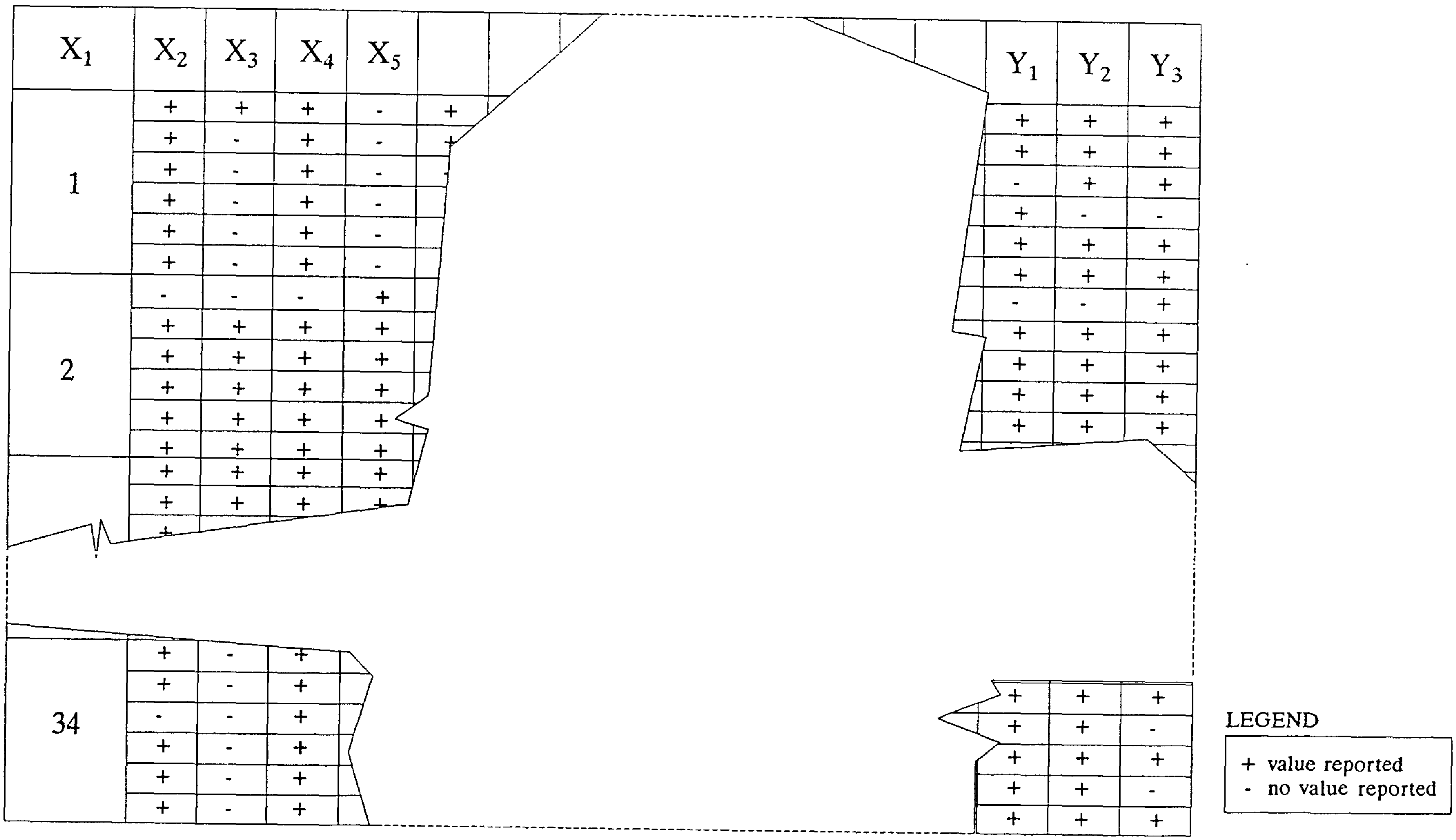

Figure 2. Overview of Database.

created for each of the three performance variables. The purpose was to make complete matrices without missing values[1]. As an example, on one project there was no data on the minimum yearly temperature, so instead of deleting the whole row containing that observation, the row was only deleted for the transverse cracking database. Thus, in the other database, e.g., rutting, where the minimum yearly temperature was not of primary concern, the column for the minimum yearly temperature was deleted. This is similar to a "pair-wise" treatment of missing values analysis of variance.

Discriminant Analysis

Discriminant Analysis is a statistical technique used to classify data into groups by maximizing the differences among the group means. To distinguish among the groups, a collection of discriminant variables (e.g., penetration, viscosity, air voids, etc.) that measure characteristics on which the groups are expected to differ should be made. The mathematical objective of discriminant analysis is to weigh and combine linearly the discriminant variables in some fashion so that the groups are forced to be as statistically distinct as possible. The discriminant analysis provides a discriminant function in the form of a mathematical equation, and its relative magnitude. After the development of a discriminant function, a frequency distribution for each of the two groups (distressed and non-distressed) is plotted (against the z-score) on one continuous horizontal axis (Figure 3). The shaded area indicates the overlap of the two distributions. The right half represents the probability (α) that a pavement which should be non-distressed is misclassified into the distressed group. Likewise, the left half indicates the probability (β) that a pavement is classified into the non-distressed group where it is actually distressed. The break between the two groups is decided such that $\alpha = \beta =$ minimum possible value. Figure 4 explains the development of a discriminant function for cracking. Figure 5 explains the practical uses of such an approach in the "real" world.

In this analysis, the data was separated into two groups, highly distressed pavements and undistressed pavements (e.g., cracked and uncracked pavements, rutted and non-rutted pavements). During the MR&D survey, the distresses were ranked on a scale of 0 to 3: zero

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[1] While trying to do an analysis of variance, these missing values result in singular matrices. The inverse of a singular matrix does not exist; hence, the ANOVA cannot be solved. As a reminder to the reader, an inverse of a r • r matrix exists only if its rank is 'r'. A matrix with a rank less than 'r' is said to be singular.

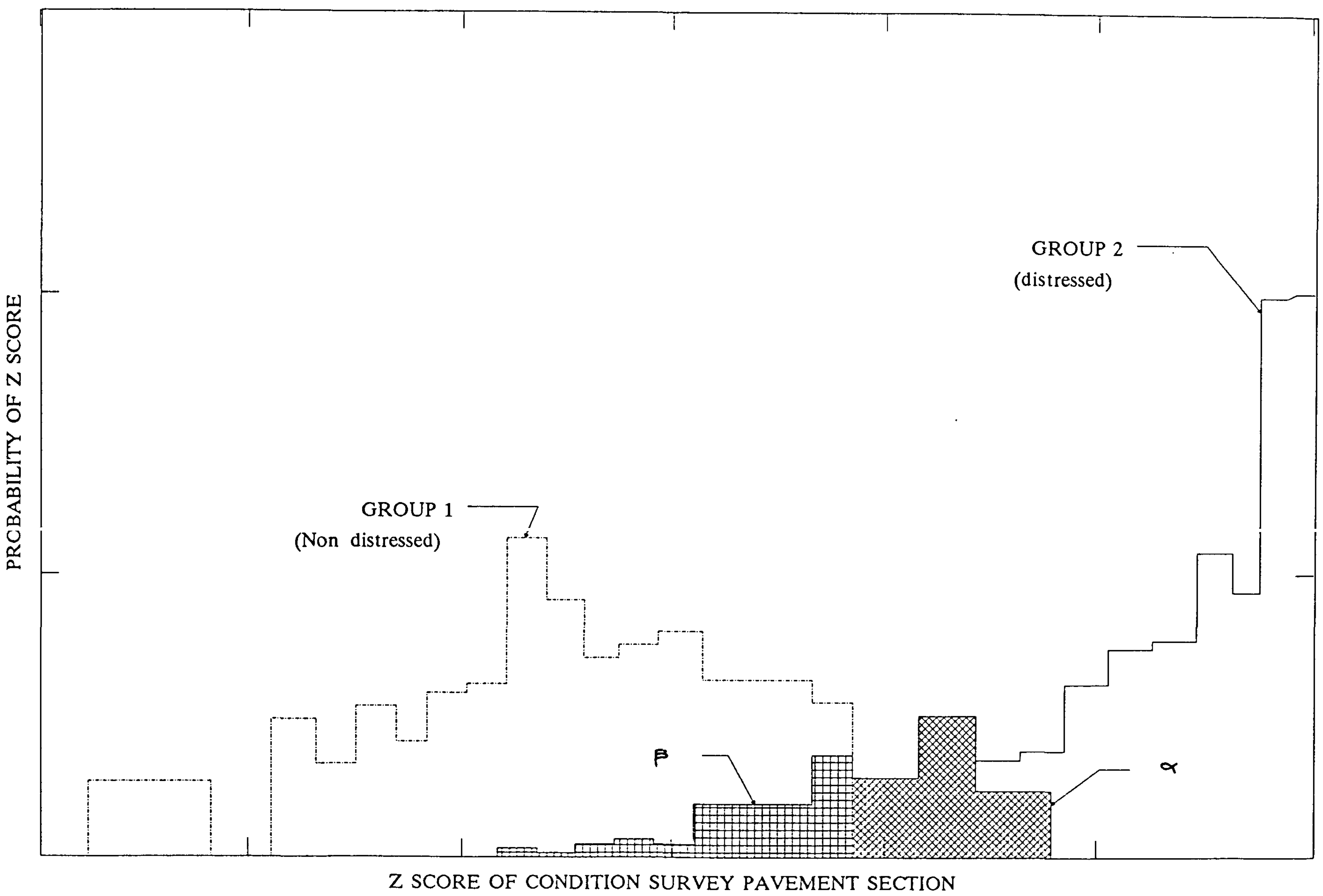
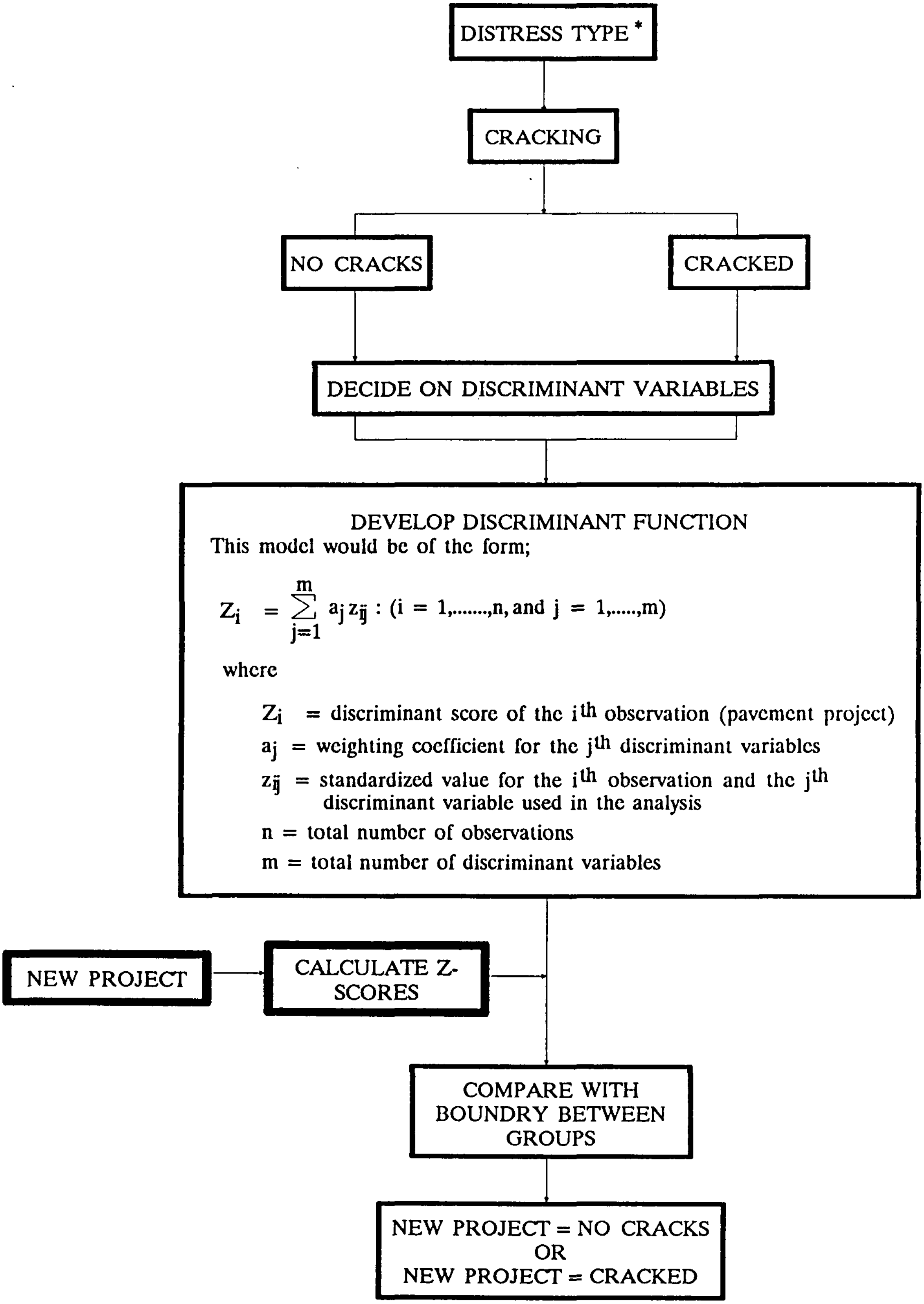


Figure 3. Frequency distribution of Z-scores.



* A similar approach can be used for developing the distress function for other distress types.

Figure 4. Development of discriminant function for cracking.

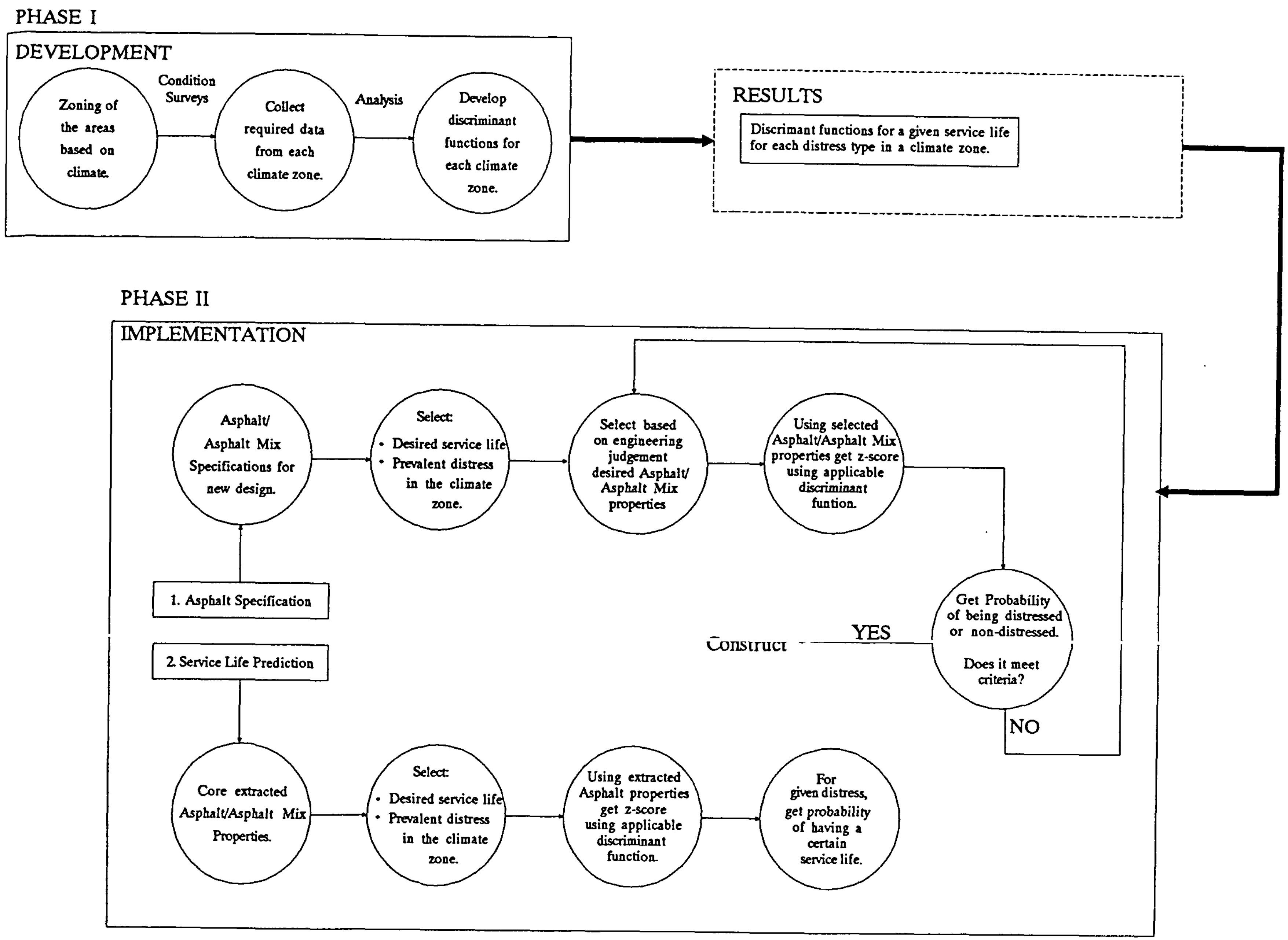


Figure 5. Prospective use of discriminant functions.

being no distress and three being highly distressed (failed on the basis of visual condition rating). The discriminant variables were the independent variables X_2-X_{15}, i.e., the recovered binder properties, asphalt mix properties, and loading and environmental conditions.

The general form of the discriminant function is as follows:

$$Z_i = \sum_{j=1}^{m} a_j \, z_{ij} \; : \; (i = 1,......,n \; and \; j = 1,......,m) \qquad \text{Eqn. 1}$$

where: Z_i = discriminant score of the i^{th} observation (pavement project)
a_j = weighting coefficient for the j^{th} discriminant variables
z_{ij} = standardized value for the i^{th} observation and the j^{th} discriminant variable used in the analysis
n = total number of observations
m = total number of discriminant variables

The standardized values, z_{ij}, are calculated as follows:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{\sigma_{x_j}} \qquad \text{Eqn. 2}$$

where: x_{ij} = value of the j^{th} distress manifestation, for the i^{th} observation being classified;
$\bar{x}_j$ = mean value of the j^{th} distress manifestation; and
σ_{xj} = standard deviation of x_j, which is equal to:

$$\sigma_{x_j} = [\sum_{i=1}^{n} (x_{ij} - \bar{x}_j)^2 \; / \; (n-1)]^{1/2}$$

As may be seen in Eqn. 1, the discriminant function is linear, hence transformations of non-linear discriminant variables are required. A multivariate analysis of variance/multivariate general linear regression analysis was used to pinpoint the important variables (and the required non-linear transformations) to be included as the discriminant variables. The results of this analysis are presented in the next section.

Multivariate General Linear Analysis

The general linear model was used for a multivariate analysis to provide a clue to the significant variables that effect pavement performance. An elementary statistical analysis provided a good "feel" for possible transformations of the data to develop such a linear model. Tables 1 and 2 provide a summary of the statistics for the data used. The general linear model used was:

$$Y_1, Y_3 = X_1 \mid X_2 \mid X_3 \mid X_4 \mid \ldots\ldots\ldots \mid X_{16}$$

The " $\mid$ " indicates all possible interactions. Due to SYSTAT processing limitations, only first-level interactions were considered.

Model for transverse cracking: After a series of transformations and trials the following model was used for transverse cracking:

$$Y_1 = \beta_0 + \beta_1 \log X_1 + \beta_1'(\log X_1)(X_2) + \beta_2'(\log X_1)(X_3) \qquad \text{Eqn. 3}$$

where: Y_1 = $(\text{Transverse Cracking}+1)^{-1}$
X_1 = 1+Void Content (Range is 1.2 - 14%)
X_2 = Recovered penetration @ 77°F (Range is 5-67 dmm)
X_3 = Recovered ring and ball softening point (range is 120.8-175.5°F)
β_0 = -0.163 (0.000)
β_1 = -18.624 (-7.022)
β_1' = 0.121 (0.804)
β_2' = 0.108 (7.177)

The R^2 for the particular model above is 0.64 (S.E. = 1.088). The values for the standardized regression coefficients[2] are shown within brackets (e.g., $\beta_1 = -18.624$ (-7.022), which imply that the regression coefficient is -18.624 and the standardized regression coefficient is -7.022). To test the existence of a regression relation (Neter et. al., 1983), the F-statistic was used. The procedure is explained as follows:

$$H_o: \beta_1 = \beta_2 = \ldots\ldots\ldots \beta_{p-1} = 0$$

$$H_a: \text{not all } \beta_k \ (k = 1, \ldots\ldots\ldots, p-1) \text{ equal zero.}$$

We use the test statistic:

$$F^* = \frac{MSR}{MSE} \qquad \text{Eqn. 4}$$

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[2] Sometimes, these standardized regression coefficients are interpreted as showing the relative importance of the independent variables. But, one must be cautious about interpreting regression coefficients, whether standardized or not. The reason is that when the independent variables are correlated among themselves, the regression coefficients are affected by the other independent variables in the model. Not only does the presence of correlations among the independent variables affect the magnitude of the standardized regression coefficients, but the spacings of the observations on the independent variables also affect the standardized regression coefficients. Such is the case for this particular (BPR) analysis; the spacing of observations on the independent variables is quite arbitrary.

Table 1. General statistics for the data sets used to develop the models for transverse cracking.

STATISTICS	PEN77 dmm (X_2)	VIS140 poises (X_4)	VIS275 centistokes (X_5)	SOFTPT °F (X_3)	VOCON % (X_6)	BITIND % (X_7)	SM2010 psi (X_8)	ADT psi (X_{10})	YRMIN °F (X_{14})	TRANCR (0-3) (Y_1)
Minimum	5.0	1524.2	280.4	120.8	1.2	10.2	1825.0	500.0	28.0	0
Maximum	67.0	700012.3	6252.3	175.5	14.0	23.8	18666.7	37000.0	59.0	3
Mean	33.3	97232.9	1504.8	143.7	4.1	15.9	6338.7	10403.2	46.0	2.2
Std. Deviation	16.5	169359.4	1291.5	3.0	2.9	2.9	3760.7	10124.7	8.7	1.1
Coef. of Variation	0.5	1.7	0.9	0.1	0.7	0.2	0.6	0.9	0.2	0.5
Skewness	0.3	2.4	2.0	0.5	1.5	0.5	1.8	1.5	-0.6	

Table 2. General statistics for the data sets used to develop the models for rutting.

STATISTICS	PEN77 dmm (X_2)	VIS140 poises (X_4)	VIS275 centistokes (X_5)	SOFTPT °F (X_3)	VOCON % (X_6)	BITIND % (X_7)	ADT vpd (X_{10})	ADT vpd (X_{11})	ASPHALTENES % (X_{12})	YRMAX °F (X_{13})	DYS/89 °F (X_{15})	RUTT (0-3) (Y_3)
Minimum	5.8	1524.2	280.4	120.8	1.2	10.2	500.0	16.1	16.0	51.0	4	1.4
Maximum	67.7	700012.3	6252.3	175.5	14.0	23.8	35000.0	45.3	45.3	91.0	99	3.0
Mean	34.2	85288.9	1458.3	142.8	4.0	15.9	9545.2	29.6	29.3	68.4	51	2.6
Std. Deviation	15.9	157852.8	1285.4	14.8	2.9	2.9	9032.5	7.1	7.1	9.4	36	0.4
Coefficient of Variation	0.5	1.9	0.9	0.1	0.7	0.2	0.9	0.2	0.2	0.1	0.7	0.2
Skewness	-0.7	2.8	2.2	0.6	1.7	0.5	1.6	0.2	0.3	-0.4	-0.1	-0.9

The decision rule to control the Type I error at α is:

$$\text{If } F^* \leq F(1-\alpha, p-1, n-p), \text{ conclude } H_o$$
$$\text{If } F^* \geq F(1-\alpha, p-1, n-p), \text{ conclude } H_a$$

where: $p-1$ = degrees of freedom of regression
$n-p$ = degrees of freedom for residuals
MSE = error mean square
MSR = regression mean square
α = significance level

Using the values from Table 3:

$$F^* = \frac{19.681}{1.183} = 16.631 \qquad \textbf{Eqn. 5}$$

Using the percentiles of F-distribution table:

$$F(.999; 3,28) = 7.217 < F^*$$

Therefore, the above regression relation (Eqn. 3) exists at a 99.9 percent confidence level. But, it should be borne in mind that the existence of a regression relation by itself does not assure that useful predictions can be made.

We can conclude that a strong relationship exists between the transverse cracking of asphalt pavements and the void content of the mix (as obtained from the recovered cores), the penetration of asphalt at 77°F (recovered) and the Ring and Ball softening point of the asphalt. However, the low R^2 indicates that Eqn. 3 may not be the best model for such a relationship.

Model for rutting: No single variable was found significant. The final model is based on a series of first level interactions as follows:

$$\begin{aligned} Y_3 = \beta_0 &+ \beta_1'(X_2)(\log X_4) + \beta_2'(X_2)(\log X_6) + \beta_3'(X_2)(\log X_7) + \beta_4'(X_3)(\log X_6) \\ &+ \beta_5'(\log X_4)(\log X_6) + \beta_6'(\log X_6)(X_7) + \beta_7'(\log X_6)(X_{15}) + \beta_8'(\log X_6)(X_{15}) \end{aligned}$$

Eqn. 6

where: Y_3 = Rutting rating (0-3)
X_2 = Recovered penetration @ 77°F (range is 5.8-67.7 dmm)
X_3 = Recovered ring and ball softening point, (range is 120.8-175.5°F)
X_4 = 1+Recovered capillary viscosity, 140°F (range is 1,524-700,012 poises)
X_6 = 1+Void content (range is 1.2-14 percent)

Table 3. Analysis of variance results for distress models.

DEPENDENT VARIABLE	CRACKING	RUTTING
Number of Observations (n)	32	31
Squared Multiple R	0.641	0.742
Standard Error of Estimate	1.088	0.268
Degrees of Freedom of Regression (p-1)	3	9
Degrees of Freedom of Residuals (n-p)	28	21
Regression Mean Square (MSR)	19.681	0.481
Error Mean Square (MSE)	1.183	0.072

X_7 = 1+Bitumen index[3] (range is 10.2-23.8 percent)
X_{13} = Yearly maximum (range is 51-81°F)
X_{15} = Days over 89°F (range is 4-99 days)
β_0 = 3.739 (0.000)
β_1 = -0.014 (-3.498)
β_2 = 0.019 (2.022)
β_3 = 0.004 (2.648)
β_4 = -0.024 (-27.815)
β_5 = 0.239 (21.647)
β_6 = -0.032 (-2.819)
β_7 = 0.018 (10.039)
β_8 = -0.006 (-3.729)

The R^2 for this particular model is 0.742 (S.E. = 0.268). Referring to Table 3, the F-ratio (F^*) can be calculated as follows:

$$F^* = \frac{0.481}{0.072} = 6.705 \qquad \text{Eqn. 7}$$

Using the percentiles of F-distribution table:

$$F\ (0.999;\ 9{,}21) = 5.13 < F^*$$

Therefore, the above regression relation exists at a 99.9 percent level.

Although no single variable was found significant, void content appears in six of the eight significant interactions. We can conclude that rutting is significantly affected by the void content.

As can be seen from the models for transverse cracking and rutting, void content of the asphalt mix is the most significant variable affecting performance (in terms of transverse cracking and rutting). Hence, it seems reasonable to use voids as a discriminant variable (actually, the discriminant variable would be log (1+void content), to make the discriminant function linear). However, a discriminant function could not be developed. Recall that one value, i.e., the average value, was used for each variable for each project. After the pair-wise treatment, this resulted in thirty-two data points for each data set, i.e., data from 32 projects, for the transverse cracking data set and thirty-one data points for the rutting data set. Only two projects in the transverse cracking

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[3]

$$Bitumen\ index \times 10^{-3} = \frac{\%\ asphalt\ (agg.\ basis)}{100 \times corrected\ surface\ area}$$

data had zero cracking and none of the projects in the rutting data set had zero rutting. Therefore, a discriminant function could not be developed since there was nothing to discriminate between. (The reader is reminded at this point that had the data been analyzed on a mainframe using all available data points, such a discrimination could possibly have been made.)

Summary Remarks

Originally, only asphalt binder properties were included in the analysis. There was a great deal of scatter associated with the binder property data (see scatter plots in Appendix B). Later, select mix properties (void content, bitumen index, etc), environmental (maximum yearly temperature, etc.) and load variables (average daily traffic, average daily truck traffic) were included in the analysis. Void content, a "mix-property," was the prime factor of significance in the model for transverse cracking and was a part of most of the significant interactions in the model for rutting. This is in keeping with the conclusions drawn in the review of state and industry reports on asphalt properties and relationship to pavement performance (Finn and Durrani, 1990).

Discriminant analysis appears to be a viable approach to analyze the data being collected in the future (SHRP long-term pavement performance studies). It can be used to:

- Specify original asphalt (and asphalt mix) properties for a given service life for the pavement, and
- Predict remaining service life of pavement based on recovered asphalt (and asphalt mix) properties.

Conclusions

1. No simple correlations existed between the pavement performance variables (transverse cracking, rutting) and the asphalt (and asphalt mix) properties selected for this analysis. In addition to there being no quantitative correlations, no trends were visible between the performance variables and the selected asphalt (and asphalt mix properties).

2. According to the multivariate general model analyses, the mix properties appear to "overshadow" the effect of binder properties in prediction of pavement distress (in this case, restricted to transverse cracking and rutting.) We can conclude that a strong relationship exists between the transverse cracking of asphalt pavements and the void content of the mix (as obtained from the recovered cores), the penetration of asphalt at 77°F (recovered), and the Ring and Ball softening point (recovered) of the asphalt. However, the low R^2 for Eqn. 3 indicates that a better model may exist for such a relationship. Although no single variable was found to be significant in the rutting model, void content appears in six of the eight significant interactions. We can conclude that rutting is significantly affected by the void content.

3. A further analysis of the BPR data is not warranted. Even trends could be established and a discriminant function developed; there would still be a question as to its usefulness. Most of the properties measured during this (BPR) study have been shown, by SHRP researchers, to be incapable of accurately characterizing asphalt/asphalt mixture behavior. As such, further studies of the BPR data would not be useful for the SHRP program.

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Appendix A: List of Variables in BPR Data

Table A-1 Key to Column Headings of Computer Printout

Symbol	Explanation	Used in Card No.
BPR	BUREAU OF PUBLIC ROADS NUMBER	1234567890ABCDEFH
CARD NO	CARD NUMBER	1234567890ABCDEFH
BL NO	BLOCK NUMBER (ROSTLER PARAMETER AND REGION)	1234567890ABCDEFH
PRJ NO	MR AND D PROJECT NUMBER	1234567890ABCDEFHJK
PROJ NO	MR AND D PROJECT NUMBER	1234567890ABCDEFHJK
SMPL NO	LONGITUDINAL STRATA/LATERAL STRATA/SAMPLE NUMBER	1234567890ABCDEFH
SOURCE	CODE NUMBER FOR CRUDE SOURCE	1
REFY	BPR REFINERY NUMBER	1
PEN 39	PENETRATION AT 39.2 F 0.1 MILLIMETERS	1 4
PEN 45	PENETRATION AT 45. F 0.1 MILLIMETERS	1 4
PEN 60	PENETRATION AT 60. F 0.1 MILLIMETERS	1 4
PEN 77	PENETRATION AT 77. F 0.1 MILLIMETERS	1 4
PEN 95	PENETRATION AT 95. F 0.1 MILLIMETERS	1 4
PENRTIO	PENETRATION RATIO	1
PV60/5	SLIDING PLATE VISCOSITY 60 F / 05SEC	1 4
PV77/5	SLIDING PLATE VISCOSITY 77 F / 05SEC	1 4
VISC140	VISCOSITY AT 140 F /POISES	1
VISC275	VISCOSITY AT 275 F /CENTISTOKES	1
DUCT 60	DUCTILITY AT 60 F /CENTIMETERS	1 4
DUCT 77	DUCTILITY AT 70 F /CENTIMETERS	1 4
SOFT PT	SOFTENING POINT / F	1 4
PAL PU	PELLET ABRASION,LOSS AT 500REV,PERCENT,UNAGED	1
PAL PA	PELLET ABRASION,LOSS AT 500REV,PERCENT AGED 7 DAYS	1
STATUS	SERVICE STATUS	1234567890ABCDEFHJK
TPV45/5	SLIDING PLATE VISCOSITY /05SEC AT 45F AFTER TFOT	3
TPV60/5	SLIDING PLATE VISCOSITY /05SEC AT 60F AFTER TFOT	3
TPV77/5	SLIDING PLATE VISCOSITY /05SEC AT 77F AFTER TFOT	3
TPV45/1	SLIDING PLATE VISCOSITY/001SEC AT 45F AFTER TFOT	3
TPV60/1	SLIDING PLATE VISCOSITY/001SEC AT 60F AFTER TFOT	3
TPV77/1	SLIDING PLATE VISCOSITY/001SEC AT 77F AFTER TFOT	3
TSHS045	SHEAR SUSCEPTIBILITY AT 45F AFTER TFOT	3
TSHS060	SHEAR SUSCEPTIBILITY AT 60F AFTER TFOT	3
TSHS077	SHEAR SUSCEPTIBILITY AT 77F AFTER TFOT	3
PV60/1	SLIDING PLATE VISCOSITY 60F /001SEC	4
PV77/1	SLIDING PLATE VISCOSITY 77F /001SEC	4

Symbol	Explanation	Used in Card No.
SHIND60	SHEAR INDEX 60F	4
SHIND77	SHEAR INDEX 77F	4
CAPV140	CAPILLARY VISCOSITY AT 140F	4
CAPV275	CAPILLARY VISCOSITY AT 275F	4
VO CON	VOID CONTENT	4
AS CON	ASPHALT CONTENT	4
MI 200	MINUS 200 MESH AGGREGATE	4
SUR AR	SURFACE AREA	4
RELI RT	RELIABILITY THAT ASPHALT IS AS STATED	45 / 0
BITIND	BITUMEN INDEX	4
PALRPA	PELLET ABRASION LOSS AT 500REV PERCENT(RECOVERED)	5
PALRMRA	PELLET ABRASION MG/REV (RECOVERED)	5
PALMRU	PELLET ABRASION MG/REV AT 500REV,UNAGED	2
PALMRA	PELLET ABRASION MG/REV AT 500REV,AGED 7 DAYS	2
ASPH	ASPHALTENES BY ROSTLER ANALYSIS /PER CENT	2 5
NBASE	NITROGEN BASES BY ROSTLER ANALYSIS /PER CENT	2 5
1ACID	FIRST ACIDAFFINS BY ROSTLER ANALYSIS /PER CENT	2 5
2ACID	SECOND ACIDAFFINS BY ROSTLER ANALYSIS/PER CENT	2 5
PARAF	PARAFFINS BY ROSTLER ANALYSIS /PER CENT	2 5
ROPAR	ROSTLER PARAMETER	2 5
GL TRAN	GLASS TRANSITION TEMPERATURE /F	5 C
SP GRV	SPECIFIC GRAVITY	2 0
STATE	STATE NUMBER - CODE CHART 1090-14	2
CONPROJ	STATE CONSTRUCTION PROJECT NUMBER	2
ORI/DUP	ORIGINAL OR DUPLICATE SAMPLE	2
SUBS	SUBSCRIPT DESIGNATION OF DUPLICATE	2
COMP	COMPOSITION ANALYSIS RUN 0=NO	2
TPEN 45	PENETRATION 100G5SEC 45F AFTER THIN FILM OVEN TEST	3
TPEN 60	PENETRATION 100G5SEC 60F AFTER THIN FILM OVEN TEST	3
TPEN 77	PENETRATION 100G5SEC 77F AFTER THIN FILM OVEN TEST	3
TPEN 95	PENETRATION 100G5SEC 95F AFTER THIN FILM OVEN TEST	3
TPEN245	PENETRATION 200G60SEC45F AFTER THIN FILM OVEN TEST	3
TPENRIO	PENETRATION RATIO AFTER THIN FILM OVEN TEST	3
TSOFTPT	SOFTENING POINT R AND B AFTER THIN FILM OVEN TEST	3
TDUCT45	DUCTILITY AT 45F AFTER THIN FILM OVEN TEST	3
TDUCT60	DUCTILITY AT 60F AFTER THIN FILM OVEN TEST	3
TDUCT77	DUCTILITY AT 77F AFTER THIN FILM OVEN TEST	3
TVIS140	VISCOSITY AT 140F AFTER THIN FILM OVEN TEST	3
TVIS275	VISCOSITY AT 275F AFTER THIN FILM OVEN TEST	3

Symbol	Explanation	Used in Card No.
ASPH AM	PER CENT ASPHALTENES AFTER MIXING	6
NBASEAM	PER CENT NITROGEN BASES AFTER MIXING	6
1ACIDAM	PER CENT FIRST ACIDAFFINS AFTER MIXING	6
2ACIDAM	PER CENT SECOND ACIDAFFINS AFTER MIXING	6
PARAFAM	PER CENT PARAFFINS AFTER MIXING	6
ROPARAM	ROSTLER PARAMETER AFTER MIXING	6
ASPH AA	PERCENT ASPHALTENES AFTER AGING	6
NBASEAA	PERCENT NITROGEN BASES AFTER AGING	6
1ACIDAA	PERCENT FIRST ACIDAFFINS AFTER AGING	6
2ACIDAA	PERCENT SECOND ACIDAFFINS AFTER AGING	6
PARAFAA	PERCENT PARAFFINS AFTER AGING	6
ROPARAA	ROSTLER PARAMETER AFTER AGING	6
PROSEL	PROJECT SELECTION 1=USED 2=SAMPLED/UNUSED	6
RID QUA	RIDING QUALITY RATING	7
RAVELL	RAVELLING RATING	7
SPALL	SPALLING RATING	7
LOSMAT	LOSS OF MATRIX RATING	7
DISINT	DISINTEGRATION YES=0 NO=3	7
RUTT	RUTTING RATING	7
CORRUG	CORRUGATION RATING	7
TRAN CR	TRANSVERSE CRACKING RATING	7
LONGCCR	LONGITUDINAL CRACKING CONSTRUCTION RATING	7
LONGLCR	LONGITUDINAL CRACKING LOAD RATING	7
SHRK CR	SHRINKAGE CRACKING	7
POLY CR	POLYGONAL CRACKING	7
LADR CR	LADDER CRACKING	7
REF/OTH	CRACKING CAUSED BY REFLECTION OR OTHER CAUSE	7
SEAL	RATING FOR MAINTENANCE-SURFACE TREATMENT	7
PATCH	RATING FOR MAINTENANCE-PATCHING	7
AS AMT	AMOUNT OF ASPHALT RATING OF SUFFICIENCY	7
SU TEXT	SURFACE TEXTURE RATING OF PERMEABILITY	7
DRAIN	DRAINAGE RATING	7
AS EVAL	EVALUATION OF ASPHALT	7
OV EVAL	OVERALL EVALUATION OF PAVEMENT	7
ADT	AVERAGE DAILY TRAFFIC VEH/DAY	7
ADTT	AVERAGE DAILY TRUCK TRAFFIC VEH/DAY	7
RATER	RATER 1=FINN/OLSEN 2=BPR 3=STATE	7
YR MAX	MEAN DAILY MAXIMUM TEMP FOR YEAR	8
YR MIN	MEAN DAILY MINIMUM TEMP FOR YEAR	8

Symbol	Explanation	Used in Card No.
NDEGDD	NORMAL DEGREE DAYS PER YEAR	8
DYS/89	NUMBER OF DAYS PER YEAR OVER 89F	8
JANMAX	NORMAL DAILY MAXIMUM FOR JANUARY	8
JANMIN	NORMAL DAILY MINIMUM FOR JANUARY	8
FEBMAX	NORMAL DAILY MAXIMUM FOR FEBRUARY	8
FEBMIN	NORMAL DAILY MINIMUM FOR FEBRUARY	8
MARMAX	NORMAL DAILY MAXIMUM FOR MARCH	8
MARMIN	NORMAL DAILY MINIMUM FOR MARCH	8
APRMAX	NORMAL DAILY MAXIMUM FOR APRIL	8
APRMIN	NORMAL DAILY MINIMUM FOR APRIL	8
MAYMAX	NORMAL DAILY MAXIMUM FOR MAY	8
MAYMIN	NORMAL DAILY MINIMUM FOR MAY	8
JUNMAX	NORMAL DAILY MAXIMUM FOR JUNE	8
JUNMIN	NORMAL DAILY MINIMUM FOR JUNE	8
JULMAX	NORMAL DAILY MAXIMUM FOR JULY	8
JULMIN	NORMAL DAILY MINIMUM FOR JULY	8
AUGMAX	NORMAL DAILY MAXIMUM FOR AUGUST	8
AUGMIN	NORMAL DAILY MINIMUM FOR AUGUST	8
SEPMAX	NORMAL DAILY MAXIMUM FOR SEPTEMBER	8
SEPMIN	NORMAL DAILY MINIMUM FOR SEPTEMBER	8
OCTMAX	NORMAL DAILY MAXIMUM FOR OCTOBER	8
OCTMIN	NORMAL DAILY MINIMUM FOR OCTOBER	8
NOVMAX	NORMAL DAILY MAXIMUM FOR NOVEMBER	8
NOVMIN	NORMAL DAILY MINIMUM FOR NOVEMBER	8
DECMAX	NORMAL DAILY MAXIMUM FOR DECEMBER	8
DECMIN	NORMAL DAILY MINIMUM FOR DECEMBER	8
NORMTOT	NORMAL TOTAL	8
DAY/.1	NUMBER OF DAYS WITH RAINFALL OVER 0.1 INCH	8
SNOW	MEAN TOTAL SNOW	8
REL HUM	RELATIVE HUMIDITY AT 0800 HRS	8
MN STAR	MONTH CONSTRUCTION STARTED	9
YR STAR	YEAR CONSTRUCTION STARTED	9
MN FIN	MONTH CONSTRUCTION FINISHED	9
YR FIN	YEAR CONSTRUCTION FINISHED	9
1TYP	DESCRIPTION OF LAYER 1 SEE CODING	9
2TYP	DESCRIPTION OF LAYER 2 SEE CODING	9
3TYP	DESCRIPTION OF LAYER 3 SEE CODING	9
4TYP	DESCRIPTION OF LAYER 4 SEE CODING	9
5TYP	DESCRIPTION OF LAYER 5 SEE CODING	9

Symbol	Explanation	Used in Card No.
6TYP	DESCRIPTION OF LAYER 6 SEE CODING	9
THCK 1	THICKNESS OF LAYER 1	9
THCK 2	THICKNESS OF LAYER 2	9
THCK 3	THICKNESS OF LAYER 3	9
THCK 4	THICKNESS OF LAYER 4	9
THCK 5	THICKNESS OF LAYER 5	9
THCK 6	THICKNESS OF LAYER 6	9
LAYER	LAYER THICKNESS OF LAYER OF INTEREST	9
LIFTS	NUMBER OF LIFTS TO PLACE LAYER OF INTEREST	9
RESURF	REASON FOR RESURFACING SEE CODE	9
PLCMAX	MAXIMUM AIR TEMPERATURE DURING PLACEMENT	9
PLCMIN	MINIMUM AIR TEMPERATURE DURING PLACEMENT	9
MIXMAX	MAXIMUM MIX TEMPERATURE DURING MIXING	9
MIXMIN	MAXIMUM MIX TEMPERATURE DURING MIXING	9
DIST	HAUL DISTANCE	9
CONT HI	ASPHALT CONTENT HIGH	9
CONT LO	ASPHALT CONTENT LOW	9
CONT AV	ASPHALT CONTENT AVERAGE	9
TESTNO	NUMBER OF TESTS USED TO DETERMINE ASPHALT CONTENT	9
LOCAT	LOCATION OF LAYER OF INTEREST	9
MIX DRY	MIXING CYCLE TIME DRY	9
MIX WET	MIXING CYCLE TIME WET	9
MIX TOT	MIXING CYCLE TIME TOTAL	9
HIPENO	PENETRATION OF ORIGINAL ASPHALT MAXIMUM	0
LOPENO.	PENETRATION OF ORIGINAL ASPHALT MINIMUM	0
AVPENO	PENETRATION OF ORIGINAL ASPHALT AVERAGE	0
PENTSTO	NUMBER OF PENETRATION TESTS USED ON ORIGINAL ASPH	0
AVPENR	PENETRATION OF RECOVERED ASPHALT AVERAGE	0
PENTSTR	NUMBER OF PENETRATION TESTS USED ON RECOVERED ASPH	0
ASSTMTH	METHOD OF TEST STRENGTH OF ASPHALT CONCRETE	0
ASSTRLT	RESULT OF TEST STRENGTH OF ASPHALT CONCRETE	0
ASDYMTH	METHOD OF TEST DENSITY OF ASPHALT CONCRETE	0
ASDYRLT	RESULT OF TEST DENSITY OF ASPHALT CONCRETE	0
AGDRMTH	DURABILITY OF AGGREGATE - TEST METHOD	0
AGDRRLT	DURABILITY OF AGGREGATE - TEST RESULT	0
AGTYPCR	TYPE OF COARSE AGGRGATE - SEE CODE	0
AGTYPFN	TYPE OF FINE AGGRGATE - SEE CODE	0
AGTXTCR	TEXTURE COARSE AGGRGATE - SEE CODE	0

Symbol	Explanation	Used in Card No.
AGTXTFN	TEXTURE FINE AGGRGATE - SEE CODE	0
FILLTYP	TYPE OF MINERAL FILLER USED	0
FILLCNT	PERCENT OF MINERAL FILLER USED	0
FIL-200	PERCENT FILLER PASSING NO 200 SIEVE	0
MNRESUR	MONTH RESURFACED	0
YRRESUR	YEAR RESURFACED	0
THKRESC	THICKNESS OR TYPE RESURFACING FROM CORE	0
THKSURC	THICKNESS OR TYPE SURFACE COURSE FROM CORE	0
THKBINC	THICKNESS OR TYPE BINDER COURSE FROM CORE	0
THKBASC	THICKNESS OR TYPE BASE COURSE FROM CORE	0
CPV77M5	SLIDING PLATE VISCOSITY,77F,05SEC MIXED CWO	A
CPV77A5	SLIDING PLATE VISCOSITY,77F,05SEC 200 HRS CWO	A
CPV77B5	SLIDING PLATE VISCOSITY,77F,05SEC 400 HRS CWO	A
CPV77C5	SLIDING PLATE VISCOSITY,77F,05SEC 600 HRS CWO	A
CPV77D5	SLIDING PLATE VISCOSITY,77F,05SEC 800 HRS CWO	A
CPV77E5	SLIDING PLATE VISCOSITY,77F,05SEC 1000HRS CWO	A
CPV77M1	SLIDING PLATE VISCOSITY,77F,001SEC MIXED CWO	A
CPV77A1	SLIDING PLATE VISCOSITY,77F,001SEC 200 HRS CWO	A
CPV77B1	SLIDING PLATE VISCOSITY,77F,001SEC 400 HRS CWO	A
CPV77C1	SLIDING PLATE VISCOSITY,77F,001SEC 600 HRS CWO	A
CPV77D1	SLIDING PLATE VISCOSITY,77F,001SEC 800 HRS CWO	A
CPV77E1	SLIDING PLATE VISCOSITY,77F,001SEC 1000HRS CWO	A
CSHINDM	SHEAR SUSC MIXED CALIF WEATHERING OVEN	B
CSHINDA	SHEAR SUSC AGED 200 HRS CALIF WEATHERING OVEN	B
CSHINDB	SHEAR SUSC AGED 400 HRS CALIF WEATHERING OVEN	B
CSHINDC	SHEAR SUSC AGED 600 HRS CALIF WEATHERING OVEN	B
CSHINDD	SHEAR INDEX	
CSHINDE	SHEAR SUSC AGED 1000HRS CALIF WEATHERING OVEN	B
CMIC77M	MICRODUCTILITY AT 77F MIXED	B
CMIC77A	MICRODUCTILITY AT 77F AGED 200 HRS AFTER CWO	B
CMIC77B	MICRODUCTILITY AT 77F AGED 400 HRS AFTER CWO	B
CMIC77C	MICRODUCTILITY AT 77F AGED 600 HRS AFTER CWO	B
CMIC77D	MICRODUCTILITY AT 77F AGED 800 HRS AFTER CWO	B
CMIC77E	MICRODUCTILITY AT 77F AGED 1000HRS AFTER CWO	B
CAL77MT	SHOT ABRASION LOSS AT 77F OF 1000GM/MIXED /CWO	B
CAL77AT	SHOT ABRASION LOSS AT 77F OF 1000GM/200 HRS/CWO	B

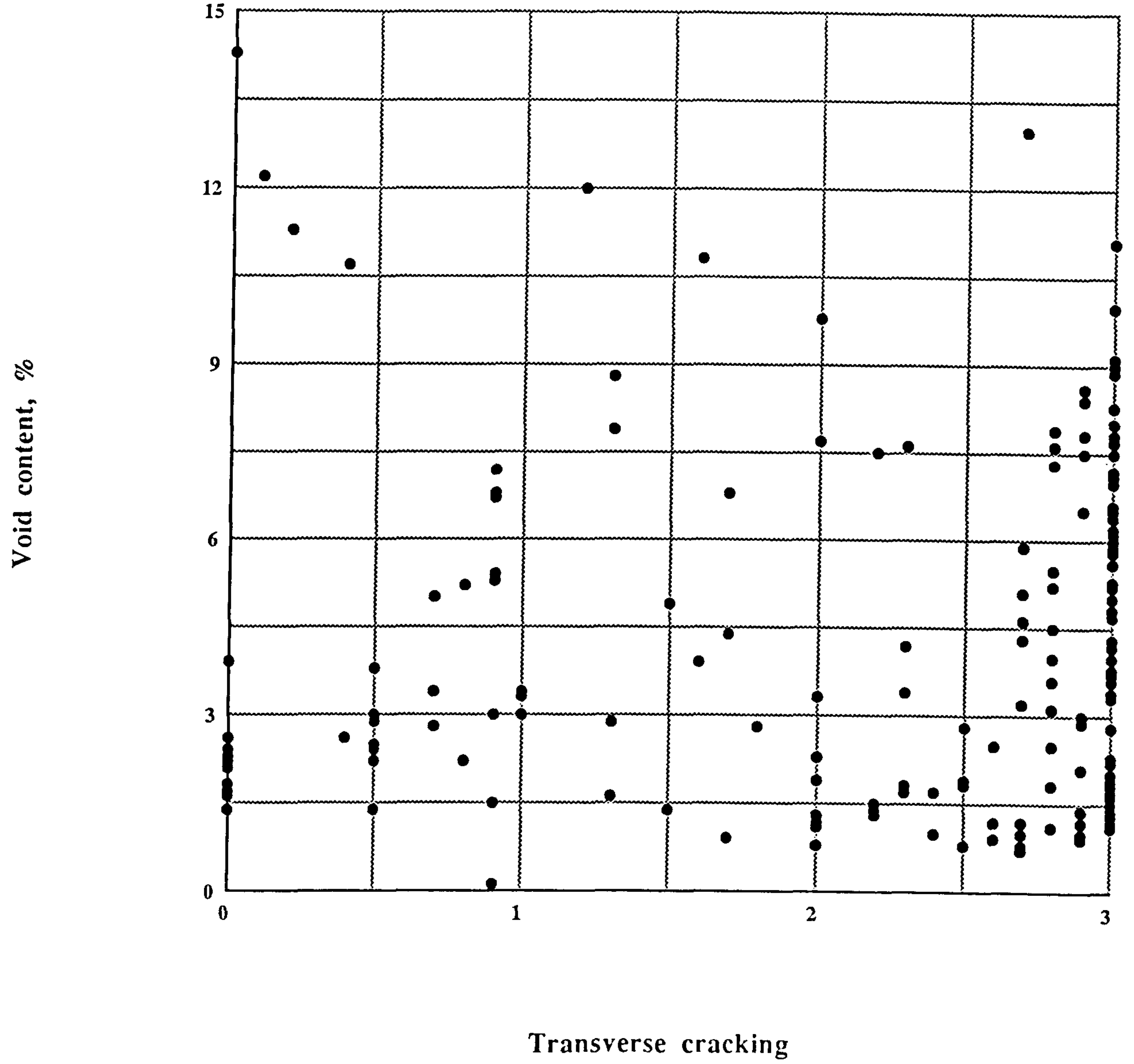
Symbol	Explanation	Used in Card No.
CAL77BT	SHOT ABRASION LOSS AT 77F OF 1000GM/400 HRS/CWO	B
CAL77CT	SHOT ABRASION LOSS AT 77F OF 1000GM/600 HRS/CWO	B
CAL77DT	SHOT ABRASION LOSS AT 77F OF 1000GM/800 HRS/CWO	B
CAL77ET	SHOT ABRASION LOSS AT 77F OF 1000GM/100 HRS/CWO	B
PPEN45	PRESENT PENETRATION AT 45F OF ORIGINAL ASPHALTS	C
PPEN60	PRESENT PENETRATION AT 60F OF ORIGINAL ASPHALTS	C
PPEN77	PRESENT PENETRATION AT 77F OF ORIGINAL ASPHALTS	C
PPEN95	PRESENT PENETRATION AT 95F OF ORIGINAL ASPHALTS	C
PPEN45X	PRESENT PEN 45F,200GM,60SEC OF ORIGINAL ASPHALT	C
PSOFTPT	PRESENT SOFTENING POINT OF ORIG ASPHLT	C
PDUCT45	PRESENT DUCTILITY AT 45F OF ORIG ASPHLT	C
PDUCT60	PRESENT DUCTILITY AT 60F OF ORIG ASPHLT	C
PDUCT77	PRESENT DUCTILITY AT 77F OF ORIG ASPHLT	C
PVSC140	PRESENT VISCOSITY AT 140F OF ORIG ASPHLT	C
PVSC275	PRESENT VISCOSITY AT 275F OF ORIG ASPHLT	C
PPV45/5	PRESENT SLIDING PLTE VISC,45F 05SEC OF ORIG ASPHLT	C
PPV60/5	PRESENT SLIDING PLTE VISC,60F 05SEC OF ORIG ASPHLT	C
PPV77/5	PRESENT SLIDING PLTE VISC,77F 05SEC OF ORIG ASPHLT	C
PPV45/1	PRESENT SLIDING PLTE VISC,45F 001SEC OF ORIG ASPHLT	C
PPV60/1	PRESENT SLIDING PLTE VISC,60F 001SEC OF ORIG ASPHLT	C
PPV77/1	PRESENT SLIDING PLTE VISC,77F 001SEC OF ORIG ASPHLT	C
PSHSU45	PRESENT SHEAR SUSCEPTIBILITY AT 45F OF ORIG ASPHLT	C
PSHSU60	PRESENT SHEAR SUSCEPTIBILITY AT 60F OF ORIG ASPHLT	C
PSHSU77	PRESENT SHEAR SUSCEPTIBILITY AT 77F OF ORIG ASPHLT	C
MPV60A5	SLIDING PLTE VISC 60F 7HRS 05SEC AFTER MOD TFOT	D
MPV77A5	SLIDING PLTE VISC 77F 7HRS 05SEC AFTER MOD TFOT	D
MPV60A1	SLIDING PLTE VISC 60F 7HRS 001SEC AFTER MOD TFOT	D
MPV77A1	SLIDING PLTE VISC 77F 7HRS 001SEC AFTER MOD TFOT	D
MPV60B5	SLIDING PLTE VISC 60F 9HRS 05SEC AFTER MOD TFOT	D
MPV77B5	SLIDING PLTE VISC 77F 9HRS 05SEC AFTER MOD TFOT	D
MPV60B1	SLIDING PLTE VISC 60F 9HRS 001SEC AFTER MOD TFOT	D
MPV77B1	SLIDING PLTE VISC 77F 9HRS 001SEC AFTER MOD TFOT	D
ASHSU60	SHEAR SUSCEPTIBILITY AT 60/F AFTER 7 HR MTFOT	D
ASHSU77	SHEAR SUSCEPTIBILITY AT 77/F AFTER 7 HR MTFOT	D
BSHSU60	SHEAR SUSCEPTIBILITY AT 60/F AFTER 9 HR MTFOT	D
BSHSU77	SHEAR SUSCEPTIBILITY AT 77/F AFTER 9 HR MTFOT	D
MVSC14A	CAPILLARY VISCOSITY AT 140/F AFTER 7HR MTFOT	D
MVSC14B	CAPILLARY VISCOSITY AT 140/F AFTER 9HR MTFOT	D
MVSC27A	CAPILLARY VISCOSITY AT 275/F AFTER 7HR MTFOT	D

Symbol	Explanation	Used in Card No.
MVSC27B	CAPILLARY VISCOSITY AT 275/F AFTER 9HR MTFOT	D
FLOTMPA	FLOW TEMPERATURE(DEGREES /F AFTER 7 HR MTFOT	D
FLOTMPB	FLOW TEMPERATURE(DEGREES /F AFTER 9 HR MTFOT	D
APEN77O	AMERICAN OIL CO PEN AT 77F ORIGINAL	E
APEN77T	AMERICAN OIL CO PEN AT 77F AFTER TFOT	E
APEN77X	AMERICAN OIL CO PEN AT 77F RECOVERED SAMPLE 1	E
APEN77Y	AMERICAN OIL CO PEN AT 77F RECOVERED SAMPLE 2	E
AVSC14O	AMERICAN OIL CO VISC AT 140F ORIGINAL	E
AVSC14T	AMERICAN OIL CO VISC AT 140F AFTER TFOT	F
AVSC14X	AMERICAN OIL CO VISC AT 140F RECOVERED SAMPLE 1	E
AVSC14Y	AMERICAN OIL CO VISC AT 140F RECOVERED SAMPLE 2	E
AVSC27O	AMERICAN OIL CO VISC AT 275F ORIGINAL	E
AVSC27T	AMERICAN OIL CO VISC AT 275F AFTER TFOT	E
AVSC27X	AMERICAN OIL CO VISC AT 275F RECOVERED SAMPLE 1	E
AVSC27Y	AMERICAN OIL CO VISC AT 275F RECOVERED SAMPLE 2	E
AASPCOX	AMERICAN OIL CO ASPHALT CONTENT SAMPLE 1	F
AASPCOY	AMERICAN OIL CO ASPHALT CONTENT SAMPLE 2	F
AAPHTSO	AMERICAN OIL CO ASPHALTENES ORIGINAL	F
AAPHTST	AMERICAN OIL CO ASPHALTENES AFTER TFOT	F
AAPHTSR	AMERICAN OIL CO ASPHALTENES RECOVERED	F
AHDRESO	AMERICAN OIL CO HARD RESINS ORIGINAL	F
AHDREST	AMERICAN OIL CO HARD RESINS AFTER TFOT	F
AHDRESR	AMERICAN OIL CO HARD RESINS RECOVERED	F
ASTRESO	AMERICAN OIL CO SOFT RESINS ORIGINAL	F
ASTREST	AMERICAN OIL CO SOFT RESINS AFTER TFOT	F
ASTRESR	AMERICAN OIL CO SOFT RESINS RECOVERED	F
AOILS O	AMERICAN OIL CO OILS ORIGINAL	F
AOILS T	AMERICAN OIL CO OILS AFTER TFOT	F
AOILS R	AMERICAN OIL CO OILS RECOVERED	F
ACM8C2U	AMERICAN OIL CO COMP MOD 10**-8 CY,20F,UNAGED	F
ACM8C2T	AMERICAN OIL CO COMP MOD 10**-8 CY,20F AFTER TFOT	F
ACM8C2R	AMERICAN OIL CO COMP MOD 10**-8 CY,20F RECOVERED	F
ACM8C2M	AMERICAN OIL CO COMP MOD 10**-8 CY,20F MIX RATIO	F
ACM8C2A	AMERICAN OIL CO COMP MOD 10**-8 CY,20F AGE RATIO	F
ACM2C U	AMERICAN OIL CO COMP MOD 10**-2 CY,80F UNAGED	F
ACM2C8T	AMERICAN OIL CO COMP MOD 10**-2 CY,80F AFTER TFOT	F
ACM2C R	AMERICAN OIL CO COMP MOD 10**-2 CY,80F RECOVERED	F
ACM2C8M	AMERICAN OIL CO COMP MOD 10**-2 CY,80F MIX RATIO	F
ACM2C8A	AMERICAN OIL CO COMP MOD 10**-2 CY,80F AGE RATIO	F

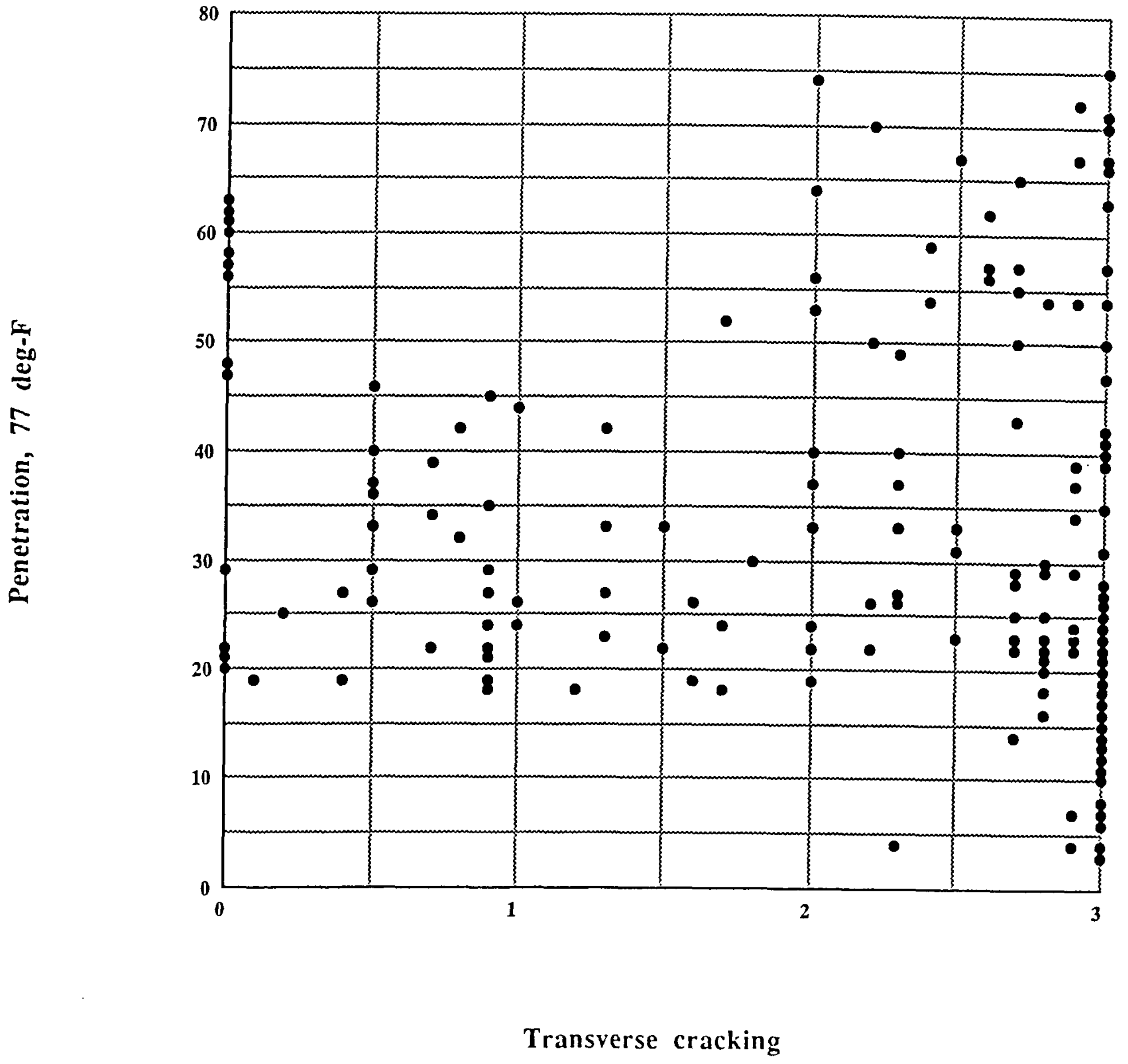
Symbol	Explanation	Used in Card No.
GRD 1.0	GRADATION PERCENT PASSING 1 IN SIEVE	H
GRD0.75	GRADATION PERCENT PASSING 3/4 IN SIEVE	H
GRD0.37	GRADATION PERCENT PASSING 3/8 IN SIEVE	H
GRD'4	GRADATION PERCENT PASSING NO 4 SIEVE	H
GRD'8	GRADATION PERCENT PASSING NO 8 SIEVE	H
GRD'16	GRADATION PERCENT PASSING NO 16 SIEVE	H
GRD'30	GRADATION PERCENT PASSING NO 30 SIEVE	H
GRD'50	GRADATION PERCENT PASSING NO 50 SIEVE	H
GRD'100	GRADATION PERCENT PASSING NO 100 SIEVE	H
GRD'200	GRADATION PERCENT PASSING NO 200 SIEVE	H
HUD'A'	HUDSON 'A' VALUE	H
SURF AR	SURFACE AREA	H
8/200R	NO 8 TO NO 200 SIEVE RATIO	H
50/200R	NO 50 TO NO 200 SIEVE RATIO	H
EFFSGAG	EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE	H
MAXSGMX	MAXIMUM SPECIFIC GRAVITY OF MIX	H
ASPCOMX	ASPHALT CONTENT MIX BASIS	H
ASPCOAG	ASPHALT CONTENT AGGREGATE BASIS	H
AIRVOID	PERCENT AIR VOIDS	H
MINVOID	PERCENT MINERAL VOIDS	H
FILVOID	PERCENT MINERAL VOIDS FILLED	H
DST/ASP	DUST / ASPHALT RATIO	H
PEN IND	PENETRATION INDEX	JKL
SM20.01	STIFFNESS MODULUS AT 20 F AT .01 SEC	JKL
SM20.10	STIFFNESS MODULUS AT 20 F AT .10 SEC	JKL
SM2010	STIFFNESS MODULUS AT 20 F AT 10. SEC	JKL
SM60.01	STIFFNESS MODULUS AT 60 F AT .01 SEC	JKL
SM60.10	STIFFNESS MODULUS AT 60 F AT .10 SEC	JKL
SM6010	STIFFNESS MODULUS AT 60 F AT 10. SEC	JKL
SM14001	STIFFNESS MODULUS AT 140 F AT .01 SEC	JKL
SM140C1	STIFFNESS MODULUS AT 140 F AT .10 SEC	JKL
SM14010	STIFFNESS MODULUS AT 140 F AT 10. SEC	JKL

Appendix B: Scatter Plots for Variables Used in Analysis

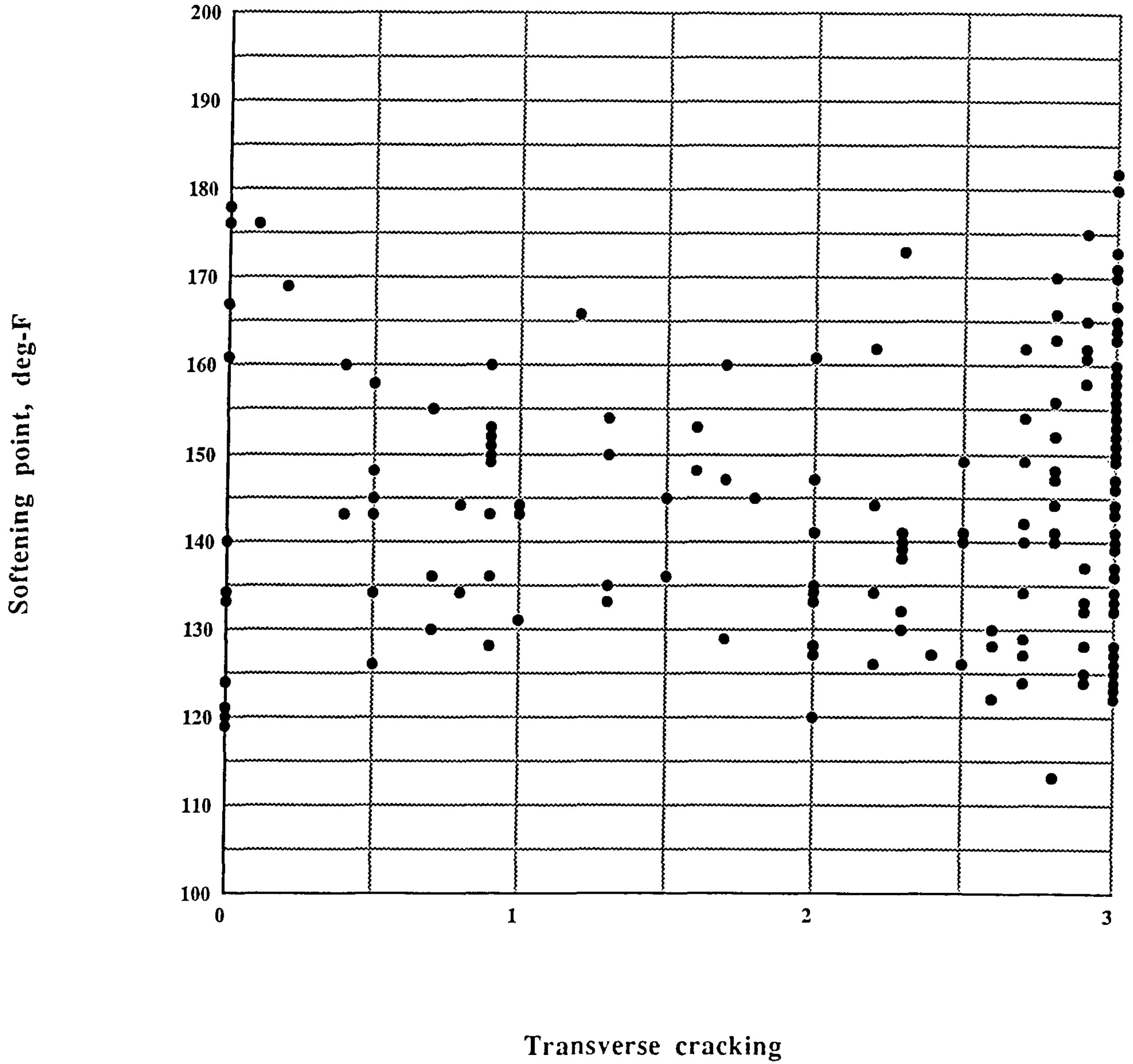
Transverse cracking vs. Void content



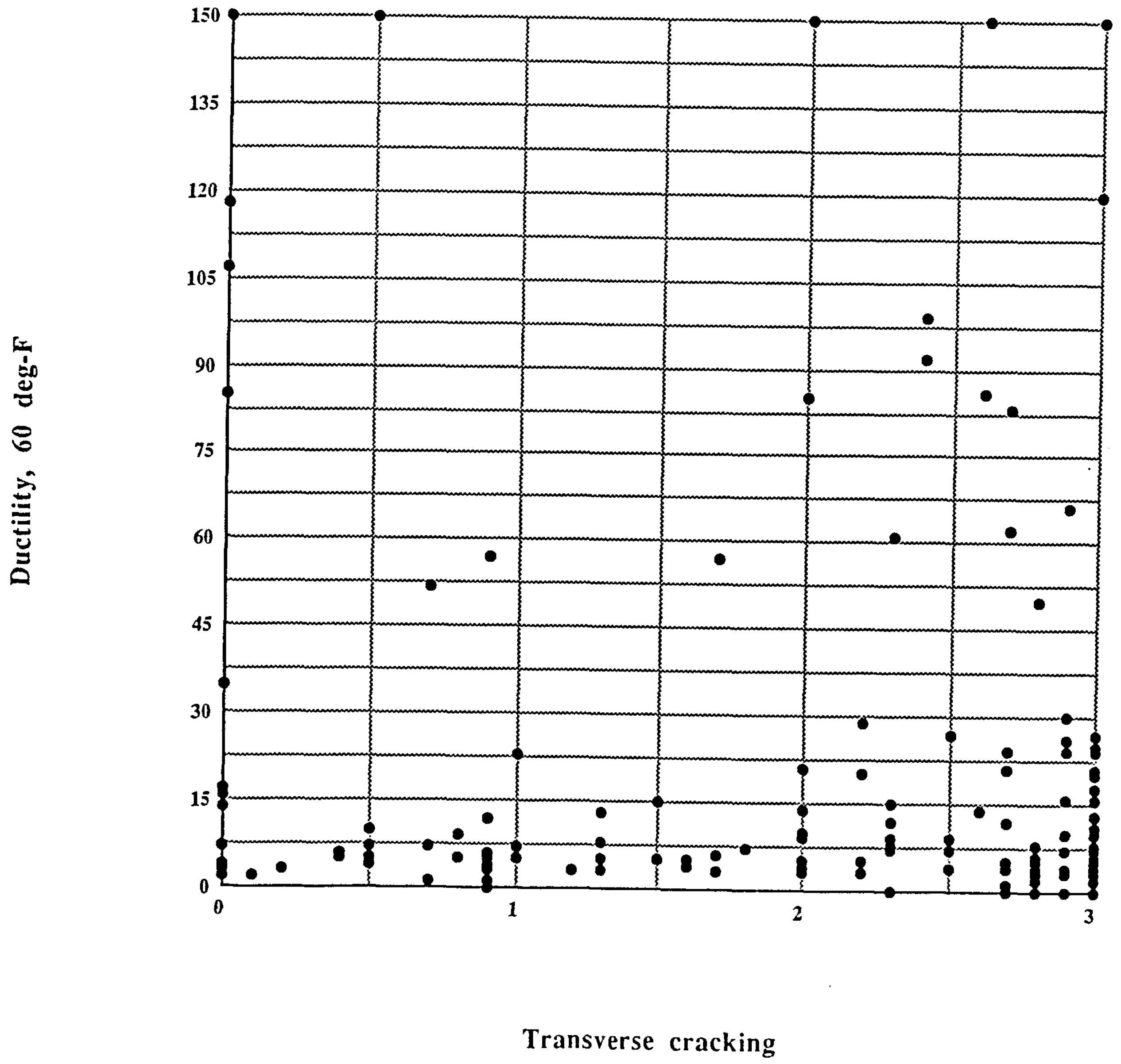
Transverse cracking vs. Penetration



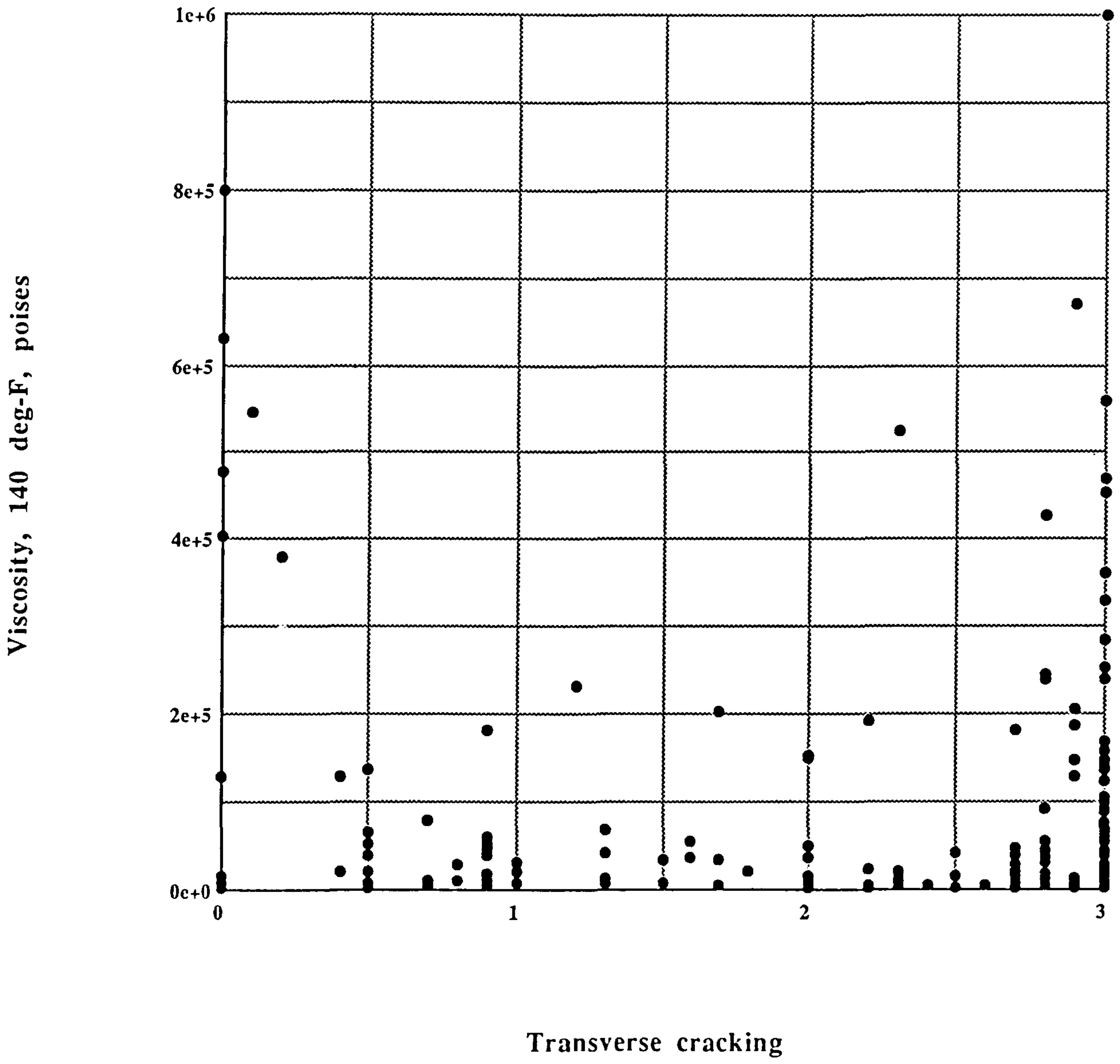
Transverse cracking vs. Softening point



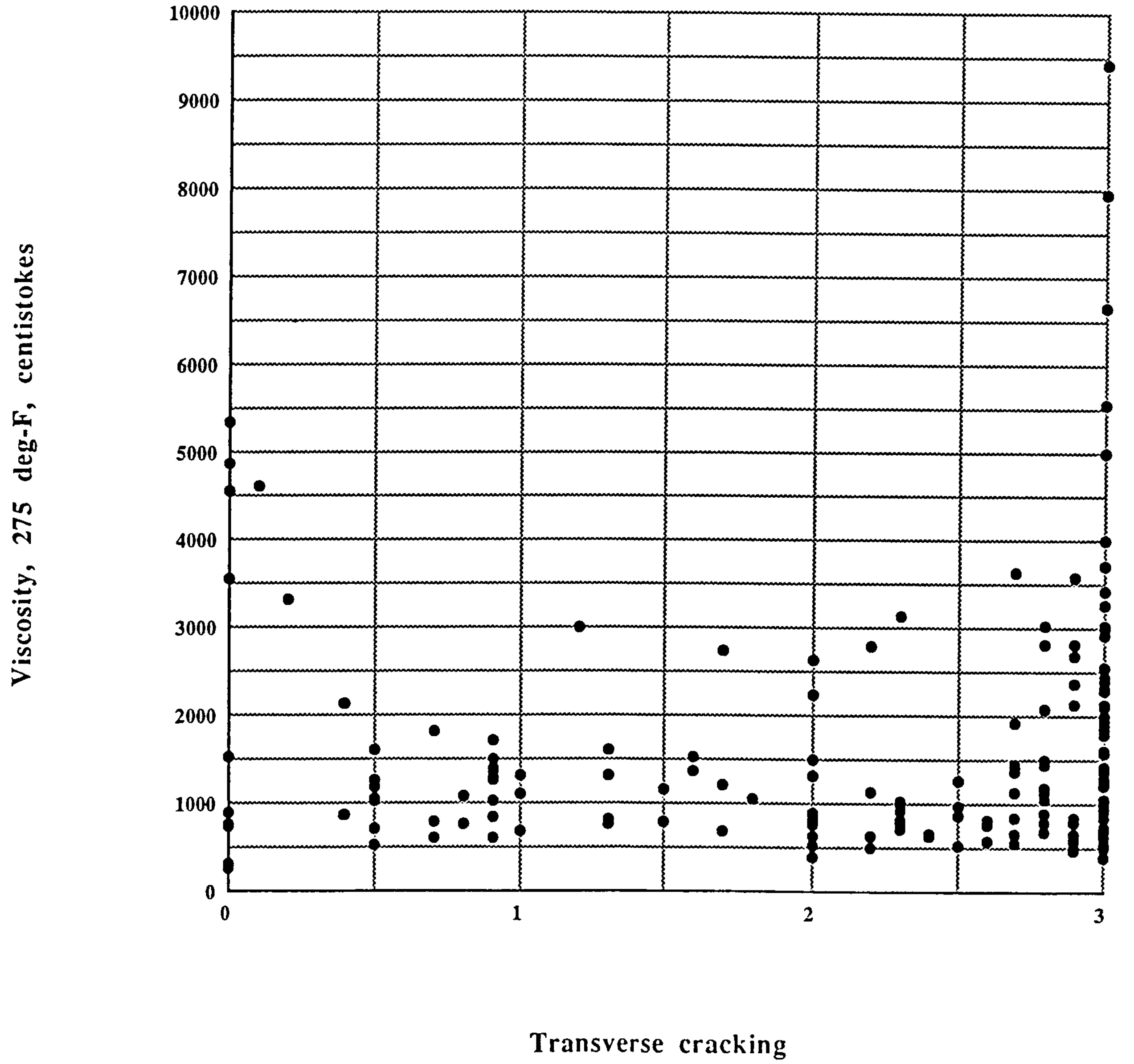
Transverse cracking vs. Ductility



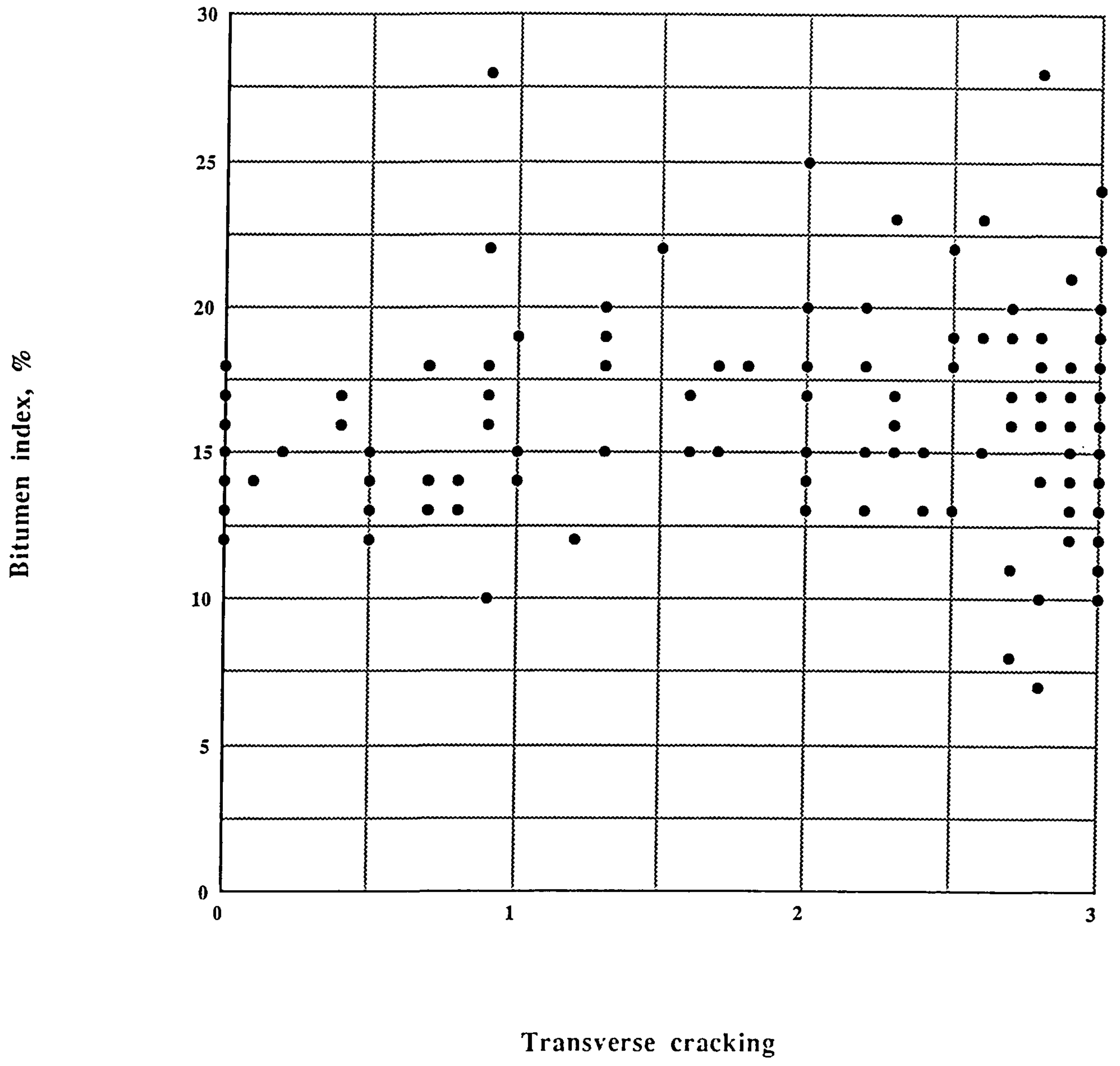
Transverse cracking vs Viscosity



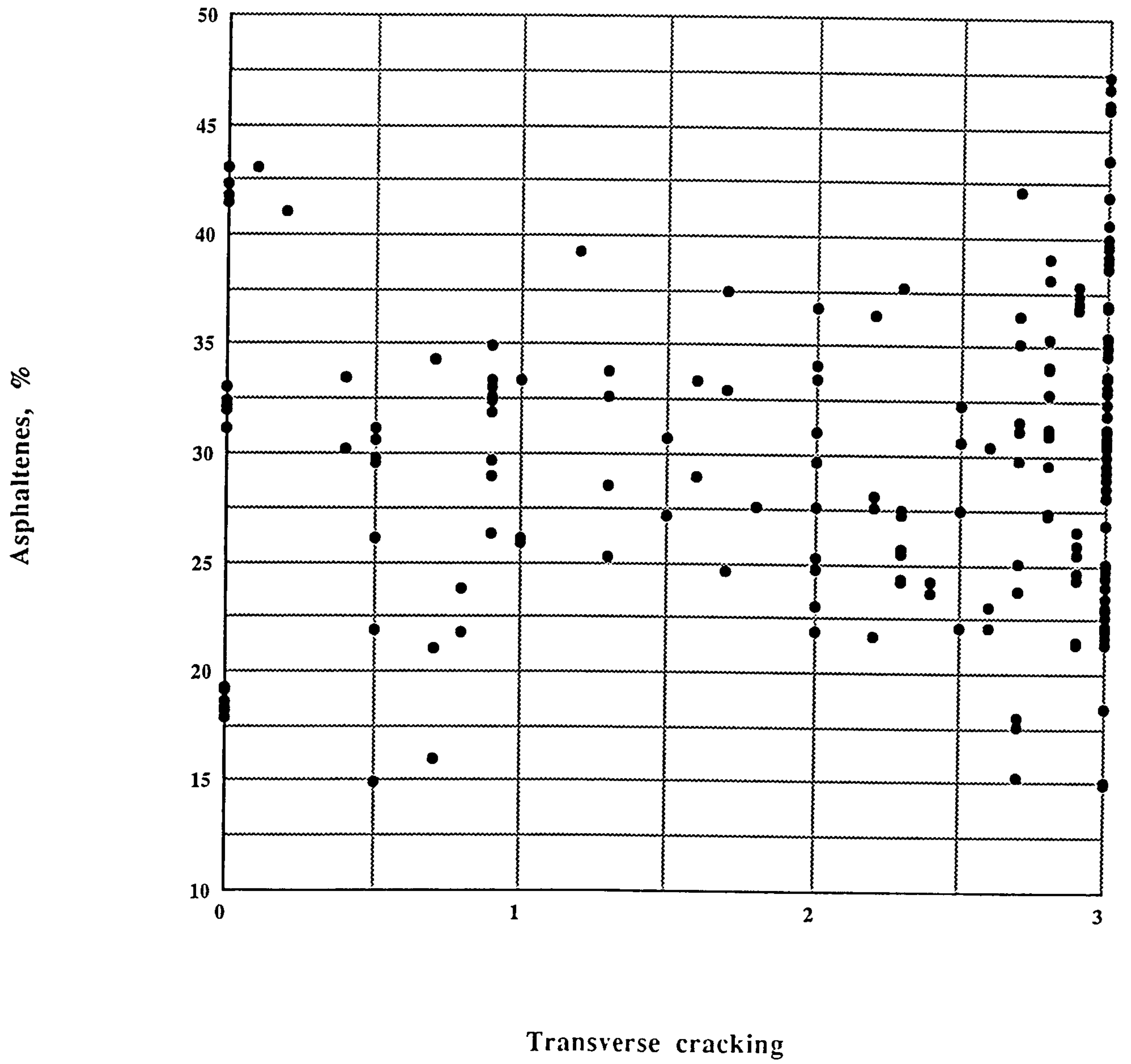
Transverse cracking vs. Viscosity



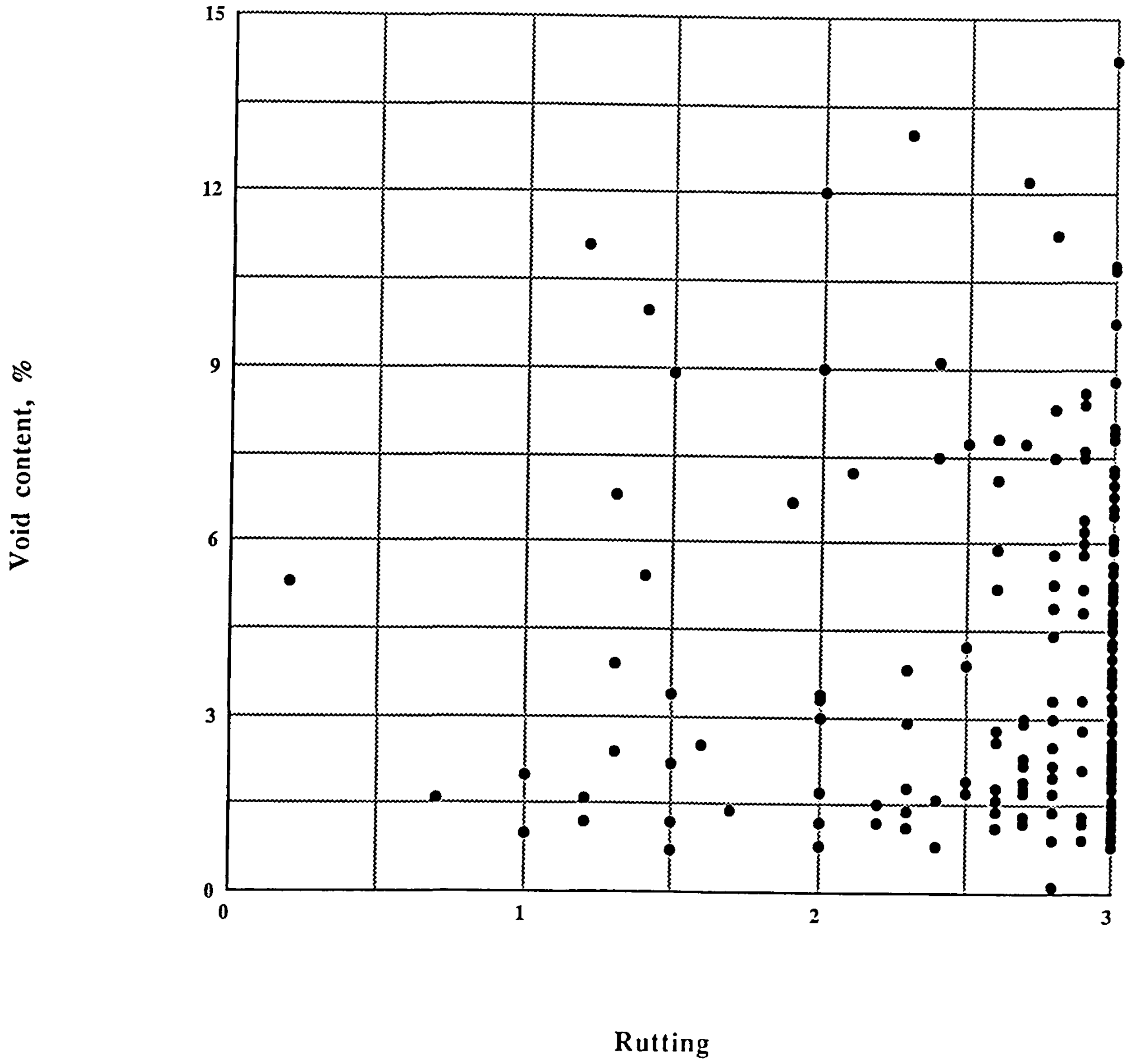
Transverse cracking vs. Bitumen index



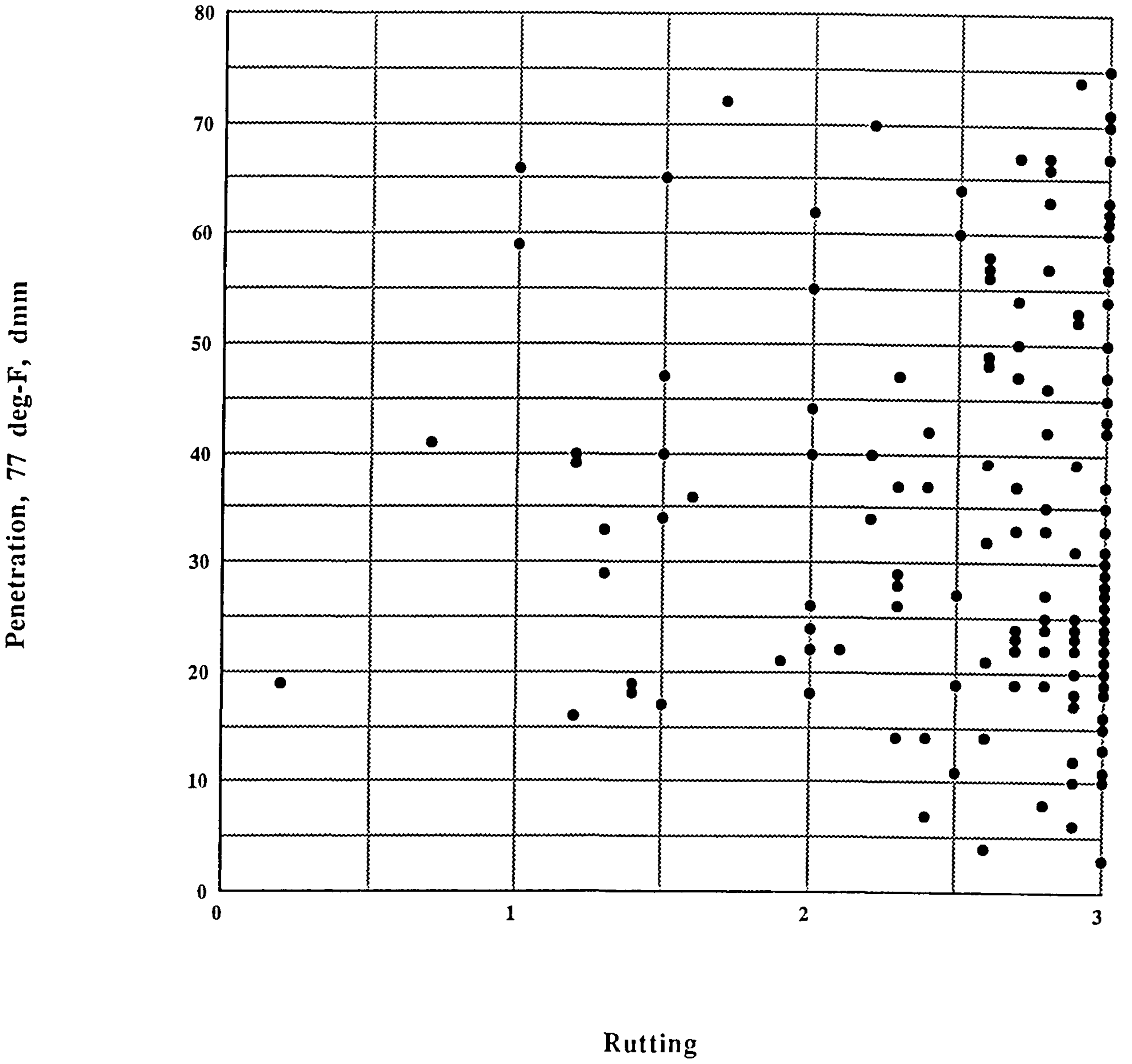
Transverse cracks vs. Asphaltenes



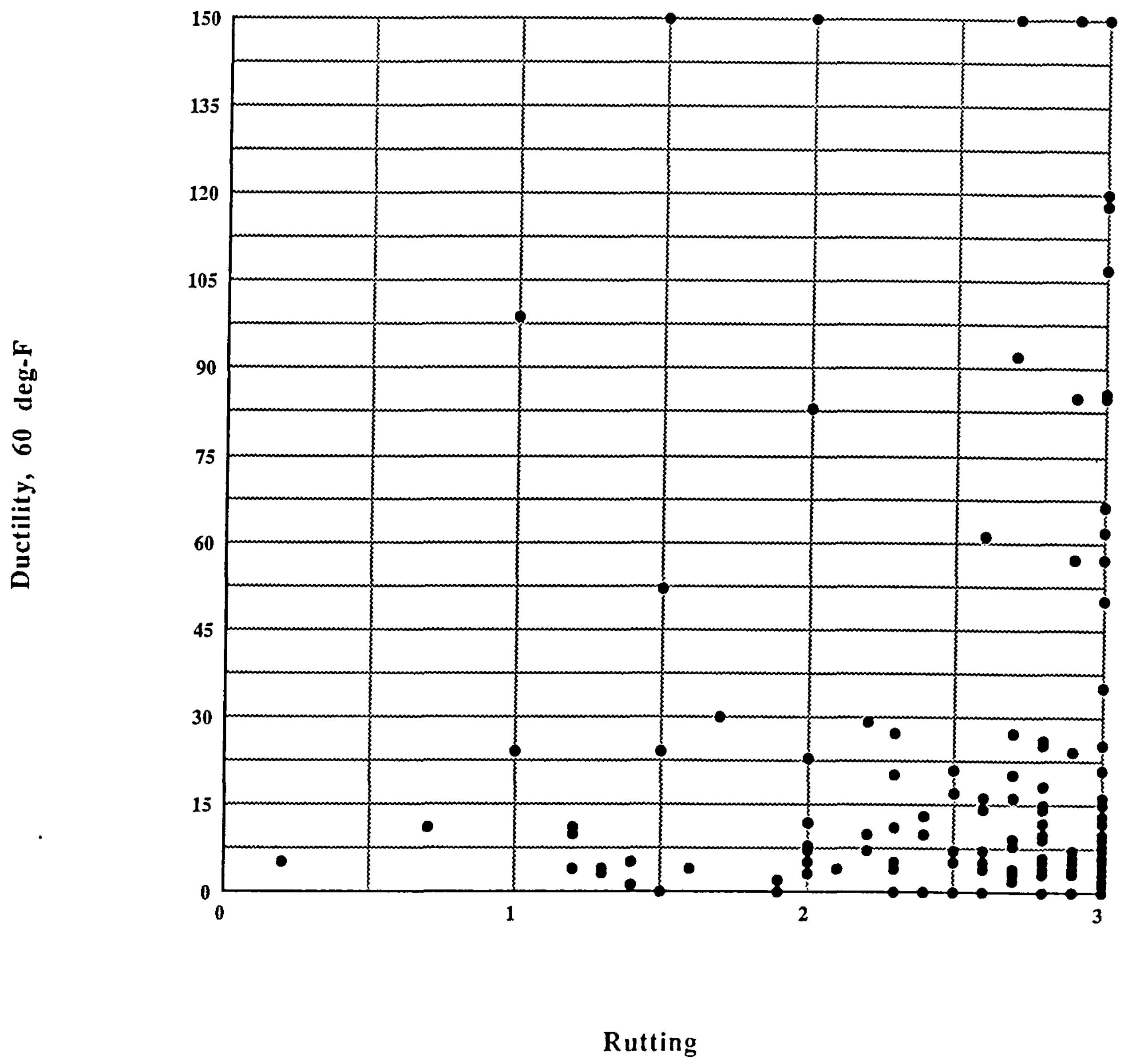
Rutting vs. void content



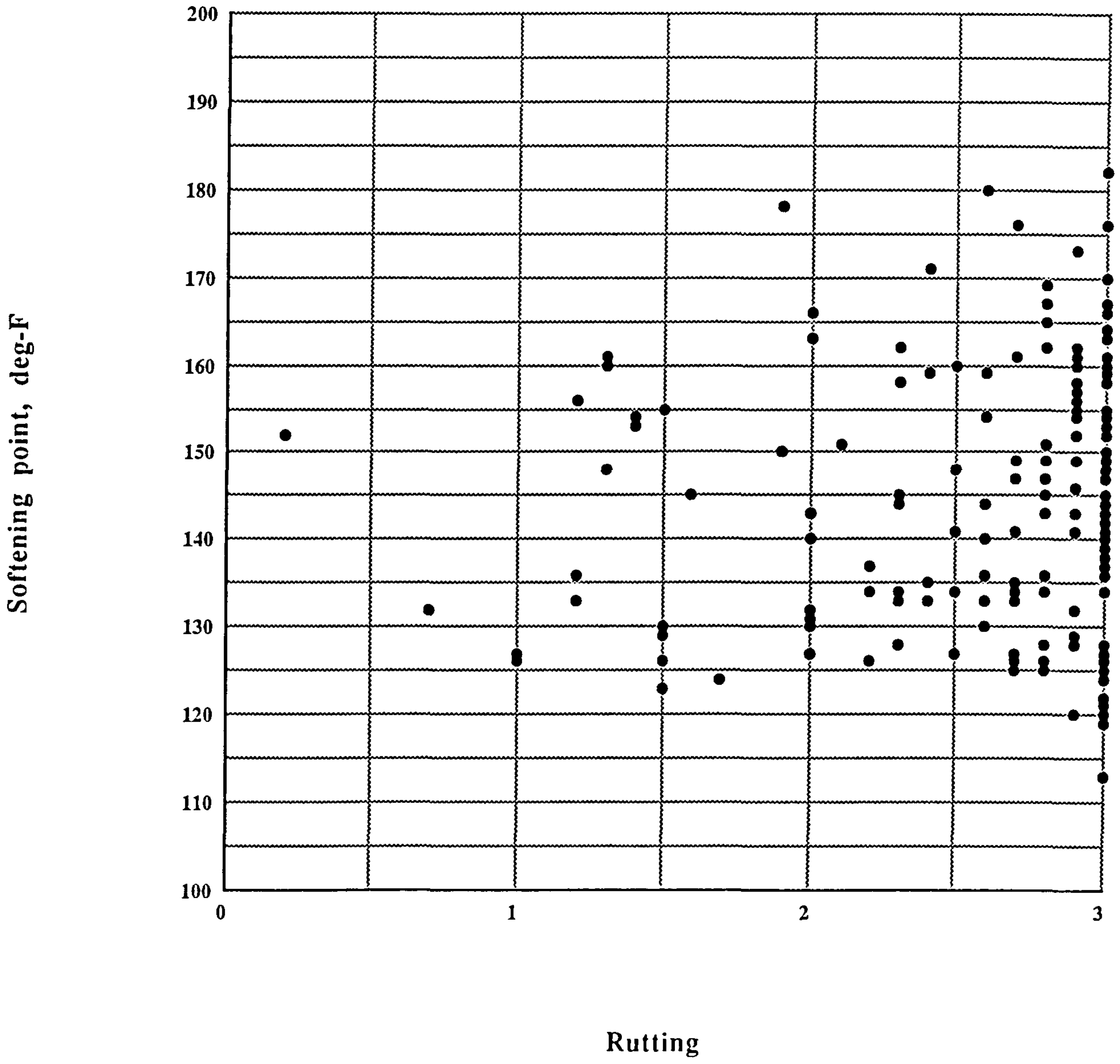
Rutting vs. Penetration



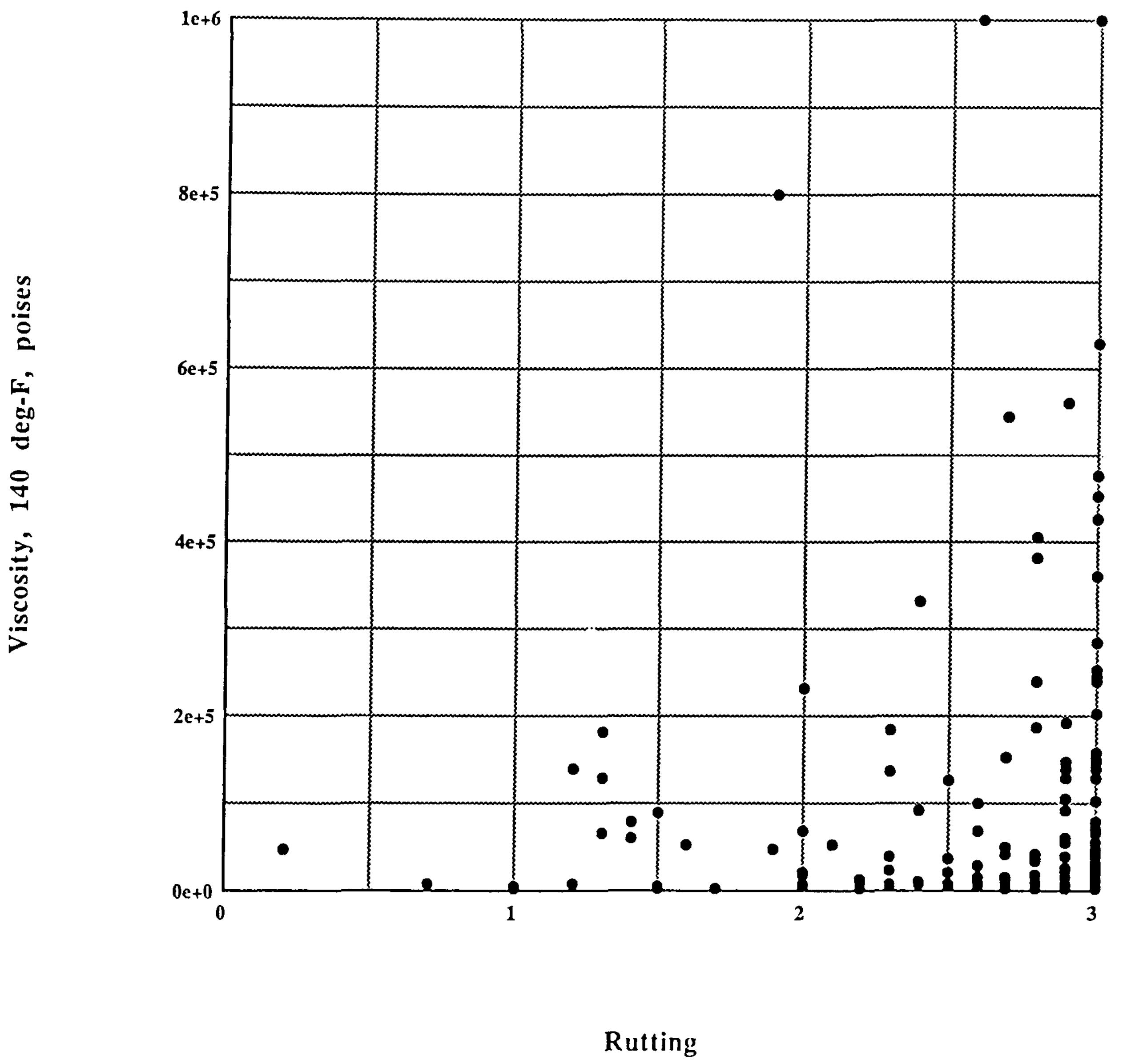
Rutting vs. Ductility



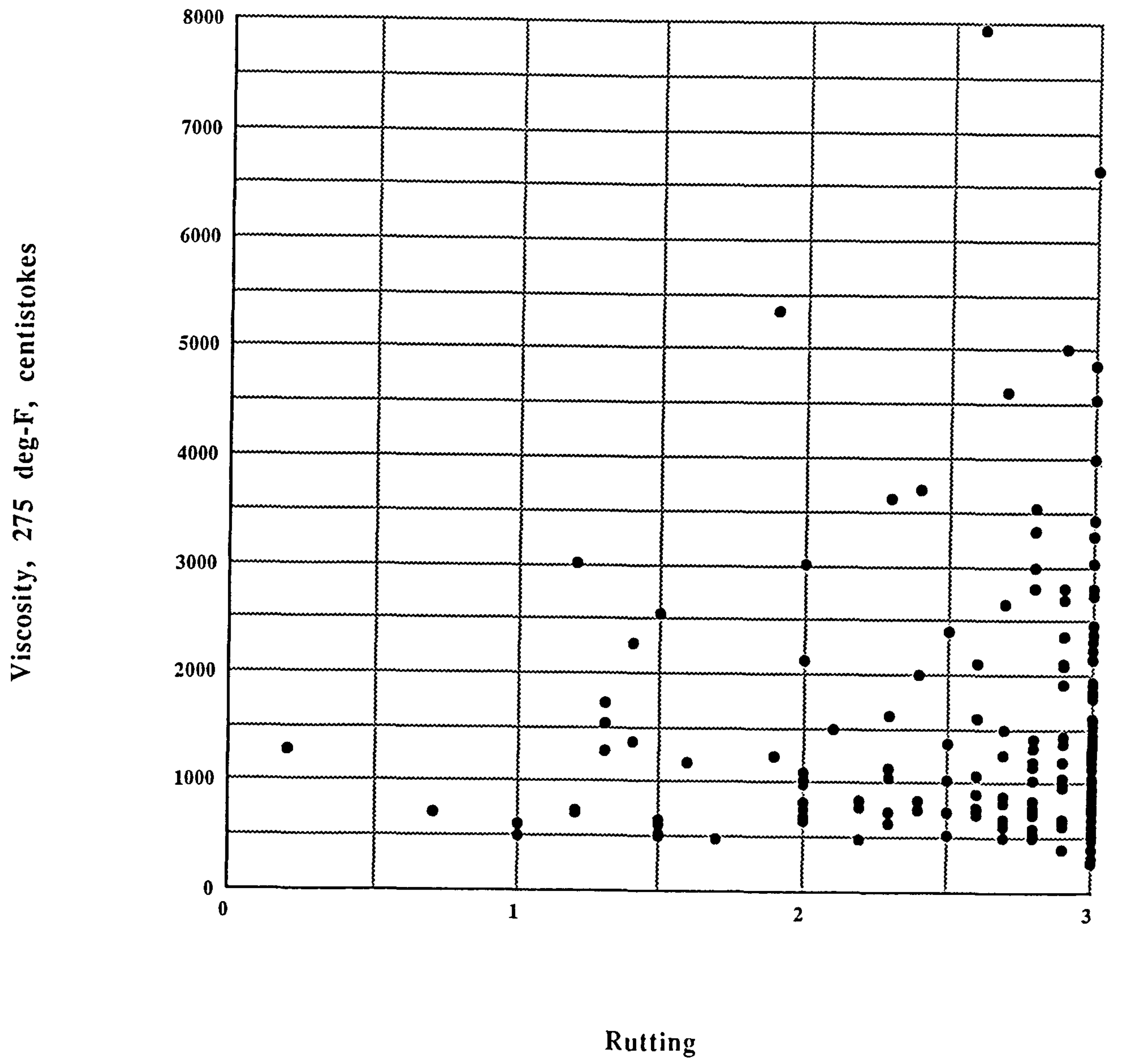
Rutting vs. Softening point



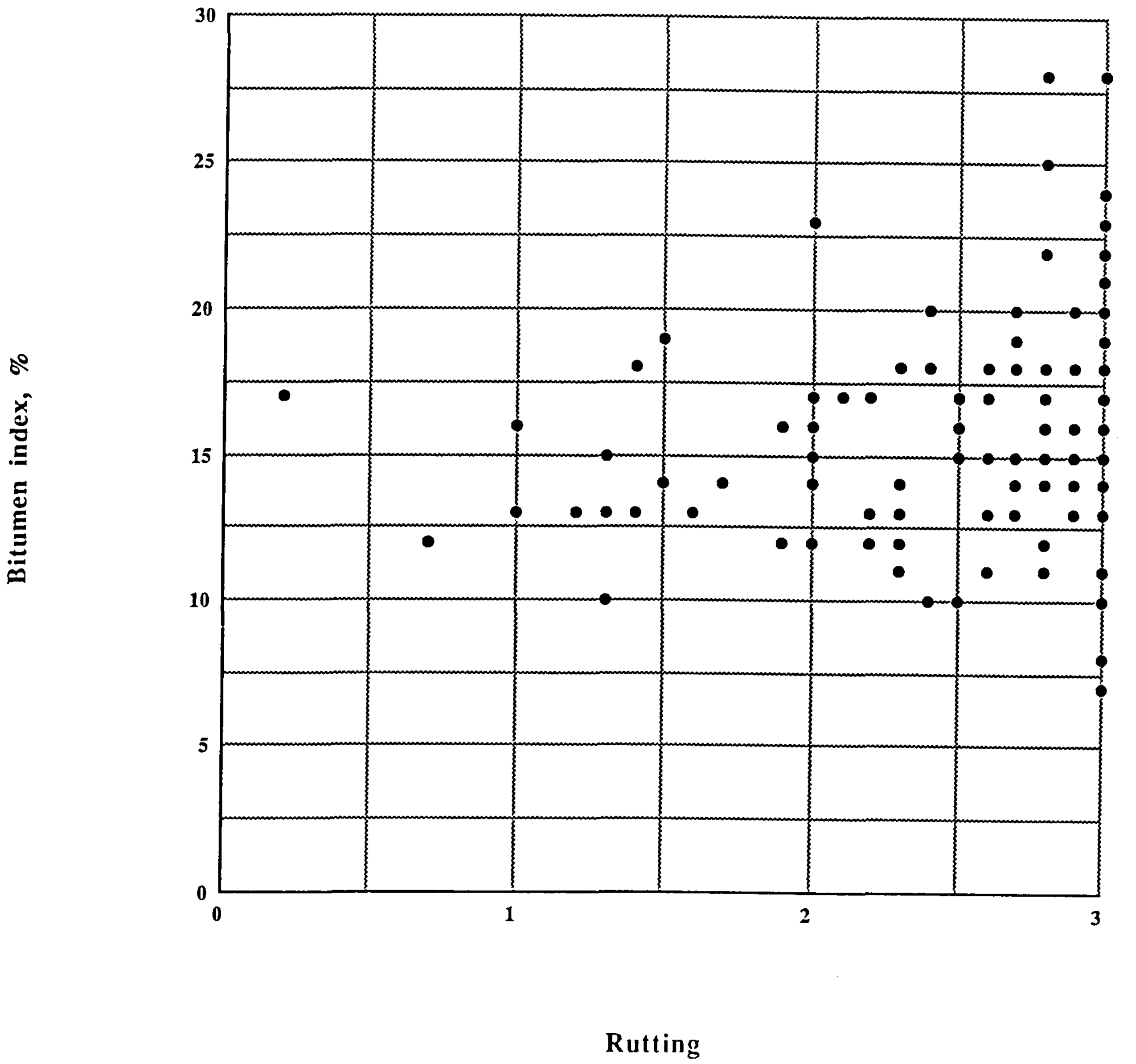
Rutting vs. Viscosity



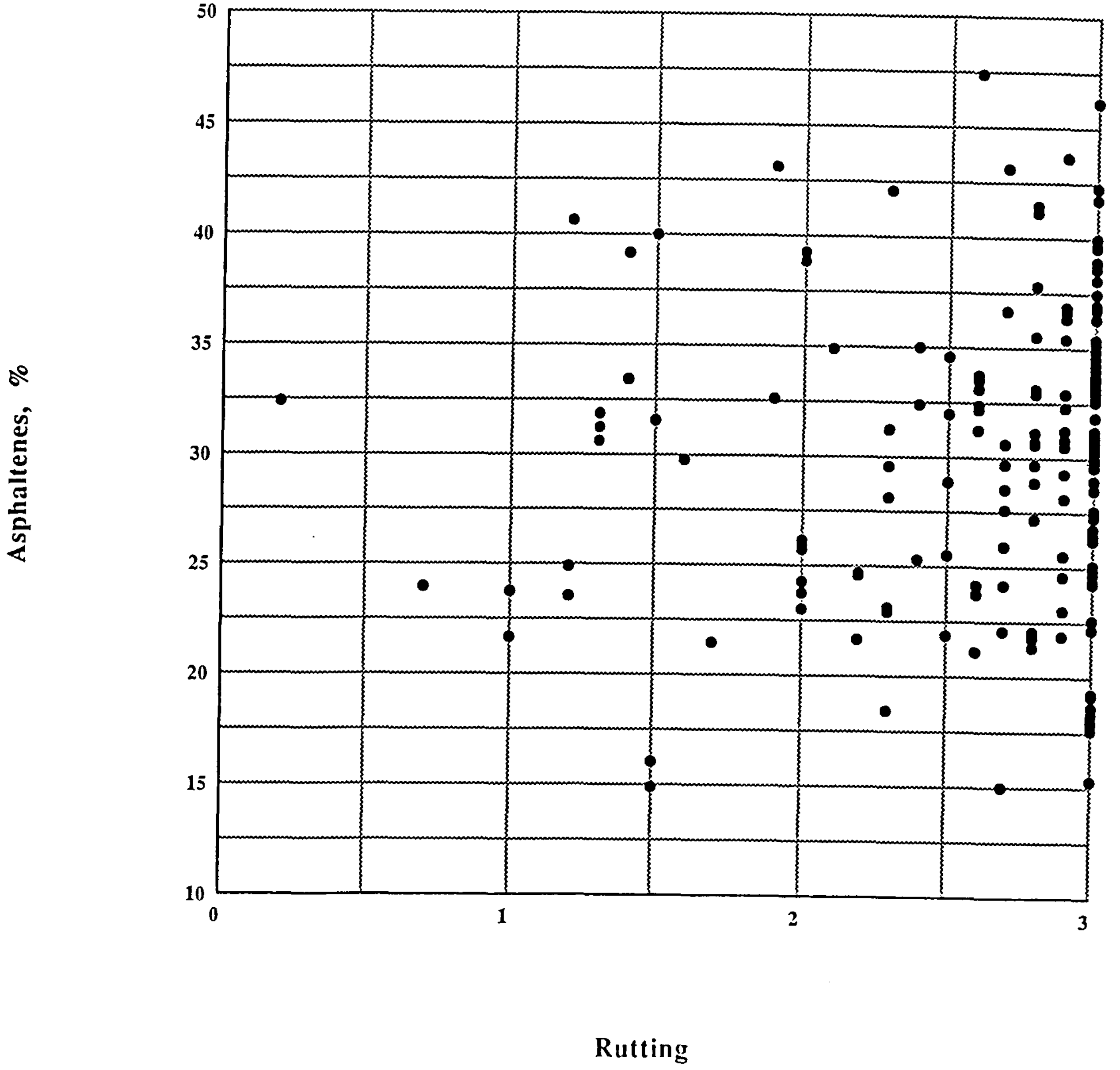
Rutting vs. Viscosity



Rutting vs. Bitumen index



Rutting vs. Asphaltenes



Appendix C: Print-Out of Database Used for Analysis

BPR data used for preliminary analyses

PROJ	PEN77	DUCT60	SOFTPT	CAPV140	CAPV275	VOCON	BITIND	SM12010	SM14010	RUTT	TRANCR	POLYCR	ADT	ADTT	ASPHALT	YRMAX	YRMIN	DYS89	LAYER
2	19.0	4.0	159.0	139715.0	2326.0	4.7	22.0	5000.0	.030	3.0	3.0	2.8	17000.0	357.0	36.800	75.	53.	65.	1.0
2	16.0	2.0	166.0	245913.0	3025.0	7.9	17.0	5100.0	.040	3.0	2.8	2.2	17000.0	357.0	38.100	75.	53.	65.	1.0
2	22.0	1.0	155.0	78655.0	1826.0	5.0	18.0	4500.0	.019	3.0	0.7	3.0	17000.0	357.0	34.300	75.	53.	65.	1.0
2	25.0	5.0	147.0	43539.0	1513.0	3.6	19.0	5100.0	.010	3.0	2.8	3.0	17000.0	357.0	34.100	75.	53.	65.	1.0
2	26.0	5.0	144.0	32851.0	1311.0	3.4	19.0	7000.0	.008	3.0	1.0	3.0	17000.0	357.0	33.400	75.	53.	65.	1.0
2	18.0	3.0	160.0	203722.0	2744.0	6.8	18.0	5100.0	.030	3.0	1.7	3.0	17000.0	357.0	37.500	75.	53.	65.	1.0
3	58.0	16.0	133.0	8780.0	754.0	2.6	18.0	1700.0	.004	2.6	0.0	0.0	1900.0	37.0	32.400	79.	56.	84.	1.5
3	48.0	7.0	140.0	16638.0	906.0	1.4	17.0	4900.0	.007	2.6	0.0	0.3	1900.0	37.0	33.100	79.	56.	84.	1.5
3	65.0	24.0	129.0	6468.0	663.0	0.7	19.0	1800.0	.003	1.5	2.7	0.3	1900.0	37.0	31.600	79.	56.	84.	1.5
3	56.0	14.0	133.0	9514.0	780.0	1.1	17.0	1800.0	.004	2.6	2.0	0.3	1900.0	37.0	33.500	79.	56.	84.	1.5
3	60.0	17.0	134.0	8573.0	739.0	1.7	17.0	1400.0	.004	2.5	0.0	0.2	1900.0	37.0	32.000	79.	56.	84.	1.5
3	57.0	14.0	133.0	8509.0	737.0	1.6	18.0	1800.0	.004	2.6	0.0	0.2	1900.0	37.0	32.200	79.	56.	84.	1.5
4	27.0	7.0	141.0	20621.0	1037.0	4.2	16.0	7500.0	.007	2.5	2.3	3.0	925.0	93.0	25.500	80.	56.	99.	1.5
4	26.0	8.0	140.0	17593.0	979.0	3.4	17.0	8000.0	.006	2.0	2.3	3.0	925.0	93.0	25.700	80.	56.	99.	1.5
4	26.0	7.0	143.0	19950.0	1032.0	3.0	15.0	7500.0	.007	2.0	0.5	3.0	925.0	93.0	26.100	80.	56.	99.	1.5
4	24.0	7.0	143.0	22141.0	1103.0	3.3	15.0	8000.0	.007	2.0	1.0	3.0	925.0	93.0	25.900	80.	56.	99.	1.5
4	19.0	5.0	148.0	37602.0	1375.0	3.9	15.0	9000.0	.011	2.5	1.6	3.0	925.0	93.0	28.900	80.	56.	99.	1.5
4	44.0	23.0	131.0	6956.0	695.0	3.0	14.0	4700.0	.003	2.0	1.0	3.0	925.0	93.0	26.100	80.	56.	99.	1.5
6	22.0	3.0	162.0	191974.0	2793.0	7.5	15.0	3800.0	.040	2.9	2.2	3.0	1610.0	396.0	36.400	81.	55.	99.	1.5
6	22.0	3.0	162.0	186595.0	2806.0	7.5	14.0	3800.0	.040	2.8	2.9	3.0	1610.0	396.0	37.800	81.	55.	99.	1.5
6	23.0	3.0	161.0	147831.0	2695.0	8.4	13.0	3700.0	.035	2.9	2.9	3.0	1610.0	396.0	36.900	81.	55.	99.	1.5
6	24.0	4.0	158.0	129698.0	2364.0	8.6	15.0	3700.0	.025	2.9	2.9	3.0	1610.0	396.0	36.700	81.	55.	99.	1.5
6	24.0	3.0	161.0	152957.0	2643.0	7.7	13.0	3500.0	.035	2.7	2.0	3.0	1610.0	396.0	36.700	81.	55.	99.	1.5
6	25.0	4.0	156.0	91976.0	2086.0	7.6	14.0	3800.0	.022	2.9	2.8	3.0	6000.0	396.0	35.400	81.	55.	99.	1.5
7	21.0	0.0	158.0	146643.0	2459.0	5.6	10.0	4800.0	.025	3.0	3.0	3.0	6000.0	780.0	38.900	77.	53.	99.	1.5
7	18.0	3.0	163.0	238893.0	3029.0	7.3	10.0	5000.0	.040	3.0	2.8	3.0	6000.0	780.0	39.000	77.	53.	99.	1.5
7	19.0	3.0	163.0	252504.0	3025.0	7.8	10.0	4800.0	.040	3.0	3.0	3.0	6000.0	780.0	38.600	77.	53.	99.	1.5
7	18.0	3.0	164.0	284436.0	3276.0	6.6	11.0	5000.0	.038	3.0	3.0	3.0	6000.0	780.0	39.700	77.	53.	99.	1.5
7	18.0	2.0	167.0	361259.0	3434.0	7.0	10.0	4800.0	.060	3.0	3.0	3.0	6000.0	780.0	39.600	77.	53.	99.	1.5
7	15.0	0.0	170.0	453500.0	4007.0	6.1	10.0	5100.0	.075	3.0	3.0	3.0	6000.0	780.0	40.000	77.	53.	99.	1.5
9	29.0	4.0	142.0	21292.0	1457.0	3.2	8.0	6000.0	.006	3.0	2.7	3.0	.	.	17.600	79.	56.	99.	2.0
9	25.0	4.0	149.0	40212.0	1909.0	4.3	8.0	4800.0	.014	3.0	2.7	2.6	.	.	18.000	79.	56.	99.	2.0
9	50.0	12.0	127.0	5153.0	845.0	1.2	8.0	4000.0	.002	3.0	2.7	2.8	.	.	15.300	79.	56.	99.	2.0
9	21.0	3.0	170.0	426946.0	2806.0	5.5	7.0	3500.0	.070	3.0	2.8	3.0	.	.	32.800	79.	56.	99.	2.0
9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	79.	56.	99.	2.0
9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	79.	56.	99.	2.0
10	36.0	4.0	145.0	53493.0	1178.0	2.5	13.0	3000.0	.009	1.6	0.5	3.0	3550.0	355.0	29.800	73.	51.	80.	1.5
10	33.0	4.0	148.0	66573.0	1275.0	2.4	13.0	3500.0	.012	1.3	0.5	3.0	3550.0	355.0	30.600	73.	51.	80.	1.5
10	29.0	3.0	160.0	182266.0	1718.0	6.8	10.0	2000.0	.030	1.3	0.9	3.0	3550.0	355.0	31.900	73.	51.	80.	1.5
10	37.0	5.0	145.0	40332.0	1057.0	2.9	12.0	2500.0	.009	2.3	0.5	3.0	3550.0	350.0	29.600	73.	51.	80.	1.5
10	29.0	4.0	158.0	136034.0	1615.0	3.8	14.0	1000.0	.025	2.3	0.5	3.0	3550.0	355.0	31.200	73.	51.	80.	1.5
10	29.0	4.0	161.0	129609.0	1531.0	3.9	15.0	2500.0	.045	1.3	0.0	3.0	3550.0	355.0	31.200	73.	51.	80.	1.5
11	42.0	25.0	134.0	9789.0	973.0	1.3	18.0	3800.0	.004	3.0	3.0	3.0	5000.0	1050.0	33.000	75.	53.	66.	1.5
11	35.0	16.0	136.0	15741.0	1210.0	3.7	15.0	7000.0	.004	3.0	3.0	3.0	5000.0	1050.0	33.600	75.	53.	66.	1.5
11	56.0	86.0	122.0	5459.0	751.0	0.9	19.0	6000.0	.001	3.0	2.6	3.0	5000.0	1050.0	30.400	75.	53.	66.	1.5
11	27.0	8.0	149.0	26843.0	1575.0	4.0	15.0	4000.0	.014	3.0	3.0	3.0	5000.0	1050.0	34.600	75.	53.	66.	1.5
11	57.0	150.0	127.0	5153.0	734.0	1.5	18.0	3000.0	.002	3.0	3.0	3.0	5000.0	1050.0	30.700	75.	53.	66.	1.5
11	23.0	6.0	144.0	39541.0	1846.0	3.4	17.0	8000.0	.008	3.0	3.0	3.0	5000.0	1050.0	36.800	75.	53.	66.	1.5
13	17.0	0.0	155.0	89525.0	2548.0	8.9	14.0	7500.0	.021	1.5	3.0	3.0	12331.0	1479.0	40.000	80.	57.	99.	.
13	14.0	0.0	162.0	183373.0	3630.0	13.0	11.0	8000.0	.038	2.3	2.7	2.2	12331.0	1479.0	42.100	80.	57.	99.	.
13	18.0	3.0	166.0	231327.0	3012.0	12.0	12.0	4800.0	.040	2.0	1.2	3.0	12331.0	1479.0	39.300	80.	57.	99.	.
13	16.0	4.0	156.0	139422.0	3003.0	11.1	13.0	7500.0	.022	1.2	3.0	3.0	12331.0	1479.0	40.600	80.	57.	99.	.
13	19.0	5.0	154.0	77678.0	2279.0	10.0	13.0	6000.0	.018	1.4	3.0	2.9	12331.0	1479.0	39.200	80.	57.	99.	.
13	22.0	5.0	163.0	68029.0	2130.0	9.0	14.0	3800.0	.040	2.0	3.0	2.2	12331.0	1479.0	38.900	80.	57.	99.	.
15	34.0	7.0	137.0	12949.0	836.0	1.2	12.0	5000.0	.006	2.2	2.9	3.0	9600.0	480.0	24.600	73.	49.	80.	2.0
15	41.0	11.0	132.0	8371.0	722.0	1.6	12.0	5000.0	.004	0.7	3.0	3.0	9600.0	480.0	24.000	73.	49.	80.	2.0
15	47.0	27.0	128.0	5618.0	636.0	1.1	13.0	4500.0	.002	2.3	3.0	3.0	9600.0	480.0	23.100	73.	49.	80.	2.0
15	39.0	10.0	133.0	8586.0	732.0	1.2	13.0	5000.0	.006	1.2	3.0	3.0	9600.0	480.0	23.500	73.	49.	80.	2.0
15	40.0	11.0	136.0	7960.0	722.0	1.6	13.0	3800.0	.004	1.2	3.0	3.0	9600.0	480.0	24.900	73.	49.	80.	2.0
15	47.0	20.0	133.0	5266.0	627.0	1.4	13.0	3300.0	.007	2.3	3.0	3.0	9600.0	480.0	22.900	73.	49.	80.	2.0
16	28.0	11.0	134.0	8821.0	735.0	1.8	14.0	11000.0	.004	2.3	3.0	3.0	3100.0	310.0	18.400	73.	49.	80.	2.0
16	47.0	150.0	125.0	3328.0	513.0	2.2	13.0	7500.0	.002	2.7	3.0	3.0	3100.0	310.0	15.000	73.	49.	80.	2.0
16	47.0	150.0	123.0	3265.0	497.0	1.2	14.0	10000.0	.002	1.5	3.0	3.0	3100.0	310.0	14.900	73.	49.	80.	2.0
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	73.	49.	80.	2.0
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	73.	49.	80.	2.0

BPR data used for preliminary analyses

PROJ	PEN77	DUCT60	SOFTPT	CAPV140	CAPV275	VOCON	BITIND	SM12010	SM14010	RUTT	TRANCR	POLYCR	ADT	ADTT	ASPHALT	YRMAX	YRMIN	DYS89	LAYER
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	73.	49.	80.	2.0
17	27.0	6.0	143.0	19012.0	1034.0	3.0	28.0	6500.0	.007	2.8	0.9	1.7	35000.0	.	29.700	60.	41.	18.	.
17	50.0	150.0	126.0	3905.0	497.0	2.0	24.0	4900.0	.002	3.0	3.0	3.0	35000.0	.	24.900	60.	41.	18.	.
17	22.0	5.0	147.0	36714.0	1316.0	3.3	25.0	7500.0	.010	2.8	2.0	0.9	35000.0	.	31.100	60.	41.	18.	.
17	35.0	12.0	136.0	10521.0	847.0	0.1	22.0	7000.0	.004	2.8	0.9	1.7	35000.0	.	28.900	60.	41.	18.	.
17	22.0	5.0	145.0	34874.0	1168.0	4.9	22.0	7000.0	.008	2.8	1.5	2.2	35000.0	.	30.700	60.	41.	18.	.
17	33.0	15.0	136.0	9075.0	777.0	1.4	22.0	6500.0	.004	2.8	1.5	2.5	35000.0	.	27.200	60.	41.	18.	.
18	50.0	20.0	134.0	6477.0	620.0	1.3	20.0	2100.0	.004	2.7	2.2	1.5	35000.0	3500.0	27.600	60.	42.	6.	1.3
18	33.0	8.0	135.0	14375.0	817.0	2.9	19.0	6500.0	.004	2.7	1.3	1.1	35000.0	3500.0	28.500	60.	42.	6.	1.3
18	54.0	66.0	128.0	5070.0	592.0	1.0	21.0	3300.0	.002	3.0	2.9	1.8	35000.0	3500.0	24.300	60.	42.	6.	1.3
18	31.0	7.0	141.0	16963.0	978.0	2.8	18.0	6500.0	.007	2.9	2.5	3.0	35000.0	3500.0	32.300	60.	42.	6.	1.3
18	70.0	150.0	124.0	2438.0	396.0	1.2	19.0	2000.0	.002	3.0	3.0	3.0	35000.0	3500.0	22.600	60.	42.	6.	1.3
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	60.	42.	6.	1.3
19	25.0	5.0	143.0	23890.0	1294.0	4.8	18.0	7800.0	.007	3.0	3.0	3.0	.	.	37.000	59.	39.	4.	.
19	28.0	1.0	140.0	16833.0	1127.0	5.9	17.0	7000.0	.006	3.0	2.7	3.0	.	.	35.200	59.	39.	4.	.
19	22.0	4.0	142.0	29169.0	1414.0	4.6	17.0	10000.0	.006	3.0	2.7	3.0	.	.	36.400	59.	39.	4.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	59.	39.	4.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	59.	39.	4.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	59.	39.	4.	.
20	30.0	0.0	140.0	14414.0	1044.0	2.5	17.0	6000.0	.006	3.0	2.8	2.7	6000.0	.	34.000	59.	39.	4.	.
20	31.0	6.0	139.0	15071.0	928.0	3.6	16.0	5500.0	.001	3.0	3.0	3.0	6000.0	.	31.900	59.	39.	4.	.
20	26.0	6.0	143.0	19872.0	1232.0	5.0	16.0	7500.0	.006	3.0	3.0	3.0	6000.0	.	35.400	59.	39.	4.	.
20	54.0	50.0	113.0	5020.0	684.0	1.1	16.0	20000.0	.000	3.0	2.8	1.9	6000.0	.	29.600	59.	39.	4.	.
20	43.0	21.0	134.0	7902.0	849.0	1.0	16.0	3700.0	.004	3.0	2.7	1.2	6000.0	.	31.200	59.	39.	4.	.
20	28.0	8.0	141.0	20057.0	1257.0	3.4	16.0	6500.0	.007	3.0	3.0	1.2	6000.0	.	34.900	59.	39.	4.	.
21	33.0	9.0	141.0	15092.0	882.0	1.2	18.0	4500.0	.007	2.7	2.0	3.0	17000.0	.	27.600	59.	39.	4.	1.5
21	37.0	15.0	138.0	10943.0	805.0	3.4	23.0	4000.0	.006	3.0	2.3	3.0	17000.0	.	27.300	59.	39.	4.	1.5
21	22.0	5.0	152.0	54117.0	1460.0	4.5	28.0	5000.0	.018	3.0	2.8	3.0	17000.0	.	31.000	59.	39.	4.	1.5
21	33.0	9.0	140.0	16056.0	880.0	0.8	22.0	4900.0	.006	3.0	2.5	3.0	17000.0	.	27.500	59.	39.	4.	1.5
21	23.0	4.0	149.0	41372.0	1265.0	1.9	19.0	6000.0	.014	2.7	2.5	3.0	17000.0	.	30.600	59.	39.	4.	1.5
21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	59.	39.	4.	1.5
22	7.0	0.0	171.0	330341.0	3710.0	9.1	10.0	15000.0	.095	2.4	3.0	2.8	12400.0	.	35.000	64.	43.	27.	.
22	14.0	0.0	159.0	91444.0	1992.0	7.5	10.0	10000.0	.013	2.4	3.0	3.0	12400.0	.	32.400	64.	43.	27.	.
22	8.0	0.0	165.0	239239.0	2992.0	8.3	11.0	7500.0	.011	2.8	3.0	2.8	12400.0	.	35.500	64.	43.	27.	.
22	19.0	0.0	151.0	41001.0	1418.0	5.8	14.0	8000.0	.030	2.8	3.0	2.5	12400.0	.	30.600	64.	43.	27.	.
22	11.0	0.0	160.0	125010.0	2407.0	7.7	10.0	8000.0	.011	2.5	3.0	2.6	12400.0	.	34.600	64.	43.	27.	.
22	14.0	0.0	159.0	98992.0	2101.0	7.1	11.0	7500.0	.008	2.6	3.0	3.0	12400.0	.	33.700	64.	43.	27.	.
22	15.0	1.0	151.0	66756.0	1775.0	6.9	10.0	15000.0	.050	.	.	.	.	.	32.900	64.	43.	27.	.
22	18.0	4.0	149.0	46295.0	1412.0	6.6	13.0	7500.0	.011	.	.	.	.	.	31.300	64.	43.	27.	.
22	20.0	5.0	149.0	43435.0	1397.0	6.5	13.0	4700.0	.025	.	.	.	.	.	32.000	64.	43.	27.	.
22	15.0	0.0	151.0	53120.0	1530.0	7.0	14.0	7500.0	.013	.	.	.	.	.	32.200	64.	43.	27.	.
22	12.0	0.0	159.0	129315.0	2219.0	8.3	11.0	10000.0	.013	.	.	.	.	.	34.400	64.	43.	27.	.
22	20.0	0.0	147.0	38420.0	1307.0	6.2	12.0	14000.0	.065	.	.	.	.	.	31.800	64.	43.	27.	.
22	21.0	4.0	148.0	52581.0	1521.0	6.1	14.0	11500.0	.035	.	.	.	.	.	33.700	64.	43.	27.	.
22	22.0	5.0	145.0	33376.0	1204.0	5.8	12.0	11000.0	.030	.	.	.	.	.	31.200	64.	43.	27.	.
22	13.0	1.0	158.0	142315.0	2360.0	11.8	17.0	9500.0	.022	.	.	.	.	.	35.000	64.	43.	27.	.
22	8.0	0.0	167.0	.	3457.0	11.0	15.0	8000.0	.030	.	.	.	.	.	35.000	64.	43.	27.	.
22	14.0	3.0	157.0	125233.0	2257.0	7.0	12.0	9000.0	.010	.	.	.	.	.	35.700	64.	43.	27.	.
22	18.0	4.0	152.0	63167.0	1543.0	6.6	13.0	7800.0	.013	.	.	.	.	.	32.600	64.	43.	27.	.
24	67.0	27.0	126.0	3623.0	515.0	1.8	13.0	1800.0	.002	2.7	2.5	3.0	9792.0	546.0	22.100	64.	41.	45.	1.5
24	70.0	29.0	126.0	3223.0	494.0	1.5	13.0	1800.0	.002	2.2	2.2	3.0	9792.0	546.0	21.700	64.	41.	45.	1.5
24	66.0	24.0	126.0	3624.0	512.0	2.0	16.0	1800.0	.002	1.0	3.0	3.0	9792.0	546.0	21.700	64.	41.	45.	1.5
24	64.0	21.0	127.0	3954.0	535.0	1.9	15.0	1950.0	.002	2.5	2.0	3.0	9792.0	546.0	21.900	64.	41.	45.	1.5
24	67.0	21.0	126.0	3607.0	523.0	1.4	14.0	1800.0	.002	3.0	3.0	3.0	9792.0	546.0	22.200	64.	41.	45.	1.5
24	72.0	30.0	124.0	2980.0	478.0	1.4	14.0	1800.0	.002	1.7	2.9	3.0	9792.0	546.0	21.500	64.	41.	45.	1.5
25	57.0	118.0	119.0	1689.0	289.0	2.3	15.0	10000.0	.001	3.0	0.0	3.0	6741.0	.	18.200	51.	28.	6.	1.5
25	61.0	107.0	124.0	1542.0	288.0	2.1	16.0	3500.0	.002	3.0	0.0	3.0	6741.0	.	18.600	51.	28.	6.	1.5
25	63.0	150.0	120.0	1365.0	269.0	2.1	16.0	5000.0	.001	3.0	0.0	3.0	6741.0	.	17.900	51.	28.	6.	1.5
25	62.0	150.0	120.0	1515.0	279.0	2.2	17.0	5500.0	.001	3.0	0.0	3.0	6741.0	.	18.300	51.	28.	6.	1.5
25	60.0	150.0	121.0	1510.0	277.0	2.2	16.0	5500.0	.001	3.0	0.0	3.0	6741.0	.	18.300	51.	28.	6.	1.5
25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	51.	28.	6.	1.5
26	21.0	0.0	150.0	46345.0	1252.0	6.7	16.0	7500.0	.013	1.9	0.9	2.4	500.0	50.0	32.600	55.	32.	8.	.
26	19.0	5.0	152.0	46186.0	1289.0	5.3	17.0	8000.0	.013	0.2	0.9	0.9	500.0	50.0	32.400	55.	32.	8.	.
26	18.0	1.0	153.0	59989.0	1370.0	5.4	18.0	8000.0	.019	1.4	0.9	0.9	500.0	50.0	33.400	55.	32.	8.	.
26	22.0	4.0	151.0	52626.0	1488.0	7.2	17.0	7000.0	.013	2.1	0.9	2.8	500.0	50.0	34.900	55.	32.	8.	.

BPR data used for preliminary analyses

PROJ	PEN77	DUCT60	SOFTPT	CAPV140	CAPV275	VOCON	BITIND	SM12010	SM14010	RUTT	TRANCR	POLYCR	ADT	ADTT	ASPHALT	YRMAX	YRMIN	DYS89	LAYER
26	24.0	4.0	149.0	40436.0	1405.0	5.3	16.0	5000.0	.012	2.8	0.9	2.9	500.0	50.0	33.100	55.	32.	8.	.
26	24.0	6.0	147.0	35455.0	1206.0	4.4	18.0	6500.0	.010	2.8	1.7	2.9	500.0	50.0	32.900	55.	32.	8.	.
27	27.0	6.0	143.0	20994.0	875.0	2.6	17.0	6500.0	.007	3.0	0.4	2.7	6827.0	1100.0	30.200	56.	34.	8.	1.0
27	54.0	120.0	125.0	4316.0	536.0	1.9	19.0	4500.0	.002	3.0	3.0	3.0	6827.0	1100.0	25.100	56.	34.	8.	1.0
27	45.0	57.0	128.0	6058.0	612.0	1.5	22.0	5000.0	.002	3.0	0.9	3.0	6827.0	1100.0	26.300	56.	34.	8.	1.0
27	57.0	62.0	124.0	3882.0	540.0	1.0	20.0	4000.0	.002	3.0	2.7	3.0	6827.0	1100.0	25.100	56.	34.	8.	1.0
27	23.0	5.0	144.0	32233.0	1141.0	5.2	18.0	7500.0	.008	3.0	2.8	3.0	6827.0	1100.0	31.300	56.	34.	8.	1.0
27	74.0	150.0	120.0	2131.0	400.0	1.3	20.0	3000.0	.009	2.9	2.0	2.9	6827.0	1100.0	21.900	56.	34.	8.	1.0
29	4.0	0.0	175.0	671389.0	3584.0	7.8	17.0	20000.0	.180	.	2.9	3.0	37000.0	1110.0	37.400	76.	50.	46.	.
29	4.0	0.0	173.0	526257.0	3129.0	7.6	15.0	19000.0	.140	.	2.3	3.0	37000.0	1110.0	37.700	76.	50.	46.	.
29	7.0	0.0	165.0	205320.0	2125.0	6.5	16.0	17000.0	.050	.	2.9	2.8	37000.0	1110.0	37.100	76.	50.	46.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	76.	50.	46.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	76.	50.	46.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	76.	50.	46.	.
31	12.0	0.0	163.0	170077.0	2930.0	4.3	20.0	9500.0	.040	.	3.0	1.0	26500.0	795.0	41.900	76.	50.	46.	.
31	6.0	0.0	173.0	470000.0	5565.0	6.4	17.0	16000.0	.120	.	3.0	2.8	26500.0	795.0	45.900	76.	50.	46.	.
31	4.0	0.0	182.0	999999.0	9416.0	7.7	17.0	19500.0	.350	.	3.0	2.7	26500.0	795.0	46.800	76.	50.	46.	.
31	4.0	0.0	180.0	999999.0	7939.0	7.8	18.0	19000.0	.320	2.6	3.0	1.7	26500.0	795.0	47.400	76.	50.	46.	.
31	6.0	0.0	173.0	560000.0	5007.0	6.4	18.0	16000.0	.120	2.9	3.0	0.4	26500.0	795.0	43.600	76.	50.	46.	.
31	3.0	0.0	182.0	999999.0	6657.0	8.0	18.0	22000.0	.380	3.0	3.0	3.0	26500.0	795.0	46.100	76.	50.	46.	.
38	71.0	150.0	122.0	2932.0	494.0	1.6	17.0	3000.0	.002	3.0	3.0	3.0	.	.	24.700	64.	42.	29.	.
38	75.0	150.0	124.0	2803.0	491.0	2.3	17.0	1700.0	.002	3.0	3.0	3.0	.	.	24.400	64.	42.	29.	.
38	23.0	4.0	154.0	64966.0	1571.0	7.2	17.0	3700.0	.020	3.0	3.0	3.0	.	.	33.700	64.	42.	29.	.
38	24.0	4.0	153.0	65422.0	1585.0	6.0	14.0	4000.0	.018	3.0	3.0	3.0	.	.	33.600	64.	42.	29.	.
38	24.0	4.0	153.0	65530.0	1606.0	7.2	20.0	4000.0	.018	3.0	3.0	3.0	.	.	33.200	64.	42.	29.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	64.	42.	29.	.
39	23.0	3.0	154.0	67507.0	1605.0	8.8	15.0	3700.0	.019	3.0	1.3	3.0	.	.	33.800	64.	42.	29.	.
39	19.0	3.0	161.0	150516.0	2236.0	9.8	18.0	5000.0	.035	3.0	2.0	3.0	.	.	34.100	64.	42.	29.	.
39	26.0	4.0	153.0	55928.0	1530.0	10.8	17.0	3500.0	.018	3.0	1.6	3.0	.	.	33.400	64.	42.	29.	.
39	27.0	5.0	150.0	42222.0	1327.0	7.9	18.0	4500.0	.012	3.0	1.3	3.0	.	.	32.600	64.	42.	29.	.
39	19.0	5.0	160.0	128415.0	2143.0	10.7	16.0	5000.0	.030	3.0	0.4	3.0	.	.	33.500	64.	42.	29.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	64.	42.	29.	.
40	37.0	16.0	133.0	8450.0	667.0	3.0	18.0	5500.0	.006	2.7	2.9	3.0	15284.0	.	25.900	56.	34.	8.	.
40	39.0	24.0	132.0	6980.0	606.0	2.1	18.0	5000.0	.004	2.9	2.9	3.0	15284.0	.	25.500	56.	34.	8.	.
40	29.0	10.0	137.0	12699.0	785.0	2.9	16.0	7500.0	.005	3.0	2.9	3.0	15284.0	.	26.500	56.	34.	8.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	56.	34.	8.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	56.	34.	8.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	56.	34.	8.	.
50	23.0	5.0	154.0	46206.0	1371.0	5.1	17.0	4000.0	.019	3.0	2.7	3.0	5100.0	.	29.800	59.	39.	4.	3.0
50	30.0	7.0	145.0	21479.0	1051.0	2.8	18.0	4500.0	.009	3.0	1.8	3.0	5100.0	.	27.600	59.	39.	4.	3.0
50	33.0	9.0	139.0	14898.0	908.0	3.4	15.0	5000.0	.001	3.0	2.3	3.0	5100.0	.	27.500	59.	39.	4.	3.0
50	21.0	4.0	154.0	68848.0	1606.0	5.9	17.0	6000.0	.020	2.6	3.0	3.0	5100.0	.	31.200	59.	39.	4.	3.0
50	23.0	5.0	150.0	45426.0	1400.0	5.3	16.0	6000.0	.014	3.0	3.0	1.8	5100.0	.	30.400	59.	39.	4.	3.0
50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	59.	39.	4.	3.0
52	62.0	150.0	130.0	5770.0	819.0	1.2	23.0	1600.0	.002	2.0	2.6	3.0	1084.0	108.0	23.000	64.	41.	45.	1.5
52	66.0	18.0	126.0	3745.0	533.0	2.0	17.0	1800.0	.002	2.8	3.0	3.0	1084.0	108.0	21.400	64.	41.	45.	1.5
52	67.0	26.0	125.0	3314.0	506.0	0.9	16.0	2000.0	.002	2.8	2.9	3.0	1084.0	108.0	21.400	64.	41.	45.	1.5
52	57.0	14.0	128.0	5084.0	580.0	2.5	15.0	2200.0	.002	2.8	2.6	3.0	1084.0	108.0	22.100	64.	41.	45.	1.5
52	63.0	25.0	126.0	3831.0	540.0	1.7	15.0	2000.0	.002	2.8	3.0	3.0	1084.0	108.0	22.000	64.	41.	45.	1.5
52	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	64.	41.	45.	1.5
53	19.0	2.0	176.0	545000.0	4618.0	12.2	14.0	4000.0	1.100	2.7	0.1	3.0	1084.0	108.0	43.100	79.	59.	83.	.
53	25.0	3.0	169.0	381000.0	3323.0	11.3	15.0	3200.0	.650	2.8	0.2	3.0	1084.0	108.0	41.100	79.	59.	83.	.
53	21.0	2.0	178.0	800000.0	5351.0	15.1	12.0	3100.0	.110	1.9	0.0	3.0	1084.0	108.0	43.100	79.	59.	83.	.
53	22.0	3.0	167.0	405000.0	3543.0	15.6	12.0	3800.0	.055	2.8	0.0	3.0	1084.0	108.0	41.500	79.	59.	83.	.
53	20.0	2.0	176.0	477000.0	4865.0	14.3	14.0	3500.0	.011	3.0	0.0	3.0	1084.0	108.0	41.800	79.	59.	83.	.
53	20.0	3.0	176.0	630000.0	4550.0	15.3	13.0	3500.0	.011	3.0	0.0	3.0	1084.0	108.0	42.300	79.	59.	83.	.
54	13.0	0.0	155.0	71828.0	1781.0	4.2	14.0	11000.0	.020	3.0	3.0	2.8	12600.0	2300.0	30.000	72.	48.	56.	1.5
54	11.0	0.0	155.0	101941.0	1945.0	5.6	14.0	8000.0	.020	3.0	3.0	1.8	12600.0	2300.0	30.600	72.	48.	56.	1.5
54	10.0	0.0	159.0	158058.0	2389.0	5.2	16.0	7500.0	.035	3.0	3.0	3.0	12600.0	2300.0	31.900	72.	48.	56.	1.5
54	10.0	0.0	155.0	105792.0	2108.0	4.8	15.0	13500.0	.022	2.9	3.0	3.0	12600.0	2300.0	30.800	72.	48.	56.	1.5
54	29.0	8.0	140.0	13831.0	788.0	1.8	14.0	8000.0	.006	3.0	2.8	3.0	12600.0	2300.0	27.300	72.	48.	56.	1.5
54	20.0	5.0	148.0	38256.0	1190.0	4.0	17.0	8000.0	.011	3.0	2.8	3.0	12600.0	2300.0	30.900	72.	48.	56.	1.5
54	25.0	6.0	141.0	18461.0	897.0	3.1	14.0	13000.0	.007	3.0	2.8	2.6	12600.0	2300.0	27.400	72.	48.	56.	1.5
54	23.0	6.0	143.0	21627.0	953.0	2.8	14.0	7800.0	.006	3.0	3.0	3.0	12600.0	2300.0	29.000	72.	48.	56.	1.5
54	27.0	7.0	140.0	16536.0	845.0	3.8	16.0	7500.0	.006	3.0	3.0	3.0	12600.0	2300.0	28.500	72.	48.	56.	1.5

BPR data used for preliminary analyses

PROJ	PEN77	DUCT60	SOFTPT	CAPV140	CAPV275	VOCON	BITIND	SM12010	SM14010	RUTT	TRANCR	POLYCR	ADT	ADTT	ASPHALT	YRMAX	YRMIN	DYS89	LAYER
54	22.0	6.0	143.0	24827.0	1048.0	3.3	14.0	15500.0	.007	2.9	3.0	1.0	12600.0	2300.0	28.100	72.	48.	56.	1.5
54	35.0	13.0	137.0	9477.0	674.0	1.9	15.0	9000.0	.004	3.0	3.0	2.6	12600.0	2300.0	26.800	72.	48.	56.	1.5
54	24.0	5.0	147.0	27954.0	1033.0	6.5	17.0	10500.0	.010	3.0	3.0	3.0	12600.0	2300.0	29.600	72.	48.	56.	1.5
54	20.0	5.0	149.0	39500.0	1199.0	5.2	15.0	6000.0	.011	2.9	3.0	2.6	12600.0	2300.0	30.800	72.	48.	56.	1.5
54	22.0	5.0	146.0	25771.0	987.0	4.8	15.0	5000.0	.008	2.9	3.0	2.6	12600.0	2300.0	29.300	72.	48.	56.	1.5
54	18.0	4.0	152.0	55806.0	1373.0	6.0	16.0	11000.0	.013	2.9	3.0	2.6	12600.0	2300.0	31.300	72.	48.	56.	1.5
54	12.0	0.0	160.0	138303.0	2114.0	6.4	14.0	9000.0	.035	2.9	3.0	2.6	12600.0	2300.0	32.900	72.	48.	56.	1.5
54	12.0	0.0	157.0	92689.0	1906.0	6.2	13.0	7000.0	.002	2.9	3.0	2.6	12600.0	2300.0	30.800	72.	48.	56.	1.5
54	17.0	0.0	154.0	61835.0	1433.0	5.8	15.0	7500.0	.019	2.9	3.0	2.6	12600.0	2300.0	30.500	72.	48.	56.	1.5
55	56.0	85.0	120.0	1707.0	293.0	1.8	15.0	7000.0	.001	3.0	0.0	3.0	6741.0	.	19.200	51.	28.	6.	.
55	47.0	35.0	124.0	2224.0	315.0	2.4	18.0	2000.0	.002	3.0	0.0	3.0	6741.0	.	19.300	51.	28.	6.	.
55	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	51.	28.	6.	.
55	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	51.	28.	6.	.
55	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	51.	28.	6.	.
55	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	51.	28.	6.	.
56	46.0	10.0	134.0	7811.0	707.0	1.4	15.0	3500.0	.004	2.8	0.5	3.0	3700.0	256.0	21.900	73.	49.	80.	1.5
56	39.0	7.0	136.0	11458.0	781.0	2.8	13.0	3800.0	.004	2.6	0.7	3.0	3700.0	256.0	21.100	73.	49.	80.	1.5
56	34.0	52.0	130.0	5374.0	613.0	3.4	14.0	9500.0	.002	1.5	0.7	3.0	3700.0	256.0	16.000	73.	49.	80.	1.5
56	40.0	150.0	126.0	3768.0	524.0	2.2	14.0	10000.0	.002	1.5	0.5	3.0	3700.0	256.0	14.900	73.	49.	80.	1.5
56	42.0	9.0	134.0	9538.0	755.0	2.2	14.0	3800.0	.004	2.8	0.8	3.0	3700.0	256.0	21.800	73.	49.	80.	1.5
56	32.0	5.0	144.0	30148.0	1068.0	5.2	13.0	4200.0	.008	2.6	0.8	3.0	3700.0	256.0	23.800	73.	49.	80.	1.5
57	59.0	99.0	127.0	4322.0	619.0	1.0	13.0	2200.0	.002	1.0	2.4	3.0	3500.0	245.0	23.700	76.	54.	95.	.
57	49.0	61.0	130.0	5948.0	713.0	1.8	15.0	3500.0	.002	2.6	2.3	3.0	3500.0	245.0	24.200	76.	54.	95.	.
57	52.0	57.0	129.0	5397.0	675.0	0.9	15.0	3300.0	.003	2.9	1.7	3.0	3500.0	245.0	24.600	76.	54.	95.	.
57	54.0	92.0	127.0	4883.0	651.0	1.7	15.0	3500.0	.002	2.7	2.4	3.0	3500.0	245.0	24.200	76.	54.	95.	.
57	55.0	83.0	127.0	4740.0	660.0	0.8	16.0	3000.0	.002	2.0	2.7	3.0	3500.0	245.0	23.800	76.	54.	95.	.
57	53.0	85.0	128.0	4957.0	643.0	1.2	14.0	3300.0	.002	2.9	2.0	3.0	3500.0	245.0	23.000	76.	54.	95.	.
58	37.0	10.0	135.0	9431.0	839.0	0.8	18.0	4500.0	.004	2.4	2.0	3.0	4100.0	120.0	25.300	76.	54.	95.	.
58	26.0	5.0	144.0	23324.0	1129.0	1.4	18.0	7000.0	.008	2.3	2.2	3.0	4100.0	120.0	28.100	76.	54.	95.	.
58	40.0	10.0	134.0	7774.0	772.0	1.2	17.0	4000.0	.004	2.2	2.0	2.2	4100.0	120.0	24.700	76.	54.	95.	.
58	40.0	12.0	132.0	7656.0	762.0	1.7	17.0	5000.0	.004	2.0	2.3	2.2	4100.0	120.0	24.300	76.	54.	95.	.
58	42.0	13.0	133.0	7166.0	760.0	1.6	20.0	4000.0	.003	2.4	1.3	3.0	4100.0	120.0	25.300	76.	54.	95.	.
58	22.0	4.0	147.0	50577.0	1491.0	2.3	18.0	7500.0	.009	2.7	2.0	2.8	4100.0	120.0	29.700	76.	54.	95.	.