Louisiana

TEXAS TRIAXIAL R VALUE CORRELATION

Highway Research

LOUISIANA DEPARTMENT OF HIGHWAYS

STATE OF LOUISIANA

UNION JUSTICE CONFIDENCE

TEXAS TRIAXIAL - R VALUE CORRELATION

by
HARRY L. ROLAND, JR.
Acting Soils Research Engineer

Research Project 61-1S, HPR 1(1)

Conducted in cooperation with the Bureau of Public Roads by Louisiana Department of Highways, Testing and Research Section.

March 1963

LOUISIANA DEPARTMENT OF HIGHWAYS
Testing and Research Section

H. L. Lehmann
Testing & Research Engineer

Verdi Adam
Highway Research Engineer

ADVISORY RESEARCH COUNCIL

H. L. Lehmann, Chairman (Testing & Research Engineer)

T. W. Parish, Chief Construction & Maintenance Engineer
J. B. Carter, Chief Design Engineer
J. H. Drake, Assistant Maintenance Engineer
I. L. Thomas, Jr., Traffic & Planning Engineer
J. C. Franklin, Planning & Programming Engineer, Bureau of Public Roads
Elvin Dantin, Director, Engineering Experiment Station, Louisiana State University
Henry A. Kallsen, Acting Head, Civil Engineering Department, Louisiana Polytechnic Institute
C. B. McCarthy, Assistant Professor of Civil Engineering, Tulane University
W. P. Wallace, Head, Civil Engineering, University of Southwestern Louisiana

SOILS PROJECT ADVISORY COMMITTEE

J. W. Lyon, Jr., Chairman (Testing Engineer)

Earl Cryar, Assistant District Engineer (Construction)
W. C. Vincent, Assistant District Engineer (Construction)
Ara Arman, Soils Engineer
Ali S. Kemahlioglu, Acting Soils Engineer
J. C. Franklin, Planning & Programming Engineer, Bureau of Public Roads

TEXAS TRIAXIAL - R VALUE CORRELATION

SYNOPSIS

The Testing and Research Section of the Louisiana Department of Highways, in cooperation with the Bureau of Public Roads, has been engaged in an effort to correlate Resistance Value (R-Value) with the Texas Triaxial Strength Class system which is the basis of the flexible pavement design method currently used in Louisiana.

Parallel to this, an attempt was made to correlate R-Value with the Group Index Method.

The materials selected for this project cover common Louisiana soils, plus artificially produced materials designed to fall within the range of Texas Triaxial Class 2.

The test results were analyzed using statistical concepts which showed an apparently good correlation to exist between R-Value and Texas Triaxial Strength Classes. The correlation for R-Value and Group Index appeared to be fairly poor, as can be seen by the scatter arrangement of the variables.

TEXAS TRIAXIAL - R VALUE CORRELATION

Introduction

In view of the fact that AASHO has undertaken a project to establish a nationally accepted Guide for the Design of Flexible Pavement Structures, the Testing and Research Section of the Louisiana Department of Highways, in January 1961, began this project in an effort to correlate the "Soil Support Value" used in the recommended AASHO design formula with the Texas Triaxial Strength Class method which is the basis of the flexible pavement design currently used in Louisiana.

The project was designed on the basis of "Soil Support Value" (S) being equal to R-Value (R) as set forth in AASHO Recommended Guide for the Design of Flexible Pavement Structures, Preliminary Draft, 1960 (Figure 10). However, since the October, 1961 version of the AASHO Recommended Guide for the Design of Flexible Pavement Structures modifies the concept of Soil Support Value (S), whereby Soil Support Value is no longer equal to R-Value, it became necessary to limit the correlation to R-Value and Texas Triaxial Strength Class with the thought in mind that as additional data are acquired, a correlation with Soil Support Value may become possible. Concurrent with this work, an attempt was made to correlate R-Value (R) with the Group Index Method.

Purpose of This Study

At the time of the instigation of this research the recommended AASHO design formula was based on a Soil Support Value which directly correlated with the "R-Value" system developed by F. N. Hveem, whereas, the flexible pavement design method currently used in Louisiana is based upon the Texas Triaxial Method. The AASHO further recommended that those states using a different design method correlate their past experience and data with the R-Value system. Although correlations, which seemed to be satisfactory, have been obtained for Group Index and CBR methods and a tentative correlation with the Texas Triaxial Strength Classes had been suggested, it appeared that the Texas Triaxial Strength Classes might require some further adjustment. It was with this objective in mind that this research project was undertaken; however, since the later version of the AASHO Recommended Guide for the Design of Flexible Pavement Structures establishes the Soil Support Value in an abstract scale, it is felt that any correlation with Soil Support Value, except for an (S) value of 3.0, as such, is beyond the scope of this report. However, a new research project being prepared for the purpose of establishing the different factors used in AASHO design formula will attempt an accurate correlation for Support Values other than 3.0.

Scope of the Study

This research project was designed to cover common Louisiana soils and untreated base materials to provide for a well balanced distribution on the R-Value scale and to encompass as wide a range as possible on the Texas Triaxial Strength Class Scale.

The soil samples and untreated base materials were collected from each Highway District in the State to insure adequate representation of soil types. The materials range from sand-shell mixtures of Texas Triaxial Class 1+, to heavy clay, Texas Triaxial Class 6.

Methods of Investigation

The soil samples were prepared and tested in accordance with the various test methods listed below:

1. AASHO Designation: T 87-49 (LDH Designation: 411-58) Standard Method of Dry Preparation of Disturbed Soil Samples for Test.
2. LDH Designation: TR 406-56 - Alternate Mechanical Method of Determination of the Liquid Limit of Soils (one point Liquid Limit).
3. AASHO Designation: T 90-54 - Standard Methods of Determining the Plastic Limit of Soils.
4. AASHO Designation: T 91-54 - Standard Method of Calculating the Plasticity Index of Soils.
5. AASHO Designation: T 99-49 - Standard Methods for the Compaction and Density of Soils.
6. LDH Designation: TR 407-51 - Standard Method of Mechanical Analysis of Soils.
7. LDH Designation: TR 410-58 - Standard Method of Triaxial Compression Test.

8. AASHO Designation: T 100-60 - Specific Gravity of Soils.

9. California Test Method No. 301-C - Method of Test for Determination of the Resistance "R" Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilometer.

In general, the primary methods of investigation consisted of subjecting the properly quartered and classified samples to Texas Triaxial and R-Value Tests with the testing procedures conforming to LDH TR 410-58 and California Test Method No. 301-C respectively. The R-Value was determined, in most cases, by molding five briquettes for each R-Value determination. Six cylinders were made for each Texas Triaxial Class determination. All other tests were performed in duplicate to insure a fair degree of accuracy.

Discussion of Test Results

A summary of test results is presented in Table I. More complete test results appear in Tables II, III and IV.

Curve A, in Figures 1 through 6, represents the curves derived by the Polynomial Curve fitting method utilizing the theory of least squares as processed by the Louisiana Department of Highways, 1620 IBM Data Processing System. The program used was designed to determine such factors as standard deviation, standard error, and index of correlation. An index of correlation of zero indicates no correlation and unity indicates perfect correlation. For purposes of comparison, a suggested correlation curve as reported in the Preliminary AASHO Recommended Guide, 1960, Chart 400-2

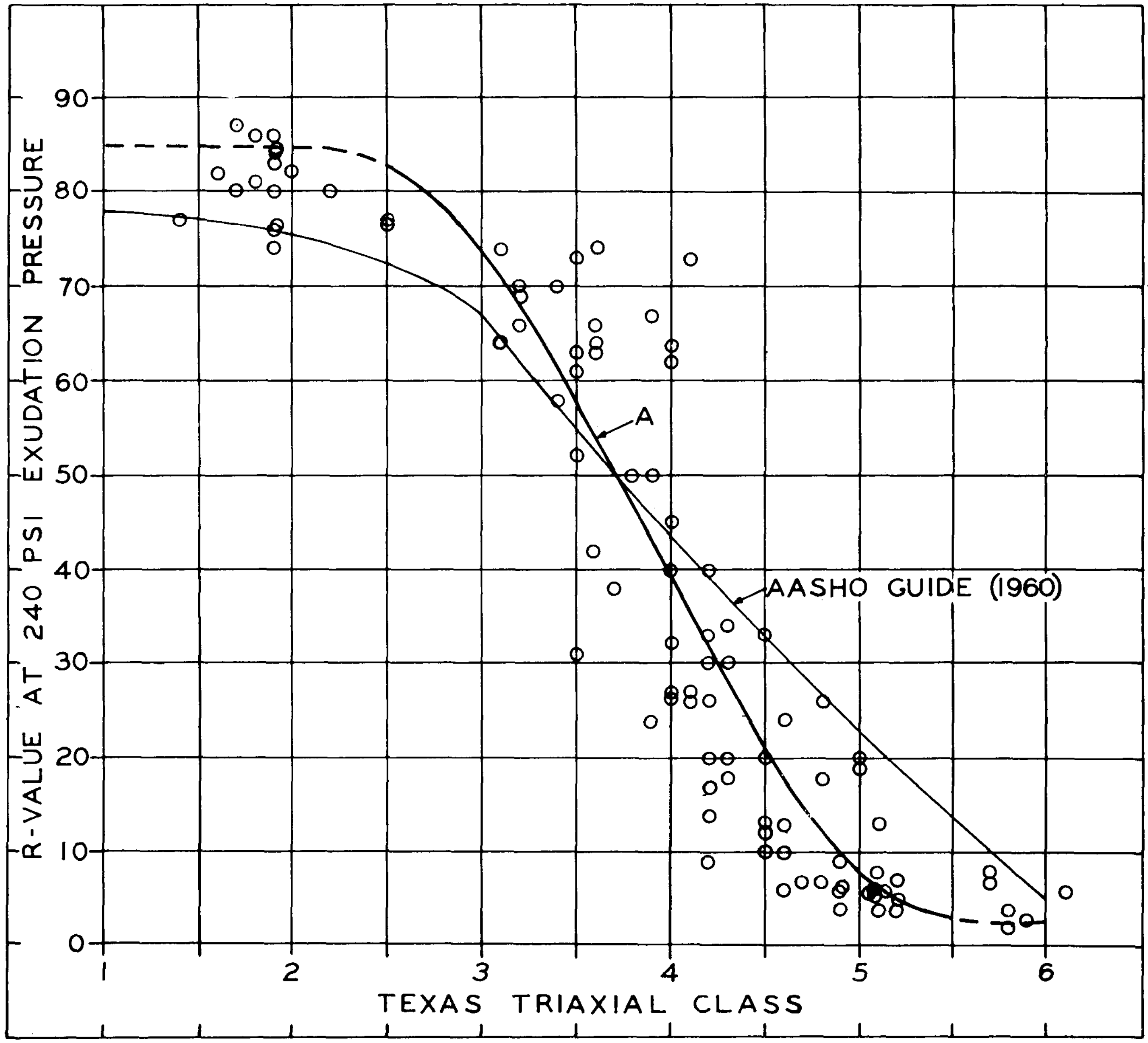

Fig. 1 - Relationship of Texas Triaxial Strength Classes and R-Values at 240 psi Exudation Pressure-Observations-95, Degree-3d, Mean-40.063, Standard Deviation-29.001, Standard Error-10.285, Index of Correlation-0.935.

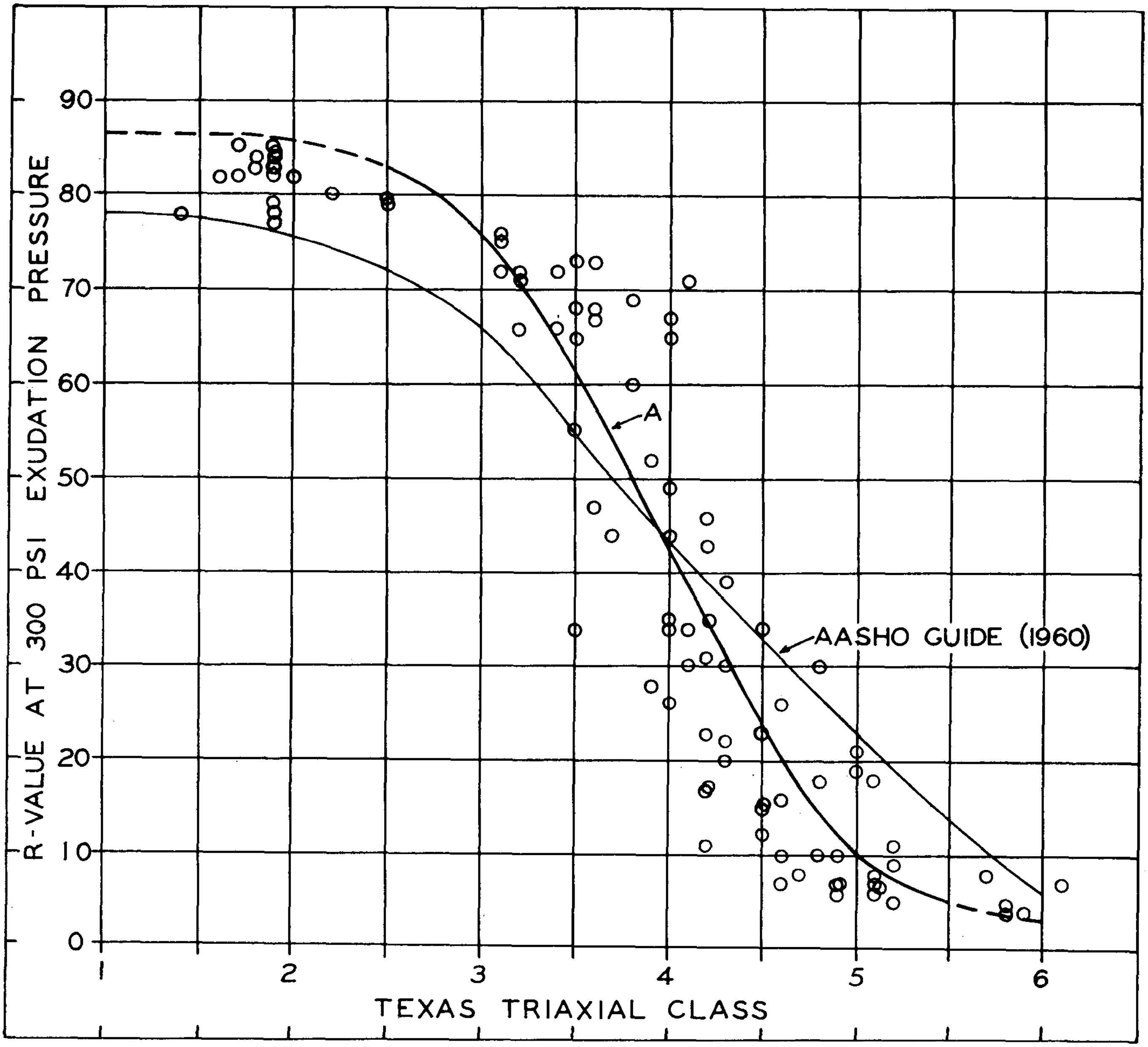

Fig. 2 - Relationship of Texas Triaxial Strength Classes and R-Values at 300 psi Exudation Pressure-Observations-95, Degree-3d, Mean-42.389, Standard Deviation-28.825, Standard Error-10.195, Index of Correlation-0.935.

(Figure 10), is shown on each of Figures 1 through 6. All observed points are shown to give the reader some idea of the scattering of results.

Figure 1 shows the relationship between Texas Triaxial Strength Classes and R-Values at 240 psi exudation pressure. In this case the third degree equation exhibits the best curve fit as evidenced by an index of correlation of 0.935 and a standard error of 10.285. These values represent the highest index of correlation and the lowest standard error after the curve was fitted to the first through sixth order polynomials. It is readily apparent from the curve (Figure 1) that the critical range is from Texas Triaxial Class 3.0 to Texas Triaxial Class 5.0. Beyond this range, the curve tends to flatten out with only slight changes in R-Values. The upper extremity of Curve A (Figures 1, 2 and 3) is dashed due to the inherent possibility of rupturing the specimen upon transfer into the stabilometer even though paper baskets were used for the granular materials. The lower extremity is dashed due to the fact that in this range the specimens are extremely difficult to mold with any degree of consistency and to the rather limited representation of data in this area.

The coefficient of determination for this curve is 0.874 which means in effect that 87.4% of the change in R-Value is caused by a change in Texas Triaxial Strength Class.

It seems that apparently a good correlation exists between R-Value at 240 psi and Texas Triaxial Strength Classes.

Figure 2 is a relationship between Texas Triaxial Classes and R-Values at 300 psi exudation pressure. Again, curve A

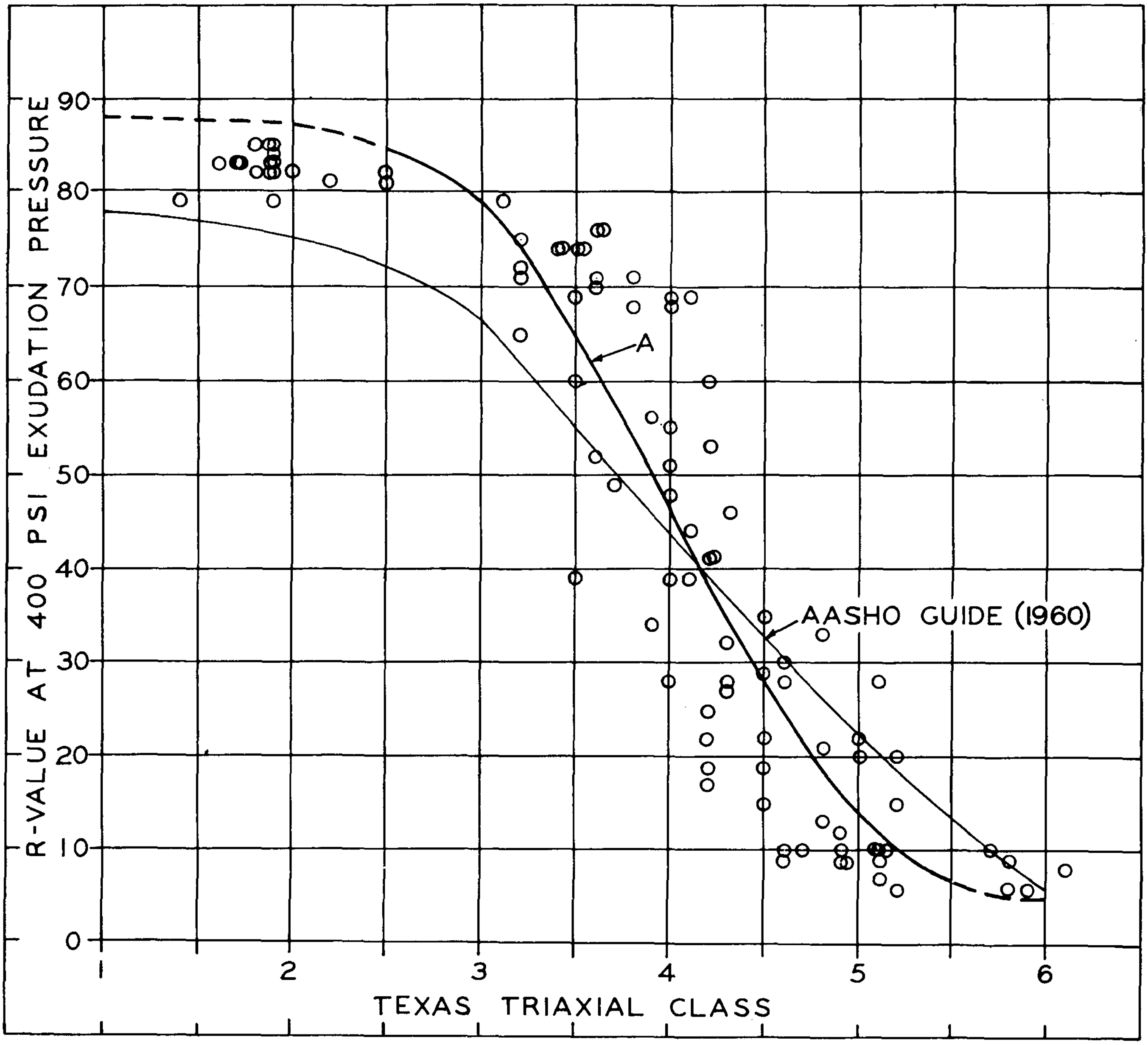

Fig. 3 - Relationship of Texas Triaxial Strength Classes and R-Values at 400 psi Exudation Pressure-Observations-95, Degree-3d, Mean-45.936, Standard Deviation-28.077, Standard Error-10.211, Index of Correlation-0.931.

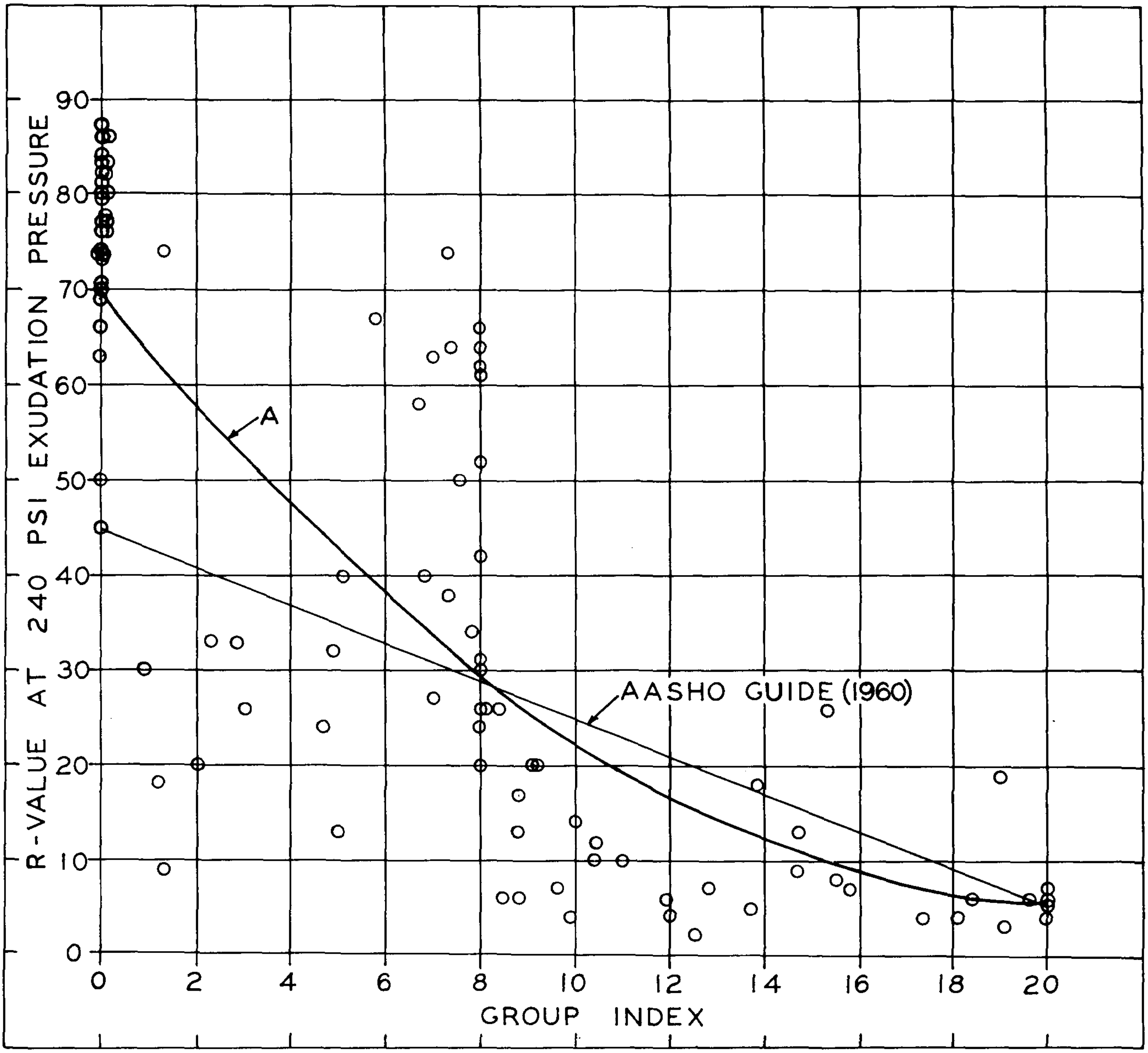

Fig. 4 - Relationship of Group Index and R-Value at 240 psi Exudation Pressure-Observations-96, Degree-2d, Mean-39.687, Standard Deviation-29.081, Standard Error-17.463, Index of Correlation-0.799.

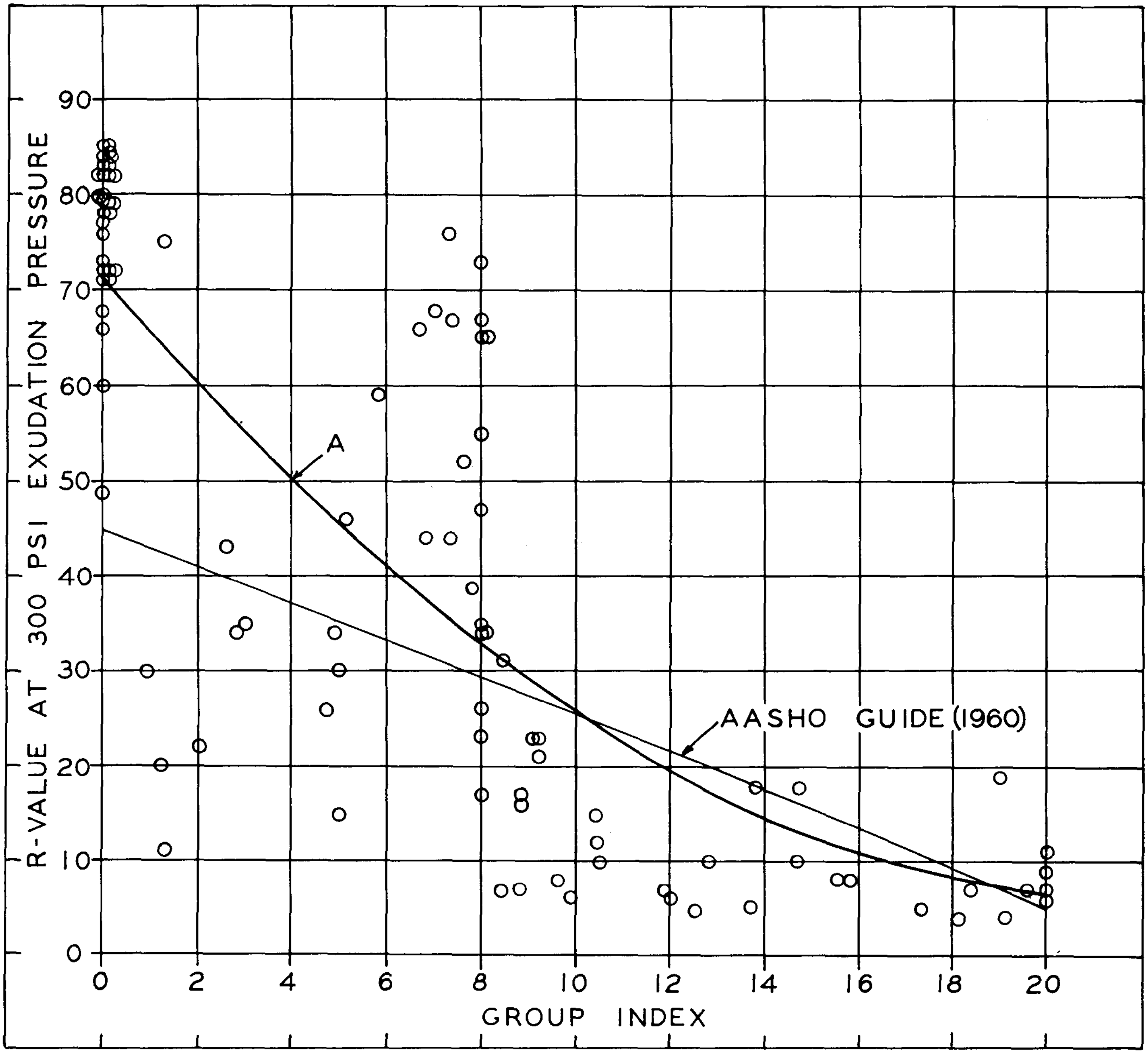

Fig. 5 - Relationship of Group Index and R-Value at 300 psi Exudation Pressure-Observations-96, Degree-2d, Mean-42.000, Standard Deviation-28.925, Standard Error-17.529, Index of Correlation-0.795.

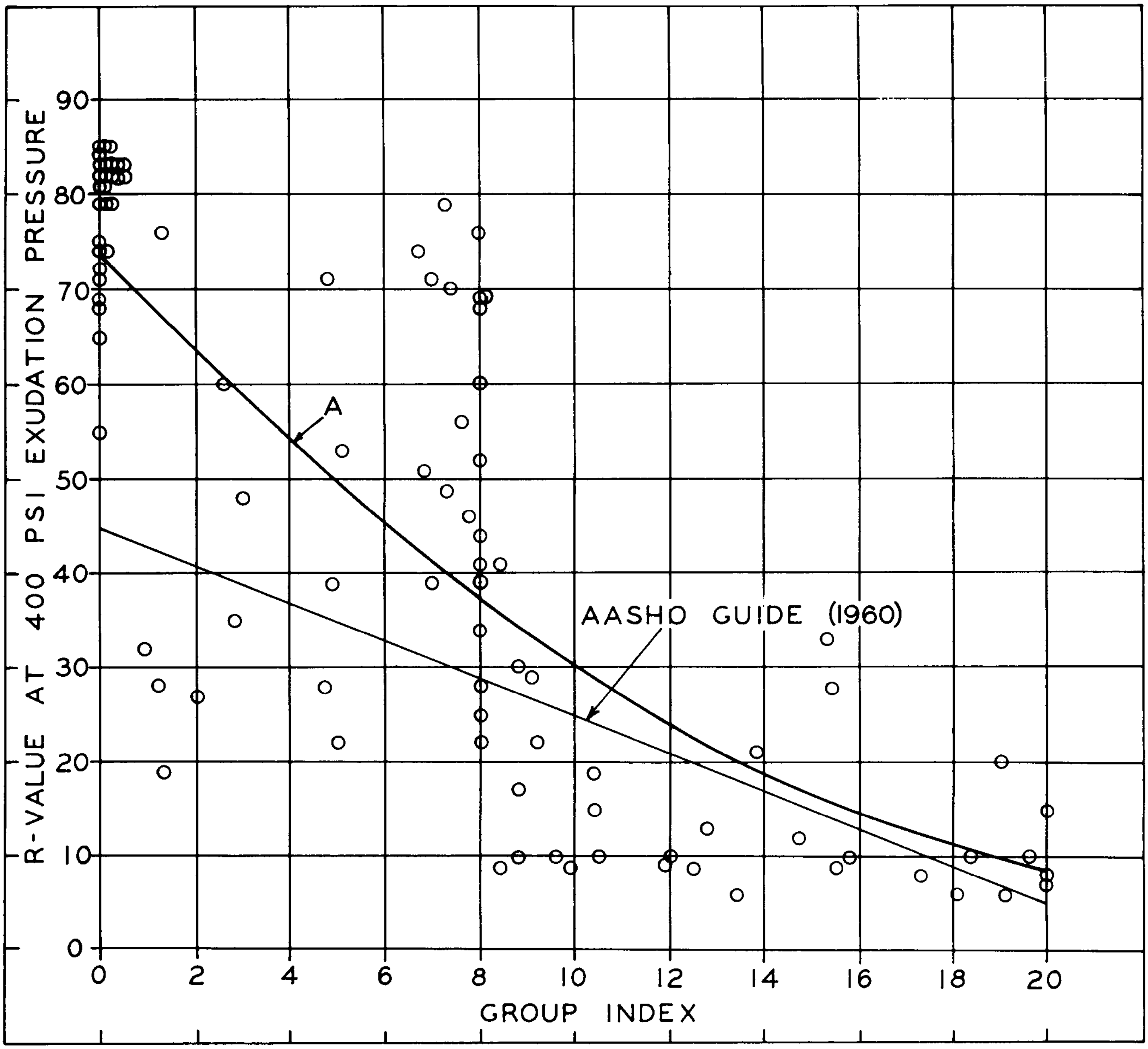

Fig. 6 - Relationship of Group Index and R-Value at 400 psi Exudation Pressure-Observations-96, Degree-2d, Mean-45.541, Standard Deviation-28.194, Standard Error-17.039, Index of Correlation-0.796.

exhibits a third order parabolic form of the general equation $Y = A_o + A_1X + A_2X^2 + A_3X^3$ as the best curve fit as evidenced by an index of correlation of 0.935 and a standard error of 10.195. The mean is 42.389 and the standard deviation is 28.825.

The coefficient of determination for curve A, (Figure 2) is also 0.874, but this curve exhibits a slightly lower standard error than does curve A, Figure 1. However, since the differences between the curves are so slight, any correlation for one curve probably holds true for the other.

Illustrated in Figure 3 is a relationship between Texas Triaxial Classes and R-Values at 400 psi exudation pressure. The third order curve is the best curve fit with an index of correlation of 0.931 and a standard error of 10.211. The mean is 45.936 and the standard deviation is 28.077. The coefficient of determination for this curve is 0.867, therefore, 86.7% of the change in R-Value is due to the change in Texas Triaxial Class and 13.3% is caused by undetermined factors.

Again, a rather good correlation seems to exist for the aforementioned conditions.

The relationships between Group Index and R-Value at 240 psi, 300 psi, and 400 psi exudation pressures are presented in Figures 4, 5 and 6 and will be discussed collectively.

The indices of correlation are, respectively, 0.799, 0.795 and 0.796 with standard errors of 17.463, 17.529, and 17.039, respectively. As can be readily seen, the differences between the three curves are minor and the correlations are approximately the same for all three curves. The important thing here is that the scattering of results suggests a rather poor relationship of the variables.

Figure 7 shows, graphically, relationships between Texas Triaxial Classes and R-Values at 240 psi exudation pressure, Group Indices and R-Values at 240 psi and the Texas Triaxial Class Scale and Group Index Scale as presented by the Preliminary AASHO Recommended Guide for the Design of Flexible Pavement Structures (Figure 10). Also included on this figure is the Soil Support Value (S) Scale from Appendix E-4, AASHO Recommended Guide for the Design of Flexible Pavement Structures, October 1961, for purposes of comparison.

Figures 8 and 9 show, graphically, relationships between Texas Triaxial Classes and R-Values at 300 psi and 400 psi exudation pressures and Group Indices versus R-Values at 300 psi and 400 psi exudation pressures. Again, the Texas Triaxial Class Scale and the Group Index Scale from chart 400-2 of the Preliminary AASHO Recommended Guide are shown.

Figure 11 is a chart for estimating R-Values at 240 psi and Soil Support Values from known Texas Triaxial Strength Classes.

Conclusions

It appears that the differences between the curves at 240 psi, 300 psi and 400 psi, in relation to Texas Triaxial Strength Classes are negligible and any correlation for one holds true for the others. However, in the strictest sense, it must be concluded that the curve at 300 psi is apparently

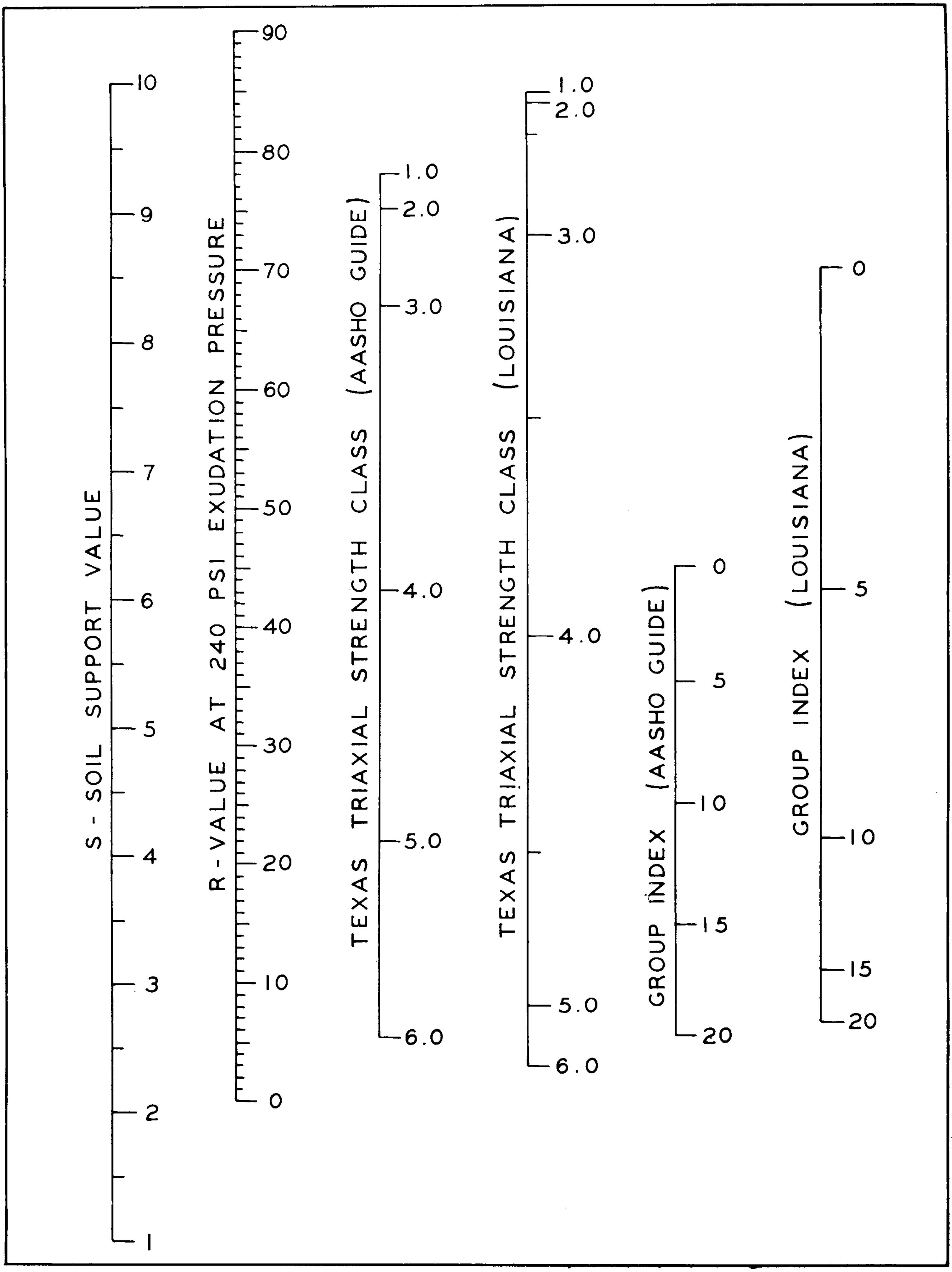

Fig. 7 - Graphical Relationship showing S-Soil Support Value (AASHO Guide), R-Value at 240 psi Exudation Pressure, Texas Triaxial Strength Class (AASHO Guide), Texas Triaxial Strength Class (Louisiana), Group Index (AASHO Guide), and Group Index (Louisiana).

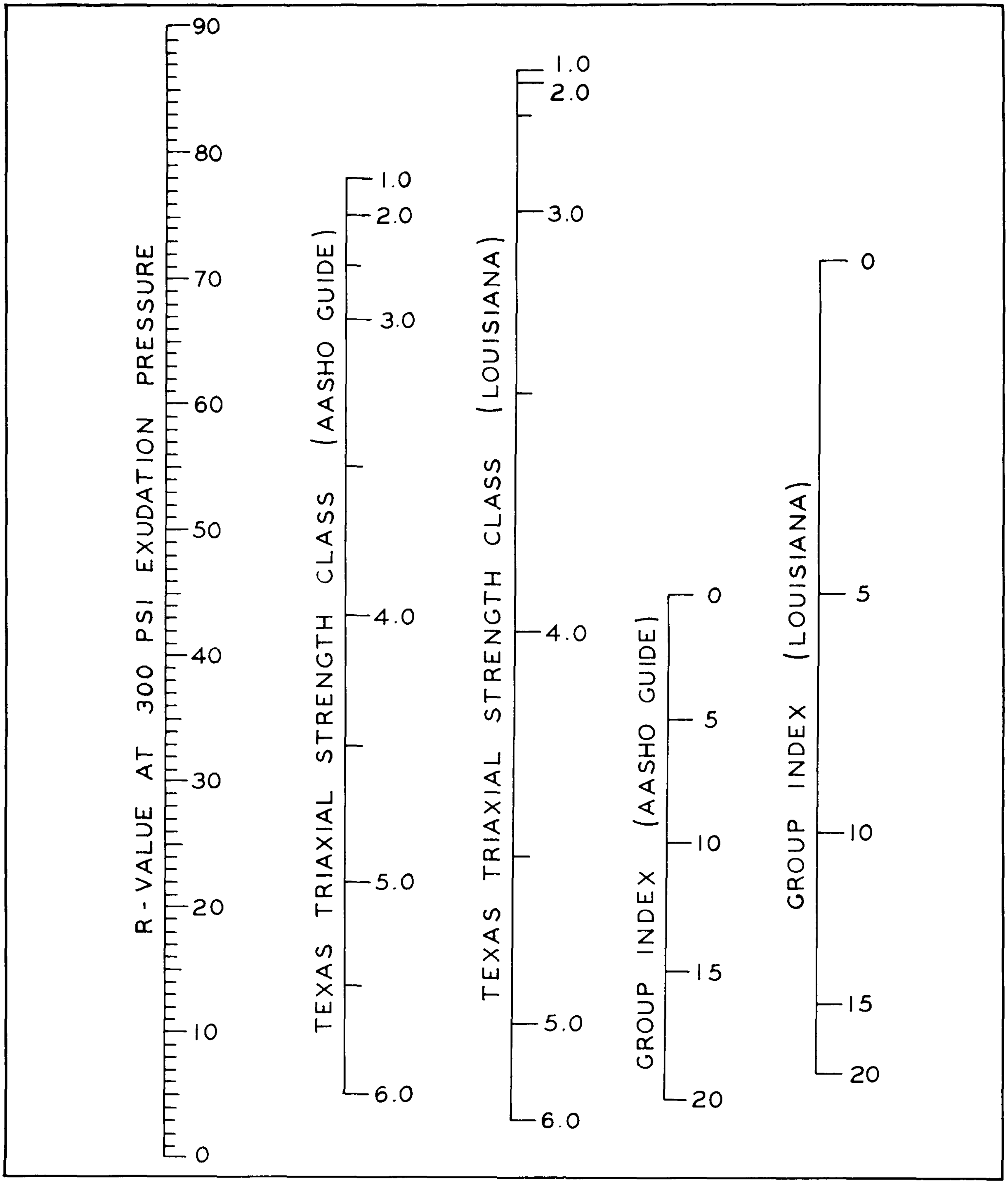

Fig. 8 - Graphical Relationship showing R-Value at 300 psi Exudation Pressure, Texas Triaxial Strength Class (AASHO Guide), Texas Triaxial Strength Class (Louisiana), Group Index (AASHO Guide), and Group Index (Louisiana).

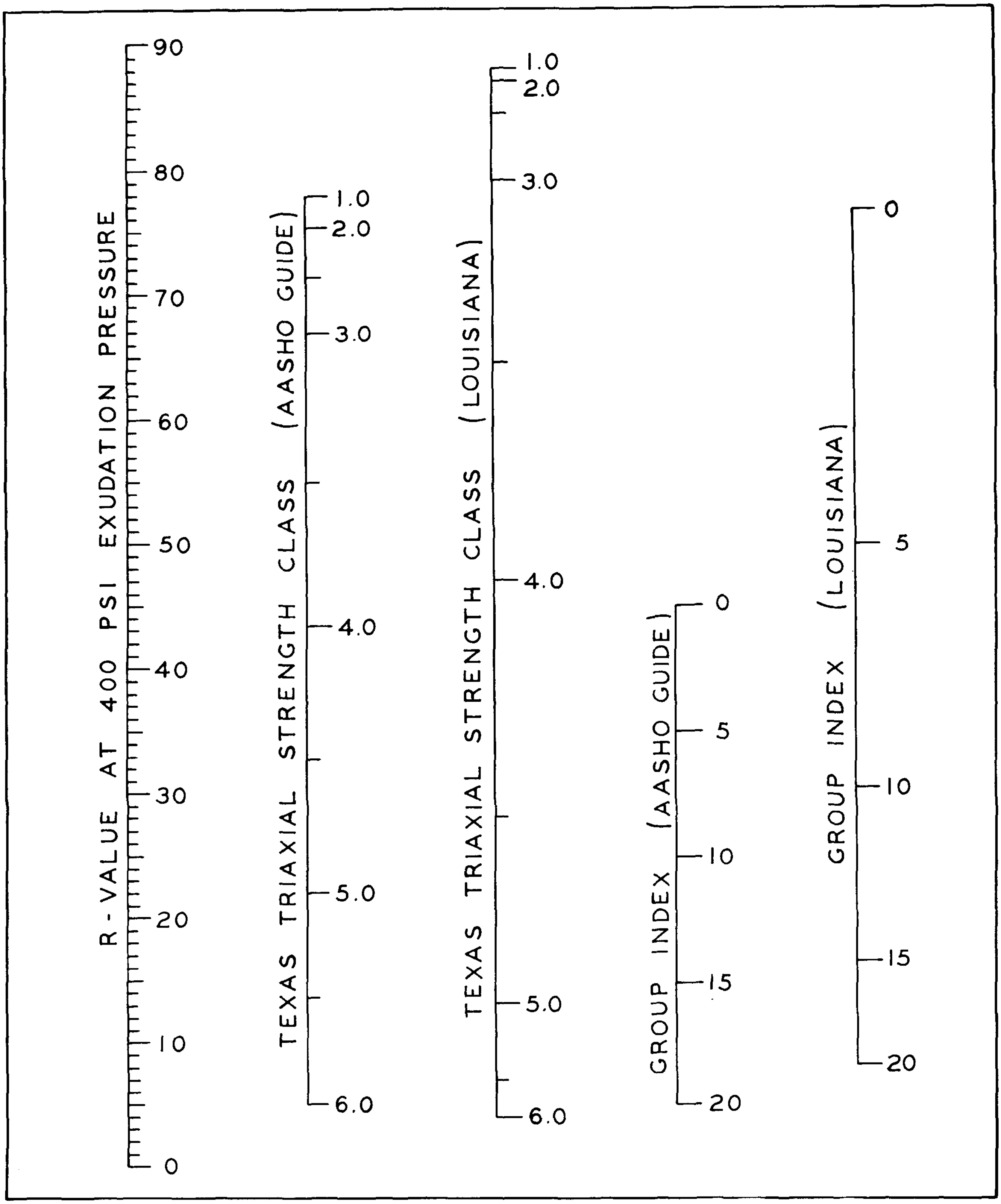

Fig. 9 - Graphical Relationship showing R-Value at 400 psi Exudation Pressure, Texas Triaxial Strength Class (AASHO Guide), Texas Triaxial Strength Class (Louisiana), Group Index (AASHO Guide), and Group Index (Louisiana).

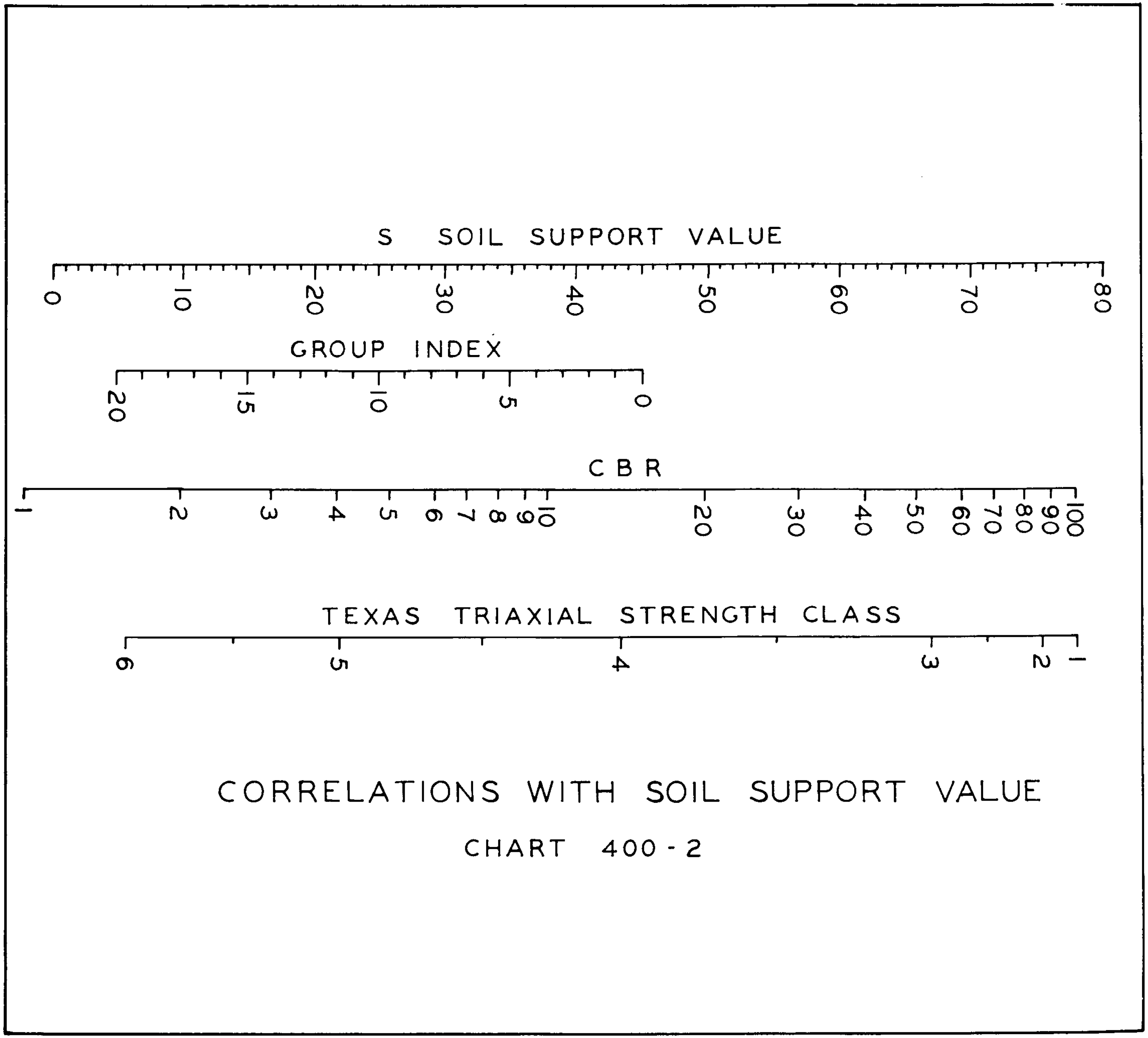

Fig. 10 - Chart showing Correlations with Soil Support Value. (AASHO Recommended Guide for the Design of Flexible Pavement Structures, Preliminary Draft, 1960).

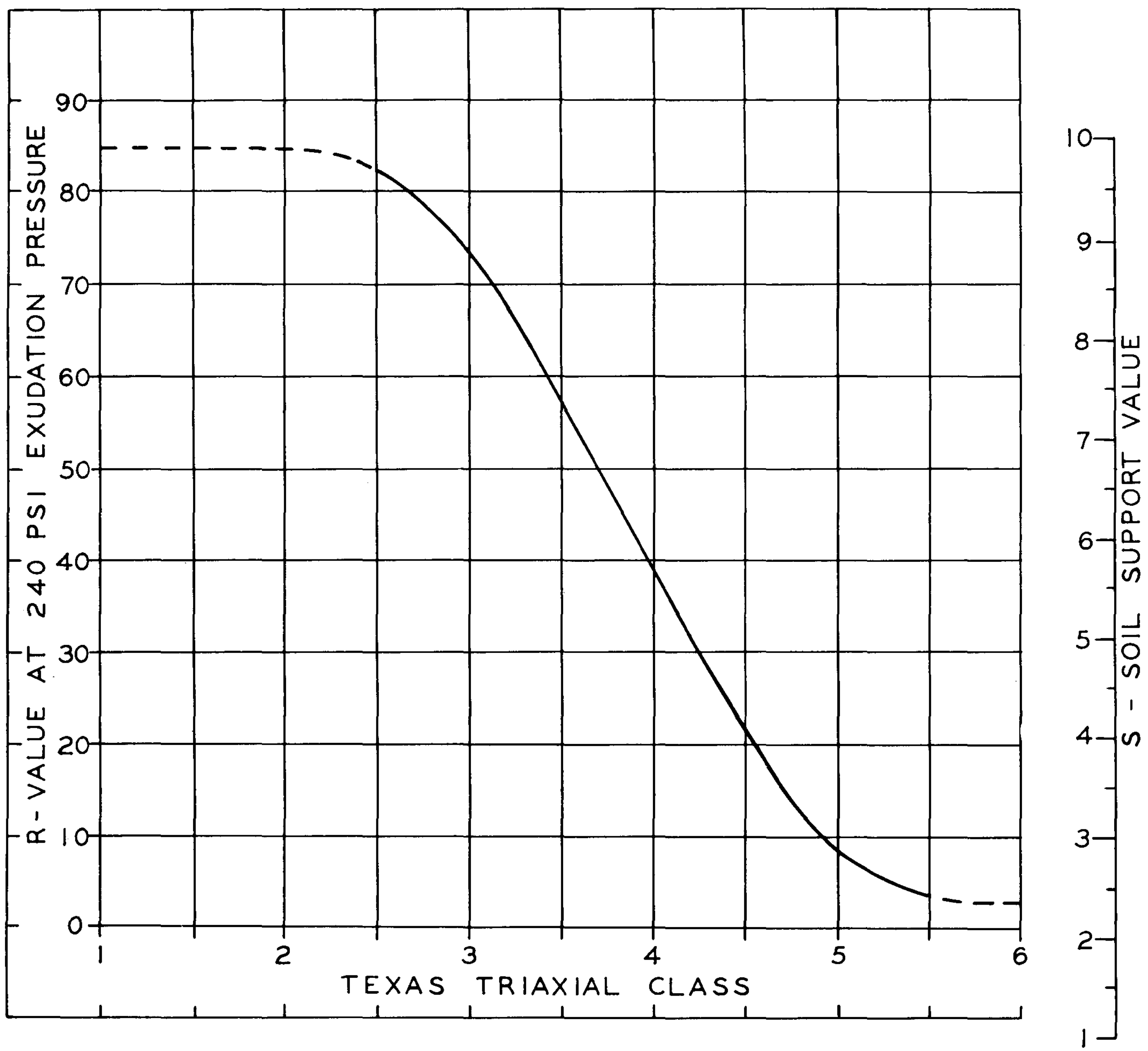

Fig. 11 - Chart for Estimating R-Value at 240 psi Exudation Pressure and Soil Support Value from Texas Triaxial Strength Class.

the better correlation due to the fact that it has the highest index of correlation, the lowest standard error and the lowest standard deviation. Nevertheless, the idea of the R-Value test is to prepare test specimens whose particle arrangement and whose moisture content and density are representative of the same soil under the worst conditions that it may reach after it is in-place in the road. While the R-Value test does not provide for the direct evaluation of the resilience factor in soils, it seems reasonable that an exudation pressure of 240 psi will increase the moisture in the test specimens and cause the greatest lowering of R-Value in critical materials[2]. This, then, seems to provide the necessary justification for the use of an exudation pressure of 240 psi.

The correlations between R-Value and Group Index, though apparently fairly good, must be viewed with a "tongue-in-cheek" attitude because of the absence of any definable trend in the scatter arrangement of the variables.

Bibliography

1. Spiegel, M. R., "Theory & Problems of Statistics," Schaum Publishing Company, New York, 1961.

2. Hveem, F. N., "A Report on an Investigation Concerning the Effect of Lowering the Exudation Pressure Interpolation Point in the R-Value Test" Test Method No. California 301-B, 1959.

TABLE I

SUMMARY OF TEST RESULTS

Sample Number	District	Textural Classification		Texas Triaxial Class	R-Value by Exudation Pressure 240 psi	300 psi	400 psi	Group Index
Z-1	08	Sandy Clay Loam	(A-6)	4.5	33	34	35	2.8
Z-4	-	Silty Clay	(A-6)	4.6	10	10	10	10.5
Z-5	08	Silty Clay Loam	(A-4)	4.0	26	26	28	8.0
Z-6	58	Med. Silty Clay	(A-7-6)	5.0	19	19	20	19.0
Z-7	58	Silty Clay	(A-6)	5.0	20	21	22	9.2
Z-8	58	Heavy Clay	(A-7-6)	5.2	7	11	20	20.0
Z-9	58	Sandy Loam	(A-4)	4.2	33	43	60	2.6
Z-10	58	Sandy Clay Loam	(A-4)	4.2	30	35	41	8.0
Z-11	58	Silty Clay Loam	(A-4)	4.2	20	23	25	8.0
Z-12	58	Sand	(A-2-4)	3.2	70	71	72	0.0
Z-13	58	Sandy Clay Loam	(A-4)	4.3	30	30	32	0.9
Z-14	61	Silty Clay	(A-7-6)	5.1	8	8	9	15.5
Z-15	61	Silty Loam	(A-4)	3.9	24	28	34	8.0
Z-16	61	Light Silty Clay	(A-7-6)	4.8	26	30	33	15.3
Z-17	61	Silty Loam	(A-4)	4.0	62	65	68	8.0
Z-18	61	Silty Clay Loam	(A-4)	3.7	38	44	49	7.3
Z-19	61	Silty Clay Loam	(A-6)	4.7	7	8	10	9.6
Z-20	61	Clay Loam	(A-6)	4.9	6	7	10	8.8
Z-21	61	Clay Loam	(A-6)	4.6	6	7	9	8.4
Z-22	61	Silty Loam	(A-4)	3.9	50	52	56	7.6
Z-23	61	Silty Loam	(A-4	3.5	31	34	39	8.0
Z-24	61	Light Silty Clay	(A-7-6)	5.2	5	5	6	13.7
Z-25	61	Silty Clay	(A-6)	4.5	10	12	15	10.4
Z-26	04	Heavy Clay	(A-7-6)	5.1	6	6	7	20.0
Z-27	04	Med. Silty Clay	(A-7-6)	5.1	13	18	28	14.7
Z-28	04	Silty Clay	(A-7-6	4.8	18	18	21	13.8
Z-29	04	Light Silty Clay	(A-6)	4.9	4	6	9	9.9
Z-30	04	Med. Silty Clay	(A-6)	5.1	4	6	10	12.0
Z-31	04	Heavy Clay	(A-7-5)	5.2	4	9	15	20.0
Z-32	07	Silty Clay	(A-7-6)	4.8	7	10	13	12.8
Z-33	07	Light Silty Clay	(A-6)	5.8	2	5	9	12.5
Z-34	07	Silty Clay	(A-6)	4.5	12	15	19	10.4
Z-35	03	Silt	(A-4)	3.5	52	55	60	8.0
Z-36	03	Loam	(A-4)	4.2	40	46	53	5.1
Z-37	03	Silty Loam	(A-4)	3.6	42	47	52	8.0
Z-38	03	Sand	(A-3)	3.2	66	66	65	0.0
Z-39	03	Silty Clay Loam	(A-6)	4.2	17	17	17	8.8
Z-40	03	Silty Clay Loam	(A-4)	4.2	14	17	22	8.0

TABLE I

SUMMARY OF TEST RESULTS (cont.)

Sample Number	District	Textural Classification		Texas Triaxial Class	R-Value by Exudation Pressure 240 psi	300 psi	400 psi	Group Index
Z-41	03	Silty Loam	(A-4)	3.8	67	69	71	5.8
Z-42	03	Silty Clay	(A-7-6)	4.9	6	7	9	11.9
Z-43	03	Silty Clay	(A-4)	4.1	26	34	44	8.0
Z-44	62	Silty Clay	(A-7-6)	-	4	5	8	17.3
Z-45	62	Silt	(A-4)	3.5	61	65	69	8.0
Z-46	62	Silty Loam	(A-4)	4.0	40	44	51	6.8
Z-47	62	Silty Clay	(A-7-6)	4.9	9	10	12	14.7
Z-48	62	Silty Clay	(A-7-6)	5.8	4	4	6	18.1
Z-49	62	Med. Silty Clay	(A-7-6)	5.1	6	7	10	19.6
Z-50	62	Silty Clay	(A-7-6)	5.1	6	7	10	18.4
Z-51	02	Silty Clay Loam	(A-6)	4.6	13	16	30	8.8
Z-52	02	Light Silty Clay	(A-7-6)	5.7	7	8	10	15.8
Z-53	02	Silt	(A-4)	4.0	64	67	69	8.0
Z-54	02	Heavy Clay	(A-7-5)	6.1	6	7	8	20.0
Z-55	-	Sand	(A-2-4)	3.4	70	72	74	0.0
Z-56	62	Clay Loam	(A-4)	3.4	58	66	74	6.7
Z-57	62	Silty Loam	(A-4)	3.1	74	76	79	7.3
Z-58	62	Med. Silty Clay	(A-7-6)	5.9	3	4	6	19.1
Z-59	62	Light Sandy Clay	(A-6)	4.5	20	23	29	9.1
Z-60	62	Silty Clay Loam	(A-4)	3.6	64	67	70	7.4
Z-61	-	Sandy Loam	(A-4)	3.6	74	75	76	1.3
Z-62	-	Light Sandy Clay	(A-4)	4.0	26	35	48	3.0
Z-63	-	Silty Loam	(A-4)	3.6	63	68	71	7.0
Z-64	-	Sandy Loam	(A-2-4)	3.2	69	72	75	0.0
Z-65	04	Sandy Loam	(A-2-4)	3.5	73	73	74	0.0
Z-66	04	Sandy Loam	(A-2-4)	3.2	73	72	71	0.0
Z-67	04	Light Sandy Clay	(A-6)	4.0	32	34	39	4.9
Z-68	04	Sand	(A-2-4)	4.1	73	71	69	0.0
Z-69	04	Silty Loam	(A-4)	3.6	66	73	76	8.0
Z-70	04	Sandy Loam	(A-2-4)	3.5	63	68	74	0.0
Z-71	61	Sand Clay Gravel	(A-2-6)	3.7	-	-	-	0.0
Z-72	61	Light Silty Clay	(A-6)	4.5	13	15	22	5.0
Z-73	04	Sandy Loam	(A-4)	4.2	9	11	19	1.3
Z-74	04	Sandy Clay Loam	(A-2-6)	4.3	18	20	28	1.2
Z-75	04	Sandy Clay Loam	(A-4)	3.8	50	60	68	0.0
Z-76	04	Sandy Clay Loam	(A-2-4)	4.0	45	49	55	0.0
Z-77	08	Light Sandy Clay	(A-6)	4.2	26	31	41	8.4
Z-78	08	Sandy Clay Loam	(A-6)	4.3	20	22	27	2.0
Z-79	08	Light Sandy Clay	(A-4)	4.6	24	26	28	4.7
Z-80	08	Clay Loam	(A-4)	4.1	27	30	39	7.0

TABLE I

SUMMARY OF TEST RESULTS (cont.)

Sample Number	District	Textural Classification	Texas Triaxial Class	R-Value by Exudation Pressure 240 psi	300 psi	400 psi	Group Index
Z-81	08	Light Sandy Clay (A-6)	4.3	34	39	46	7.8
Z-82	03	Rotted Reef Shell	1+ (1.9)	83	84	85	0.0
Z-83	03	65% Rotted Reef Shell 35% Loam	1+ (1.9)	76	77	79	0.0
Z-84	03	65% Rotted Reef Shell 35% Clean Sand	1+ (1.8)	86	84	82	0.0
Z-85	07, 03	65% Graded Reef Shell 35% Loam	1+ (1.9)	74	78	82	0.0
Z-86	07, 03	75% Graded Reef Shell 25% Loam	1+ (1.8)	81	83	85	0.0
Z-87	61, 03	75% Clam Shell 25% Clean Sand	1+ (1.9)	84	84	83	0.0
Z-88	61, 03	65% Clam Shell 35% Clean Sand	2.0	82	82	82	0.0
Z-89	61	100% Clam Shell	1+ (1.4)	77	78	79	0.0
		Natural Mix-					
Z-90	02	65% Clam Shell 35% Reef Shell	1+ (1.6)	82	82	83	0.0
Z-91	02	35% Clam Shell 65% Reef Shell	1+ (1.9)	86	85	85	0.0
Z-92	02	50% Clam Shell 50% Reef Shell	1+ (1.7)	80	82	83	0.0
Z-93	02	65% Clam Shell 35% Reef Shell	1+ (1.7)	87	85	83	0.0
Z-94	61	60% Clam Shell 40% Sandy Loam	1+ (1.9)	76	79	83	0.0
Z-95	02, 61	50% Reef Shell 50% Sandy Loam	1+ (1.9)	84	83	82	0.0
Z-96	02, 61	30% Clam Shell 20% Reef Shell 50% Sandy Loam	1+ (1.9)	80	82	84	0.0
Z-97	61	50% Clam Shell 50% Sandy Loam	2.5	77	79	82	0.0
Z-98	02, 61	40% Reef Shell 60% Sandy Loam	2.2	80	80	81	0.0
Z-99	02, 61	30% Clam Shell 10% Reef Shell 60% Sandy Loam	2.5	77	79	81	0.0

Notes:

1. Group Indices are determined according to AASHO M 145-49.
2. Textural Classifications are based on U. S. Bureau of Chemistry and Soil Classification Standards.

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-1	08	27	15	12	47	2.8	119.5 @ 12.7	2.69	A-6 Sandy Clay Loam
Z-4	-	34	18	16	100	10.5	105.0 @ 19.0	2.65	A-6 Silty Clay
Z-5	08	34	26	8	97	8.0	98.0 @ 19.3	2.59	A-4 Silty Clay Loam
Z-6	58	55	23	32	92	19.0	97.5 @ 23.5	2.67	A-7-6 Med. Silty Clay
Z-7	58	31	18	13	86	9.2	105.2 @ 16.0	2.70	A-6 Silty Clay
Z-8	58	80	29	51	100	20.0	90.5 @ 29.5	2.67	A-7-6 Heavy Clay
Z-9	58	N.P.	N.P.	N.P.	48	2.6	121.8 @ 10.5	2.65	A-4 Sandy Loam
Z-10	58	26	20	6	92	8.0	106.0 @ 16.0	2.63	A-4 Sandy Clay Loam
Z-11	58	24	18	6	84	8.0	111.0 @ 15.0	2.64	A-4 Silty Clay Loam
Z-12	58	N.P.	N.P.	N.P.	19	0.0	114.6 @ 11.6	2.65	A-2-4 Sand
Z-13	58	26	20	6	40	0.9	114.6 @ 14.6	-	A-4 Sandy Clay Loam
Z-14	61	46	18	28	95	15.5	101.8 @ 20.0	2.63	A-7-6 Silty Clay
Z-15	61	23	17	6	82	8.0	106.8 @ 14.7	2.59	A-4 Silty Loam
Z-16	61	48	20	28	88	15.3	102.7 @ 19.5	2.69	A-7-6 Light Silty Clay
Z-17	61	N.P.	N.P.	N.P.	74	8.0	101.0 @ 17.3	2.59	A-4 Silty Loam

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES (cont.)

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-18	61	20	17	3	72	7.3	114.0 @ 13.2	2.61	A-4 Silty Clay Loam
Z-19	61	28	14	14	78	9.6	112.7 @ 15.5	--	A-6 Silty Clay Loam
Z-20	61	31	20	11	66	8.8	108.7 @ 16.6	2.64	A-6 Clay Loam
Z-21	61	26	13	13	73	8.4	113.2 @ 14.3	2.57	A-6 Clay Loam
Z-22	61	25	15	10	92	7.6	98.4 @ 19.4	2.57	A-4 Silty Loam
Z-23	61	N.P.	N.P.	N.P.	82	8.0	106.7 @ 16.5	2.61	A-4 Silty Loam
Z-24	61	47	19	28	91	13.7	102.4 @ 21.4	2.69	A-7-6 Light Silty Clay
Z-25	61	39	22	17	96	10.4	102.6 @ 17.6	2.69	A-6 Silty Clay
Z-26	04	61	23	38	100	20.0	90.7 @ 28.0	2.66	A-7-6 Heavy Clay
Z-27	04	50	28	22	98	14.7	89.6 @ 25.8	2.57	A-7-6 Med. Silty Clay
Z-28	04	45	23	22	97	13.8	100.5 @ 22.7	2.65	A-7-6 Silty Clay
Z-29	04	32	16	16	73	9.9	108.7 @ 14.5	2.58	A-6 Light Silty Clay
Z-30	04	37	17	20	95	12.0	103.5 @ 19.7	2.61	A-6 Med. Silty Clay
Z-31	04	69	34	35	100	20.0	88.4 @ 30.0	2.63	A-7-5 Heavy Clay
Z-32	07	42	21	21	100	12.8	100.2 @ 19.7	2.61	A-7-6 Silty Clay

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES (cont.)

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-33	07	40	19	21	86	12.5	106.6 @ 17.2	2.68	A-6 Light Silty Clay
Z-34	07	35	20	15	96	10.4	101.5 @ 18.3	2.60	A-6 Silty Clay
Z-35	03	N.P.	N.P.	N.P.	94	8.0	101.4 @ 15.6	2.53	A-4 Silt
Z-36	03	17	13	4	61	5.1	118.4 @ 11.6	2.60	A-4 Loam
Z-37	03	N.P.	N.P.	N.P.	83	8.0	105.6 @ 16.5	2.63	A-4 Silty Loam
Z-38	03	N.P.	N.P.	N.P.	8	0.0	105.0 @ 12.9	2.58	A-3 Sand
Z-39	03	30	18	12	96	8.8	110.3 @ 15.7	2.59	A-6 Silty Clay Loam
Z-40	03	29	21	8	93	8.0	100.3 @ 15.3	2.57	A-4 Silty Clay Loam
Z-41	03	N.P.	N.P.	N.P.	64	5.8	102.7 @ 16.4	2.59	A-4 Silty Loam
Z-42	03	42	23	19	97	11.9	99.6 @ 19.0	2.52	A-7-6 Silty Clay
Z-43	03	34	24	10	100	8.0	100.0 @ 18.3	2.69	A-4 Silty Clay
Z-44	62	48	12	36	100	17.3	103.4 @ 19.1	2.59	A-7-6 Silty Clay
Z-45	62	23	20	3	95	8.0	105.5 @ 13.4	2.63	A-4 Silt
Z-46	62	19	17	2	68	6.8	116.9 @ 11.4	2.59	A-4 Silty Loam
Z-47	62	41	14	27	94	14.7	104.8 @ 17.9	2.68	A-7-6 Silty Clay

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES (cont.)

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-48	62	51	18	33	99	18.1	108.0 @ 15.4	2.61	A-7-6 Silty Clay
Z-49	62	59	21	38	100	19.6	99.5 @ 22.2	2.61	A-7-6 Med. Silty Clay
Z-50	62	54	22	32	100	18.4	101.2 @ 20.2	2.57	A-7-6 Silty Clay
Z-51	02	36	24	12	100	8.8	100.4 @ 19.0	2.66	A-6 Silty Clay Loam
Z-52	02	48	23	25	94	15.8	100.0 @ 19.2	2.61	A-7-6 Light Silty Clay
Z-53	02	N.P.	N.P.	N.P.	96	8.0	102.4 @ 18.2	2.68	A-4 Silt
Z-54	02	78	30	48	100	20.0	89.1 @ 26.8	2.61	A-7-5 Heavy Clay
Z-55	-	N.P.	N.P.	N.P.	16	0.0	123.8 @ 10.6	2.67	A-2-4 Sand
Z-56	62	22	15	7	67	6.7	118.1 @ 12.5	2.66	A-4 Clay Loam
Z-57	62	20	17	3	72	7.3	112.2 @ 11.8	2.63	A-4 Silty Loam
Z-58	62	55	22	33	100	19.1	94.4 @ 23.9	2.67	A-7-6 Med. Silty Clay
Z-59	62	38	20	18	61	9.1	101.8 @ 21.3	-	A-6 Light Sandy Clay
Z-60	62	30	24	6	73	7.4	108.1 @ 15.6	2.65	A-4 Silty Clay Loam
Z-61	-	N.P.	N.P.	N.P.	42	1.3	115.9 @ 10.9	2.66	A-4 Sandy Loam
Z-62	-	29	19	10	50	3.0	113.9 @ 14.8	2.79	A-4 Light Sandy Clay

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES (cont.)

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-63	-	N.P.	N.P.	N.P.	70	7.0	114.8 @ 11.8	2.72	A-4 Silty Loam
Z-64	-	N.P.	N.P.	N.P.	32	0.0	124.1 @ 13.4	3.05	A-2-4 Sandy Loam
Z-65	04	N.P.	N.P.	N.P.	27	0.0	116.0 @ 13.0	2.68	A-2-4 Sandy Loam
Z-66	04	N.P.	N.P.	N.P.	35	0.0	121.4 @ 10.8	2.67	A-2-4 Sandy Loam
Z-67	04	33	18	15	59	4.9	126.4 @ 11.8	2.97	A-6 Light Sandy Clay
Z-68	04	N.P.	N.P.	N.P.	14	0.0	111.7 @ 13.2	2.52	A-2-4 Sand
Z-69	04	N.P.	N.P.	N.P.	82	8.0	107.0 @ 14.1	2.49	A-4 Silty Loam
Z-70	04	N.P.	N.P.	N.P.	25	0.0	130.5 @ 9.1	2.54	A-2-4 Sandy Loam
Z-71	61	23	12	11	27	0.0	130.5 @ 9.1	2.51	A-2-6 Sand Clay Gravel
Z-72	61	28	14	14	61	5.0	111.5 @ 16.0	2.62	A-6 Light Silty Clay
Z-73	04	20	11	9	42	1.3	124.0 @ 10.0	2.49	A-4 Sandy Loam
Z-74	04	29	14	15	35	1.2	112.0 @ 15.2	2.64	A-2-6 Sandy Clay Loam
Z-75	04	21	15	6	47	0.0	120.0 @ 12.0	2.50	A-4 Sandy Clay Loam
Z-76	04	19	12	7	24	0.0	120.0 @ 11.6	2.65	A-2-4 Sandy Clay Loam
Z-77	08	36	19	17	65	8.4	110.8 @ 17.2	2.92	A-6 Light Sandy Clay

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES (cont.)

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-78	08	28	14	14	40	2.0	113.2 @ 15.1	2.55	A-6 Sandy Clay Loam
Z-79	08	26	16	10	57	4.7	115.3 @ 14.7	2.67	A-4 Light Sandy Clay
Z-80	08	25	17	8	71	7.0	114.6 @ 14.0	2.64	A-4 Clay Loam
Z-81	08	37	22	15	64	7.8	110.3 @ 18.2	-	A-6 Light Sandy Clay
Z-82	03	N.P.	N.P.	N.P.	3	0.0	94.4 @ 13.0	-	Rotted Reef Shel
Z-83	03	N.P.	N.P.	N.P.	11	0.0	121.2 @ 12.2	-	65% Rotted Reef Shel 35% Loam
Z-84	03	N.P.	N.P.	N.P.	3	0.0	125.0 @ 7.5	-	65% Rotted Reef Shel 35% Clean Sand
Z-85	07, 03	N.P.	N.P.	N.P.	20	0.0	123.0 @ 9.8	-	65% Graded Reef Shel 35% Loam
Z-86	07, 03	N.P.	N.P.	N.P.	12	0.0	128.8 @ 9.8	-	75% Graded Reef Shel 25% Loam
Z-87	61, 03	N.P.	N.P.	N.P.	4	0.0	129.5 @ 8.5	-	75% Clam Shell 25% Clean Sand
Z-88	61, 03	N.P.	N.P.	N.P.	4	0.0	130.5 @ 7.5	-	65% Clam Shell 35% Clean Sand
Z-89	61	N.P.	N.P.	N.P.	2	0.0	130.0 @ 7.2	-	100% Clam Shell
Z-90	02	N.P.	N.P.	N.P.	7	0.0	128.0 @ 9.6	-	65% Clam Shell 35% Reef Shell
Z-91	02	N.P.	N.P.	N.P.	3	0.0	108.7 @ 8.0	-	35% Clam Shell 65% Reef Shell
Z-92	02	N.P.	N.P.	N.P.	3	0.0	118.0 @ 8.5	-	50% Clam Shell 50% Reef Shell

TABLE II

PHYSICAL PROPERTIES OF TEST SAMPLES (cont.)

Sample Number	District	Liquid Limit	Plastic Limit	Plasticity Index	% Passing # 200	Group Index	Max. Density & Opt. Moisture	Specific Gravity	Textural Classification
Z-93	02	N.P.	N.P.	N.P.	4	0.0	115.7 @ 9.0	-	65% Clam Shell 35% Reef Shell
Z-94	61	N.P.	N.P.	N.P.	27	0.0	130.0 @ 9.2	-	60% Clam Shell 40% Sandy Loam
Z-95	02, 61	N.P.	N.P.	N.P.	27	0.0	123.5 @ 10.0	-	50% Reef Shell 50% Sandy Loam
Z-96	02, 61	N.P.	N.P.	N.P.	29	0.0	123.4 @ 10.0	-	30% Clam Shell 20% Reef Shell 50% Sandy Loam
Z-97	61	N.P.	N.P.	N.P.	29	0.0	130.0 @ 9.5	-	50% Clam Shell 50% Sandy Loam
Z-98	02, 61	N.P.	N.P.	N.P.	21	0.0	122.0 @ 10.3	-	40% Reef Shell 60% Sandy Loam
Z-99	02, 61	N.P.	N.P.	N.P.	19	0.0	123.4 @ 10.0	-	30% Clam Shell 10% Reef Shell 60% Sandy Loam

TABLE III

GRADATIONS OF TEST SAMPLES
Z-1 through Z-81

Sample Number	% Passing		Sample Number	% Passing	
	No. 40	No. 200		No. 40	No. 200
Z-1	91	47	Z-42	100	97
Z-4	100	100	Z-43	100	100
Z-5	100	97	Z-44	100	100
Z-6	100	92	Z-45	100	95
Z-7	100	86	Z-46	94	68
Z-8	100	100	Z-47	100	94
Z-9	96	48	Z-48	100	99
Z-10	95	92	Z-49	100	100
Z-11	100	84	Z-50	100	100
Z-12	100	19	Z-51	100	100
Z-13	95	40	Z-52	100	94
Z-14	100	95	Z-53	100	96
Z-15	100	82	Z-54	100	100
Z-16	100	88	Z-55	79	16
Z-17	100	74	Z-56	96	67
Z-18	100	72	Z-57	98	72
Z-19	100	78	Z-58	100	100
Z-20	100	66	Z-59	95	61
Z-21	100	73	Z-60	100	73
Z-22	100	92	Z-61	96	42
Z-23	100	82	Z-62	96	50
Z-24	96	91	Z-63	100	70
Z-25	100	96	Z-64	68	32
Z-26	100	100	Z-65	98	27
Z-27	100	98	Z-66	80	35
Z-28	100	97	Z-67	89	59
Z-29	100	73	Z-68	100	14
Z-30	100	95	Z-69	100	82
Z-31	100	100	Z-70	74	25
Z-32	100	100	Z-71	60	27
Z-33	100	86	Z-72	98	69
Z-34	100	96	Z-73	79	42
Z-35	100	94	Z-74	100	35
Z-36	98	61	Z-75	100	47
Z-37	100	83	Z-76	79	24
Z-38	99	8	Z-77	86	65
Z-39	100	96	Z-78	95	40
Z-40	100	93	Z-79	80	57
Z-41	100	64	Z-80	90	71
			Z-81	87	64

TABLE IV

GRADATIONS OF TEST SAMPLES
Z-82 through Z-99

Sample Number	Per Cent Passing								
	1"	3/4"	3/8"	No. 4	No. 10	No. 40	No. 80	No. 100	No. 200
Z-82	100	99.6	81.4	55.1	33.0	9.8	4.9	4.5	2.6
Z-83	100	100	72.5	37.0	20.1	13.6	12.2	11.9	11.1
Z-84	100	100	84.9	67.6	53.0	31.9	5.2	4.3	2.9
Z-85	100	99.4	84.4	71.3	55.6	42.7	31.6	28.0	19.7
Z-86	100	100	73.0	56.9	42.3	29.6	19.9	17.2	12.0
Z-87	100	100	78.1	54.4	41.5	28.1	6.4	5.4	3.8
Z-88	100	100	87.5	74.7	65.5	40.0	8.1	6.6	4.3
Z-89	100	100	53.0	14.3	5.0	3.0	2.6	2.4	2.1
Z-90	100	100	83.1	57.4	39.8	21.9	12.0	10.6	6.6
Z-91	100	100	88.9	72.6	39.9	20.3	7.0	6.7	5.7
Z-92	100	100	72.7	40.6	26.0	4.4	3.4	3.1	2.5
Z-93	100	100	56.9	32.3	16.6	6.3	4.9	4.8	3.8
Z-94	100	100	86.1	67.8	56.9	52.9	51.8	49.9	27.0
Z-95	100	100	92.0	83.8	72.9	62.3	60.8	59.2	27.3
Z-96	100	100	89.6	77.9	69.6	62.2	61.2	59.3	28.7
Z-97	100	100	81.7	71.0	65.6	61.8	59.7	57.9	28.7
Z-98	100	100	88.8	82.0	75.0	68.7	63.3	53.6	20.8
Z-99	100	100	91.0	81.8	74.5	69.6	56.4	45.6	19.2