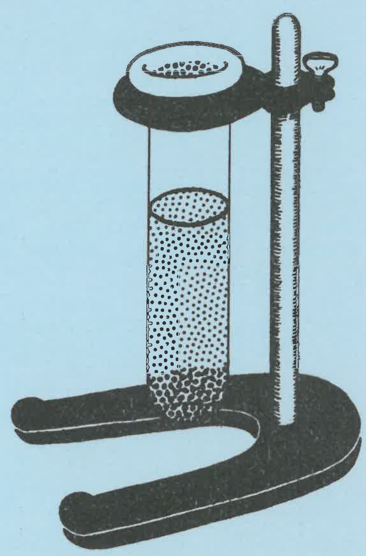
Final Report

EFFECTS OF CHEMICAL AND MINERALOGICAL PROPERTIES ON THE ENGINEERING CHARACTERISTICS OF ARKANSAS SOILS



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ARKANSAS STATE HIGHWAY DEPARTMENT
DIVISION OF PLANNING AND RESEARCH
IN COOPERATION WITH
U. S. DEPARTMENT OF TRANSPORTATION
BUREAU OF PUBLIC ROADS

RESEARCH PROJECT 19

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FINAL REPORT
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TABLE OF CONTENTS

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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

PREFACE

Arkansas Highway Department Research Project No. 19 entitled "Effects of Chemical and Mineralogical Properties on the Engineering Characteristics of Arkansas Soils" was approved by the Bureau of Public Roads and the Arkansas Highway Department to be effective July 1, 1964. Dr. M. E. Horn, Associate Professor in Agronomy, was assigned as the Principal investigator. He resigned his University appointment May 31, 1968 and the responsibilities of Principal Investigator were assumed by Dr. G. A. Place, Associate Professor in Agronomy. Dr. W. R. Coston, Research Assistant in Agronomy, who has been with the project since its beginning, was responsible for all laboratory analyses made at the University of Arkansas Soil Research Laboratory. The project also provided Dr. Coston the opportunity to earn the doctorate degree.

Since the Project was initiated, data for chemical, physical, mineralogical and engineering properties were obtained from 213 soil samples taken from 82 soil series in 15 Arkansas counties. These soils were formed from parent materials such as loess, alluvium, coastal plains deposits, calcareous marl or sedimentary bedrock residium such as chert, sandstone, siltstone, shale and limestone. A technical report was prepared for each county and may be consulted if information for a specific soil series is needed.

ABSTRACT

Soil samples were collected from 82 soil series in 15 Arkansas counties and analyzed for engineering, chemical, and mineralogical properties.

The objectives were (1) determine if soil chemical and physical properties can be related to soil engineering properties, and (2) determine if clay mineralogical composition is related to the chemical and physical properties that are related to soil engineering properties.

All data were subjected to linear regression analysis. First, the data from all 15 counties were combined and results for liquid limit (LL), plasticity index (PI), group index (GI), maximum density (MD), and optimum moisture (OM) were treated as dependent variables. The independent variable was either, cation exchange capacity (CEC), % clay (C), % expandable clay (PE), exchangeable potassium (K) or exchangeable calcium (Ca). Then the data were subdivided according to texture, horizons, plastic or non-plastic, parent material, and families to determine if R^2 values could be improved. The mineralogical and chemical data were also analyzed by the two groupings. The variables, illite (I), amorphous material (A), quartz (Q), vermiculite (V), montmorillonite (M), kaolinite (Ka), exchangeable potassium (K), and CEC were each treated under separate analysis as the independent variable and all others functioned as the dependent variables.

The results revealed:

1. Data for (CEC) or (C) from all 15 counties can be combined and used to predict (LL), (PI), (GI), (MD), and (OM).

2. Mineralogical data can be used to predict (CEC) of these respective soils.
3. There was no advantage in dividing the data into soil subgroupings.

RESEARCH IMPLEMENTATION

The purpose of sampling is to select a sample that represents the average composition of the whole. After a homogeneous sample is collected it is the intent of the analyzer to obtain precise and accurate measurements. Thus, it behooves a researcher to continuously seek new and better procedures that can be used to improve the accuracy of measurements made on the population in question.

There is reason to question the reliability of the present techniques that are being utilized to measure engineering properties of soils. Therefore, if other parameters could be measured with greater precision and related to engineering properties the level of competence would be increased. Results from this study indicate this is possible. The parameters, cation exchange capacity (CEC) expressed as me/100 g of soil and % clay (C) of the soil, can be measured with greater accuracy by different individuals than can the engineering properties such as Atterberg Limits. These new parameters can be related to the engineering properties by the following equations:

	R^2
1. Clay functioning as independent variable	
LL = 1.128 (C) + 1.708	0.817**
PI = 0.614 (C) - 3.240	0.803**
GI = 0.136 (C) + 0.510	0.648**
MD = -0.348 (C) + 114.281	0.475**
OM = 0.245 (C) + 12.330	0.681**
2. CEC functioning as independent variable	
LL = 1.661 (CEC) + 5.174	0.663**
PI = 0.948 (CEC) - 2.078	0.714**

GI = 0.616 (CEC) + 0.330	0.691**
MD = - 0.625 (CEC) + 115.060	0.570**
OM = 0.400 (CEC) + 12.432	0.677**

The above equations show that five engineering parameters can be evaluated from a single measurement, (C) or (CEC), that can be obtained quickly, precisely, accurately, and economically. Cost factors will not be presented because that is beyond the scope of this study.

It is not suggested that the above equations be implemented because they are based on only 205 observations. Hence, a large number of samples from many soil types should be collected in order to refine the equations. The greatest contribution attained from this study is establishment of the fact that other parameters can be used to predict engineering properties of soils.

LIST OF TABLES

INTRODUCTION

Engineering properties of soils vary because the nature and property of the soil clays vary. These clays, even in relatively small amounts, influence engineering use because of their influence on water retention and movement and, consequently, on the stability of soils when they are used as foundation materials. Since virtually all highways are built on soils or geologic materials from which they are derived, it is important to gain knowledge about basic soil properties that influence engineering uses. Early investigations dealt mainly with measurements of physical properties and did not investigate the fundamental causes of the particular properties involved. However, in recent years more attention has been given to investigation of relationships between soil chemical and mineralogical properties and soil physical properties. Investigations of the mineralogical composition of soil clays, their distribution in various particle size groups and with depth in the soil profile, and their chemical environment provide information useful in predicting the performance of a soil under various engineering uses. Studies of this nature are important because they provide a basic knowledge of soil properties that can be very useful in detecting soils of unusual nature that may not be recognized by testing physical characteristics alone.

Gill and Reaves (2) studied the relationships of several soils and attempted to associate these properties with the mechanical strength of soils. They found, with the exception of compressibility, cation exchange capacity (CEC) was the chemical property that correlated best with the physical properties of the soils studied. Farrar and Coleman (1) also conducted similar studies and obtained correlation coefficients of 0.90 or greater for CEC vs Liquid Limit, CEC vs Total Surface Area, and Liquid Limit vs Total Surface Area. LeFerre also (3) determined that soil plasticity (PI) is largely a function of soil surface area. These three studies are compatible since they show that CEC and PI are related to soil surface area. Farrar and Coleman (1) noted that values for CEC and Clay content could possibly be used to predict Atterberg limits.

The objectives of this investigation were to determine by regression analysis: (1) if soil chemical and physical properties can be used to predict soil engineering properties, (2) if grouping soils data according to texture, horizons, plastic, non-plastic, parent materials, and families will improve the predictors for engineering properties, and (3) if mineralogy of the clay fraction is related to the chemical and physical properties that are used to predict the soil engineering properties.

PROCEDURES

Duplicate soil samples were collected by the USDA Soil Conservation Service from 82 soil series in 15 Arkansas counties (Figure 1). Appendix Tables 1 and 2 give the county, number of samples and series collected from each county, and the series names for the soils that were sampled. Appendix Table 3 gives the series and horizons that were analyzed for engineering and mineralogical properties. One set of samples was used by the Arkansas Highway Department in making engineering tests that include Atterberg Limits (liquid limits, plastic limits, and plasticity index), Group Indexes, Maximum Density, and Optimum Moisture. The second set was used by project personnel to determine clay mineralogy composition of these soils that included montmorillonite, kaolinite, illite, vermiculite, quartz, amorphous material, and percent expandable material (montmorillonite plus vermiculite). In addition, complete sets of samples from all horizons present in each of the 82 soil series were used by project personnel in making particle size distribution and chemical analyses. Two sets of particle size measurements were made. One was for fine silt (5.0-2.0μ), coarse clay (2.0-0.2μ), medium clay (0.2-0.08μ), fine clay, (<0.08μ) and total clay. The second one was for very coarse sand, coarse sand, medium sand, fine sand, very fine sand, total sands, silt, and clay. The chemical analysis included pH, % O.M., P, K, Ca, Mg, Na, H, % Base Saturation, Cation Exchange Capacity (CEC) and Free Iron Oxides. The CEC was assumed to be the sum of the cations measured above. Details of these methods are given in Appendix B of the Technical Reports.

The engineering, chemical, and mineralogical data were statistically analyzed with multiple linear regression to determine if engineering properties could be obtained from chemical and physical properties of the soil and mineralogical data

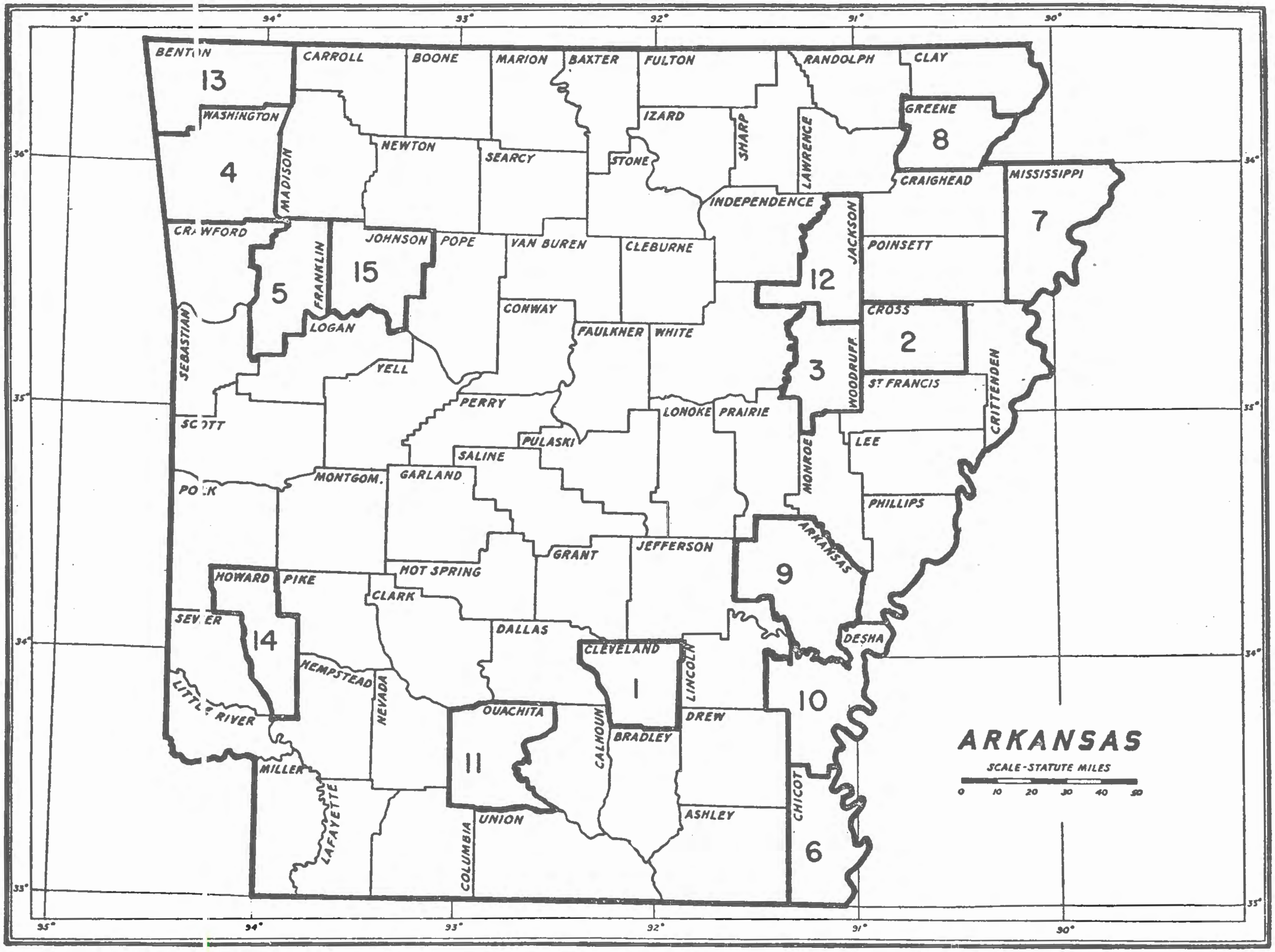

FIGURE I - Counties Sampled For Project 19.

could be used to predict the chemical or physical properties that predict engineering properties.

RESULTS AND DISCUSSION

Variation in engineering properties that can be ascribed to soil chemical and physical properties was measured by obtaining their coefficients of determination (R^2)†. The results are given in Table 1 and include all the observations (n = 205) obtained from the 15 counties. The engineering properties were best related to cation exchange capacity (CEC) of the clay fraction and clay content (C) of the soil. In comparing these two variables, higher R^2 values were obtained for clay content vs liquid limit (LL), plasticity index (PI), and optimum moisture (OM), and lower values for maximum density (MD), and group index (GI). The highest R^2 value (0.817) was obtained for (C) vs (LL). Thus, 82% of the variation in (LL) can be accounted for by the variation in clay content of the soils. With this information, regression equations (Table 2) can be constructed and used to predict (LL) values by measuring the clay content of these soils. The same type of expression can be used to predict (PI) values with a great deal of confidence since (C) vs (PI) has an R^2 value of 0.803. Even though clay content does not account for as much variation as, perhaps, is desired the expressions should be useful in determining engineering properties of soils because the determination of clay is simple, accurate, and highly reproducible as compared to the values that are obtained for engineering properties. The same argument can be used with (CEC) data to predict engineering properties (Table 2). Even though the R^2 values were good, it was sssumed they could be improved, if the data were subdivided into

† R^2 is equal to the proportion of the total variability of the dependent variable that may be ascribed to the effect of the independent or causative variable. For example, in Table 1 CEC vs LL has an R^2 of 0.663. This means the variation in CEC accounts for 66.3% of the variation in LL.

Table 1. Coefficients of determination (R^2) for the independent variables, soil chemical and physical properties, and the dependent variables, engineering properties.

Soil* Properties	Engineering Properties				
	LL †	PI	GI	MD	OM
CEC	0.663	0.714	0.691	0.570	0.677
C	0.817	0.803	0.648	0.475	0.681
PE	0.448	0.514	0.452	0.361	0.442
S	0.373	0.316	0.416	0.271	0.294
M2M	0.266	0.233	0.425	0.240	0.244
K	0.413	0.444	0.413	0.362	0.371
Ca	0.218	0.287	0.333	0.227	0.231

* n = 205

† LL - liquid limits, PI - Plasticity index, GI - Group index, MD - Maximum density, OM - Optimum moisture, CEC - Cation exchange capacity, C - % clay, PE - % expandable clay (montmorillonite + vermiculite), S - % sand, M2M - material passing 200 mesh sieve, and K and Ca exchangeable with 1.0 N neutral ammonium acetate.

Table 2. Linear regression equations for predicting engineering properties of soils in 15 counties.†

A. Clay - Independent Variable	R^2
LL§ = 1.128 (C) + 1.708	0.817**¶
PI = 0.614 (C) - 3.240	0.803**
GI = 0.136 (C) + 0.510	0.648**
MD = - 0.348 (C) + 114.281	0.475**
OM = 0.245 (C) + 12.330	0.681**
B. CEC - Independent Variable	
LL = 1.661 (CEC) + 5.174	0.663**
PI = 0.948 (CEC) - 2.078	0.714**
GI = 0.616 (CEC) + 0.330	0.691**
MD = - 0.625 (CEC) + 115.060	0.570**
OM = 0.400 (CEC) + 12.432	0.677**

† Equations are based on 205 observations.

§ See Footnote (†) in Table 1 for definition of symbols.

¶ (*) and (**) denote R^2 values are significant at 0.05 P and 0.01 P, respectively.

the soil groupings shown in Table 3. The results in Table 4 show that only a few R^2 values for (LL) and (PI) were increased; six for (LL) and four for (PI). In all cases except one, (CEC) for alluvium parent material, the increase in R^2 values occurred where the amount of clay (C) in the soil was involved. The highest value (0.918) was obtained for clay content in Coastal Plains parent material vs (LL). However, in most cases the increase was only slightly greater than the value of 0.817 that was obtained when the data from all 15 counties were combined and analyzed. Thus, another approach was undertaken to determine if higher R^2 values could be attained. Data from the 15 counties were again combined and analyzed by multiple linear regression analysis. Separate analyses were used where each independent variable was eventaully treated as the dependent variable while the remaining variables were treated as independent variables. The results in Table 5 show that high R^2 values were obtained. However, in every equation that had high R^2 values it was necessary to include a large number of independent variables. Thus, these equations are not practical because measurements on a large number of variables would be required. Also, the R^2 values are not much better than those given in Table 2. Therefore, the data were again subdivided into the groupings shown in Table 3 and subjected to multiple linear regression analysis. The objective was to obtain equations that have only one or two independent variables and R^2 values not less than 0.750. Most of the equations did not conform to this criteria and have been put in Appendix Table 4 for a matter of record. The expressions that conform to the criteria have been included in Table 6. The expressions in Table 6 for the dependent variable (LL) are of little practical value because the only independent variable that occurs in the equations is PI. Since (LL) values are used to calculate PI values, there was no advantage in subdividing the soil samples to obtain better expressions for predicting (LL).

Table 3. Soil groupings for regression analyses.

Sources	Number of Observations Mineralogical	Engineering
1. Textures		
a. C †	29	29
b. SiL, Si	75	76
c. L, CL	27	27
d. SL, LS, S, SC, SCL	36	37
e. SiC, Si, CL	37	36
2. Horizons		
a. A	39	39
b. B	99	100
c. C & R	66	66
3. Plastic Soils	163	163
4. Non-Plastic Soils	41	42
5. Parent Materials		
a. Alluvium Soils 1) Counties: Chicot, Desha, Woodruff, Jackson Mississippi	66	65
b. Alluvium - Loess Soils 1) Counties: Chicot, Desha, Arkansas, Cross, Woodruff, Jackson, Mississippi, Greene	99	98
c. Coastal Plains 1) Counties: Ouachita, Cleveland	28	27
d. Sandstone and Siltstone Soils 1) Counties: Washington, Johnson, Franklin	52	54
6. Soil Families		
a. Very fine clayey (>61% Clay)	12	12
b. Fine clayey (36-60% Clay)	43	43
c. Fine silty, fine loamy (18-35% Clay)	78	80
d. Sandy, Coarse loamy and coarse silty, (<18% Clay)	71	70

† C - Clay, SiL - silt loam, Si - silt, L - loam, CL - clay loam, SL - sandy loam, LS - loamy sand, S - sand, SC - sandy clay, SCL - sandy clay loam, SiC - silty clay, SiCl - silty clay loam.

Table 4. Coefficients of determination (R^2) for clay and cation exchange capacity vs engineering properties for the soil groupings.

Soil Groups	Soil Variables	Engineering Properties LL	PI	GI	MD	OM
1. Textures						
a. C	C	0.801	0.750	0.432	0.413	0.347
	CEC	0.371	0.396	0.434	0.233	0.153
b. SiL, Si	C	0.530	0.598	0.147	0.006	0.190
	CEC	0.433	0.575	0.268	0.147	0.394
c. L, CL	C	0.582	0.402	0.179	0.051	0.216
	CEC	0.514	0.434	0.482	0.533	0.591
d. SL, LS, S, SC, SCL	C	0.828	0.767	0.140	0.020	0.089
	CEC	0.371	0.377	0.154	0.004	0.326
e. SiC, SiCL	C	0.533	0.472	0.386	0.287	0.318
	CEC	0.624	0.587	0.599	0.408	0.454
2. Horizons						
a. A	C	0.605	0.696	0.454	0.360	0.430
	CEC	0.557	0.663	0.430	0.468	0.527
b. B	C	0.748	0.674	0.591	0.612	0.681
	CEC	0.696	0.669	0.663	0.672	0.676
c. C & R	C	0.867	0.867	0.712	0.558	0.785
	CEC	0.692	0.736	0.726	0.552	0.692
3. Plastic Soils	C	0.806	0.745	0.602	0.558	0.686
	CEC	0.699	0.676	0.654	0.623	0.658
4. Non-Plastic Soils	C	0.453	0.450	0.064	0.003	0.061
	CEC	0.183	0.183	0.225	0.018	0.163
5. Parent Materials						
a. Alluvium	C	0.834	0.861	0.694	0.571	0.729
	CEC	0.815	0.852	0.733	0.534	0.706
b. Alluvium-Loess	C	0.817	0.837	0.667	0.551	0.721
	CEC	0.774	0.806	0.686	0.567	0.731
c. Coastal Plains	C	0.918	0.762	0.719	0.687	0.839
	CEC	0.773	0.731	0.803	0.723	0.769
d. Sandstone & Siltstone	C	0.835	0.878	0.593	0.361	0.684
	CEC	0.674	0.748	0.704	0.486	0.738
6. Families						
a. >61% Clay	C	0.372	0.292	0.050	0.135	0.263
	CEC	0.209	0.217	0.425	0.259	0.248
b. 36-60% Clay	C	0.287	0.142	0.200	0.223	0.168
	CEC	0.311	0.230	0.255	0.203	0.130
c. 18-35% Clay	C	0.214	0.194	0.048	0.080	0.155
	CEC	0.500	0.461	0.362	0.578	0.602
d. <18% Clay	C	0.440	0.411	0.156	0.033	0.017
	CEC	0.282	0.242	0.348	0.058	0.214

Table 5. Multiple linear regression analysis of the engineering and chemical data from all locations.[†]

Regression Equations (n = 205) [§]	R^2
LL = 0.752 (S) - 0.365 (Si) + 0.619 (BS) - 0.843 (K) + 0.822 (M2M) - 0.729 (H) + 0.814 (CEC) + 0.279 (C) - 2.468	0.786**[¶]
PI = - 3.266 (M2M) - 0.852 (CEC) - 1.275 (BS) + 0.838 (K) + 187.689	0.652**
GI = 0.610 (BS) + 0.520 (Si) - 0.254 (CEC) + 1.599 (M2M) - 0.173 (Ca) + 0.551 (H) - 0.065 (C) - 82.817	0.882**
MD = - 0.029 (M2M) + 0.007 (Si) - 0.014 (BS) - 0.002 (K) + 0.006 (Ca) - 0.006 (H) + 0.006 (CEC) + 0.002 (C) + 2.010	0.646**
OM = - 0.865 (S) + 1.016 (Si) + 0.080 (BS) + 0.346 (CEC) + 0.083 (Ca) - 0.473 (H) - 0.047 (K) - 8.897	0.941**
CEC = - 0.085 (S) - 0.063 (Si) - 0.049 (C) + 3.336 (K) + 0.759 (Ca) + 0.806 (H) + 0.053 (PE) + 0.128 (OM) - 0.057 (LL) + 0.305 (PI) - 0.135 (GI) + 0.034 (BS) + 5.780	0.970**
C = - 0.989 (Si) - 0.987 (S) + 98.979	0.986**
PE = - 0.467 (S) - 0.471 (Si) - 0.577 (C) - 3.171 (K) + 0.660 (CEC) + 0.425 (PI) + 47.678	0.593**
M2M = 2.381 (GI) + 0.639 (Si) + 0.486 (C) - 19.656 (K) - 0.828 (Ca) - 0.478 (OM) + 0.594 (CEC) - 1.701 (PI) + 0.501 (LL) + 0.269 (BS) + 11.168	0.841**

[†] Variables include S, Si (silt), C, K, Ca, H (exchangeable hydrogen), CEC, BS (% base saturation), M2M, LL, PI, GI, MD, OM, PE.

[§] See foot note in Table 1 for definition of symbols.

[¶] (*) and (**) denote R^2 values are significant at 0.05 P and 0.01 P respectively.

The results in Table 6B were obtained when PI was treated as the dependent variable. Four equations were obtained when (LL) was included as one of the independent variables. The best relationships occurred for those categories involving the texture extremities; sands and very fine clays. (PI) was best related to (LL) and this is to be expected since (PI) is defined in terms of (LL). Since the objective was to predict engineering properties by means of (CEC) or clay content, (LL) was omitted as an independent variable and the data were again computed. The second part of Table 6B gives these results. Two equations (sands and soils with less than 18% clay) were obtained and in both cases clay content was the only independent variable. (PI) values could be predicted for sandy soils by measuring their clay content, since the equation accounts for 77% of the variation in (PI). However, this is not as good as the same expression that was obtained when all the soils from the 15 counties were considered ($R^2 = 0.803$ in Table 1). The results in Table 5B also show that when all the soils were considered in conjunction with other independent variables besides clay content, R^2 was increased to 0.901. However, this equation is not practical because some of the independent variables are engineering properties.

Relationships involving (GI) as the dependent variable are given in Table 6C. Since (GI) values are based on a relationship between (LL), (PI), and (M2M) the results in Table 6C could be expected. Since no other independent variables occurred in the equations (PI) and (M2M), there were no useful predictors for (GI) obtained by subdividng the data.

The last dependent variable under consideration was maximum density (MD) (Table 6D). The moisture content where a soil is most densely compacted is considered to be the optimum moisture (OM). Therefore, (MD) should be related to (OM) and the equations in Table 5D verify this relationship. Four of the equations

Table 6. Multiple linear regression equations for the dependent variables LL, PI, GI, and MD within soil groupings.†

A. Liquid Limit (LL)

Groupings	Equations	n	R^2
1. Textures			
C	0.877 (PI) + 1.175 (OM) + 4.694	29	0.938**
SL, LS, S, SC, SCL	2.656 (PI) + 1.517	37	0.914**
2. Horizons			
B	0.945 (PI) + 1.181 (OM) + 0.592	100	0.934**
3. Non-Plastic	3.145 (pi) - 0.001	42	0.999**
4. Families			
18-35% Clay	0.943 (PI) + 0.894 (OM) + 6.001	80	0.834**
<18% Clay	3.360 (PI) + 1.571	70	0.880**

B. Plasticity Index (PI)

Groupings	Equations	n	R^2
1. Including LL			
a. Texture			
SL, LS, S, SC, SCL	0.344 (LL) - 0.210	37	0.910**
b. Families			
>61% Clay	0.959 (LL) - 33.164	12	0.920**
<18% Clay	0.262 (LL) - 0.087	70	0.880**
c. Non-Plastic	0.318 (LL) + 0.0004	42	0.999**
2. Excluding LL			
a. Texture			
SL, LS, S, SC, SCL	0.446 (C) - 2.259	37	0.767**
b. Families			
>61% Clay	No significant terms	12	-------
<18% Clay	0.514 (C) - 2.518	70	0.411**
c. Non-Plastic	No significant terms	42	-------
d. All soils	0.259 (C) + 0.448 (OM) + 0.218 (MD) + 0.096 (GI) - 0.005 (M2M) - 31.009	205	0.901**

C. Group Index

Groupings	Equations	n	R^2
1. Textures			
SiL, Si	0.281 (PI) + 0.109 (M2M) - 3.366	76	0.750**
L, CL	0.547 (PI) + 1.920	27	0.784**
SL, LS, S, SC, SCL	0.150 (PI) - 0.104 (M2M) - 2.686	37	0.853**
SiC, SiCL	0.725 (pi) - 0.071	36	0.919**

Table 6. (Continued)

C. (Continued)			
1. Families			
36-60% Clay	0.746 (PI) - 0.360	43	0.884**
<18% Clay	0.126 (PI) + 0.104 - 2.437	70	0.858**
D. Maximum Density (MD)			
1. Textures			
C	-1.406 (OM) + 130.410	29	0.759**
SiL, Si	-1.990 (OM) + 0.235 (C) + 136.681	76	0.799**
L, CL	-1.640 (OM) + 137.894	27	0.833**
SL, LS, S, SC, SCL	-2.345 (OM) + 0.311 (C) + 142.181	37	0.921**
SiC, SiCL	-1.733 (OM) - 138.459	36	0.949**
2. Horizons			
A	-1.932 (OM) + 138.231	39	0.846**
B	-1.731 (OM) + 139.013	100	0.953**
C & R	-2.066 (OM) + 0.129 (LL) + 139.78	66	0.932**
3. Parent Materials			
Alluvium	-1.903 (OM) + 0.176 (PE) + 137.149	65	0.914**
Alluvium-Loess	-1.899 (OM) + 0.161 (PE) + 137.641	98	0.920**
Coastal Plains	-1.478 (OM) + 135.956	27	0.906**
4. Families			
>61% Clay	-1.387 (OM) + 129.059	12	0.675**
36-60% Clay	-1.479 (OM) + 132.705	43	0.806**
18-35% Clay	-2.055 (OM) + 0.168 (C) + 139.910	80	0.926**
<18% Clay	-2.326 (OM) + 0.391 (C) + 140.880	70	0.874**

† Footnote (†) in Table 2 gives the variables used in the multiple linear regression analysis.

also contain (C) as an independent variable, two others have (PE) and another one has (LL). When the R^2 values were considered for these relationships without (OM) they were less than 0.500. Therefore, these equations for (MD) have very little practical value.

Extensive mineralogical investigations were conducted to assist in detecting soils of unusual nature that might not be recognized by testing physical characteristics alone. Results in the previous section have shown that clay content and its (CEC) are related to engineering properties. Therefore, mineralogical data were obtained to determine if certain minerals were related to (CEC). Coefficients of determination (R^2) were determined for the dependent variable, (CEC), and the independent variable, clay minerals, for 204 observations. The results are as follows:

K†	I	A	Q	V	M	Ka
0.521	0.192	0.118	0.008	0.005	0.576	0.003

The best relationships occurred between (CEC) and exchangeable (K) and (CEC) and montmorillonite content. Since the respective (R^2) values were accounting for only 50 to 60 percent of the variation in (CEC), soil groupings (Table 3) were established and (R^2) values were obtained between (CEC) and the mineralogical variables. The results in Table 7 show that the best relationships still exist between (CEC) and (K) and (CEC) and montmorillonite. However, the (R^2) values for various groups were only slightly improved over those obtained when all soils were considered together.

† K - exchangeable clay (me/100 g), I - illite, A - amorphous material, Q - quartz V - vermiculite, M - montmorillonite, and Ka - kaolinite.

Table 7 - Coefficients of determination (R^2) for the dependent variable, cation exchange capacity, and the independent variables, clay minerals.

Soil Groups	Minerals						
1. Textures	K	I	A	Q	V	M	Ka
C †	0.403	0.003	0.010	0.005	0.071	0.345	0.299
SiL, Si	0.340	0.152	0.027	0.002	0.004	0.362	0.009
L, CL	0.031	0.075	0.019	0.056	0.006	0.300	0.013
SL,LS,S,SC,SCL	0.149	0.048	0.151	0.002	0.017	0.282	0.003
SiC, SiCL	0.430	0.009	0.011	0.010	0.007	0.429	0.120
2. Horizons							
A	0.449	0.642	0.050	0.085	0.014	0.540	0.021
B	0.474	0.090	0.122	0.003	0.035	0.393	0.004
C & R	0.621	0.225	0.172	0.206	0.001	0.743	0.028
3. Plastic Soils	0.472	0.143	0.094	0.002	0.031	0.552	0.002
4. Non-Plastic Soils	0.149	0.187	0.022	0.033	0.128	0.073	0.035
5. Parent Materials							
Alluvium	0.607	0.578	0.147	0.355	0.022	0.699	0.230
Alluvium - Loess	0.615	0.490	0.102	0.229	0.018	0.671	0.153
Coastal Plains	0.298	0.216	0.307	0.014	0.085	0.510	0.096
Sandstone and Siltstone	0.180	0.133	0.001	0.004	0.118	0.003	0.264
6. Families							
>61% Clay	0.271	0.386	0.130	0.102	0.295	0.127	0.399
36-60% Clay	0.333	0.007	0.081	0.003	0.054	0.428	0.160
18-35% Clay	0.268	0.107	0.003	0.002	0.036	0.582	0.115
<18% Clay	0.192	0.132	0.001	0.031	0.065	0.207	0.016

† See footnote in Table 1 for definition of symbols.

Table 8 - Multiple linear regression analysis of the mineralogical data from all locations.

Regression Equations (n=205)	R^2
†	
CEC = 24.932 (K) + 0.449 (M) + 0.324 (V) + 4.415	0.714**
K = 0.011 (CEC) - 0.009 (V) + 0.011 (I) - 0.028 (A) 0.002 (M) - 0.001 (BS)	0.646**
Q = 1.078 (K) - 0.193 (Ka) - 0.310 (V) + 0.458 (I) - 0.073 (BS) + 8.374	0.151**
V = -7.197 (K) + 0.392 (I) - 0.132 (M) + 0.102 (CEC) + 1.984	0.335**
M = -7.526 (K) + 0.891)CEC) - 0.847 (V) + 0.514 (I) - 0.329 (Ka) - 0.583	0.649**
Ka = -0.937 (K) + 0.139 (CEC) + 0.109 (V) + 0.354 (I) - 0.111 (M) - 0.138 (Q) - 0.986 (BS) + 7.473	0.294**
I = 11.872 (K) - 0.006 (CEC) - 0.109 (M) + 0.196 (K) + 0.184 (Q) + 0.621 (V) + 0.034 (BS) - 3.041	0.551**
A = -2.574 (K) + 0.149 (CEC) - 0.010 (V) + 1.221	0.133**
BS = 50.283 (K) - 2.003 (Ka) + 1.169 (I) - 1.054 (Q) + 45.689	0.371**

† CEC - cation exchange capacity (me/100g), K - exchangeable potassium, Q - quartz, V - vermiculite, M - montmorillonite, Ka - kaolinite, I - illite, A - amorphous material, BS - % base saturation.

The next step was then to analyze the data by multiple linear regression analysis. The results are given in Table 8 and include equations for each mineralogical variable being treated as the dependent variable. The results show that 71.4% of the variation in (CEC) can be accounted for by measuring the amounts of exchangeable (K), montmorillonite, and vermiculite. The data were analyzed a second time with CEC serving as the dependent variable. Also, the independent variables, (K) and (BS), were omitted. The following equation was obtained:

$$CEC = 0.570\ (M) + 0.375\ (I) + 8.103 \qquad R^2 = 0.606^{**\dagger}$$

These results show that (V) was eliminated from the equation and (I) appeared. The equation did not contain (K) since it was discarded from the data before the statistical analysis was conducted. The results from both analyses and those given in Table 6 show that (M) accounts for a considerable part of the variation in (CEC). The only other equations given in Table 8 are those for the dependent variables (K), (M), and (I). None of these equations accounted for more than 65% of the variation in terms of the above mentioned dependent variables. They were not satisfactory because they all contained five independent variables.

Since the largest R^2 value for the expressions given in Table 8 was 0.714, the data were subdivided according to the groups given in Table 2 and analyzed by multiple linear regression. The regression analyses of the data were conducted by treating each independent variable as the dependent variable. The results are given in Appendix Table 5. The equations that had R^2 values greater than 0.500 and no more than three independent variables are given in Table 9. The results in Table 9A are given for the dependent variable, (CEC). The equation for, Soil Containing More Than 60% Clay, had a R^2 value of 0.816. This was the only equation

† See footnote ¶ in Table 4 for explanation of (**).

that had an R^2 value greater than the one given for (CEC) in Table 8 (n = 204). When potassium was treated as the dependent variable the equations for Clay Textured and Alluvium Parent Material were the only ones that had R^2 values greater than the one given in Table 8 for (K) (0.646). When quartz was treated as the dependent variable equations for Clay Textured Soils and the (C & R) Horizon occurred. Their respective R^2 values of 0.672 and 0.575 are considerably better than the one (0.151) obtained when no subgrouping was used.

Relationships involving vermiculite as the dependent variable (Table 9D) were obtained for soils with Clay Texture, Soils Containing More Than 61% Clay, and Soils Containing 36 to 60% Clay. R^2 values for these subgroupings were better than those obtained without subgrouping. The same was true for (Ka) and (I), but only one subgrouping for (M), (Alluvium Parent Material) produced a R^2 value better than the one obtained without subgrouping.

SUMMARY AND CONCLUSIONS

Soil samples were collected from 82 soil series in 15 Arkansas counties and analyzed for engineering, chemical, and mineralogical properties.

The objectives of this investigation were to determine if soil chemical and physical properties can be related to soil engineering properties and if the mineralogical composition of the clay fraction is related to the chemical and physcial properties that are related to soil engineering properties.

The data from all 15 counties were combined and subjected to linear regression analysis. In separate analyses, cation exchange capacity (CEC), % clay (C), % expandable clay (PE), and exchangeable potassium (K) and calcium (Ca) were treated as independent variables and liquid limit (LL), plasticity index (PI), group index (GI), maximum density (MD), and optimum moisture (OM), were treated

Table 9 - Multiple linear regression equations for the mineralogical properties within soil groupings.

A. Cation Exchange Capacity (CEC)

	Groupings	Equations	n	R^2
1.	Textures			
	SiL, Si	14.451 (K) + 0.330 (M) + 7.447	75	0.604**
2.	Horizons			
	B	31.002 (K) + 0.282 (M) + 6.650	99	0.598**
3.	Plastic Soils	23.048 (K) + 0.417 (M) + 6.786	163	0.671**
4.	Families			
	>60% Clay	48.610 (K) - 1.376 (I) + 32.257	12	0.816**
	18-35% Clay	9.151 (K) + 0.444 (M) + 8.632	78	0.635**
	<18% Caay	13.501 (K) + 0.635 (V) + 0.292 (M) + 4.423	71	0.516**

B. Potassium (K)

	Groupings	Equations	n	R^2
1.	Texture			
	C	-0.015 (V) + 0.014 (I) + 0.009 (CEC) + 0.039	29	0.748**
	SiC, SiCL	-0.027 (V) + 0.017 (I) + 0.016 (CEC) - 0.105	37	0.622**
2.	Plastic Soil	-0.011 (V) + 0.013 (I) + 0.009 (CEC) + 0.070	163	0.580**
3.	Parent Material			
	Alluvium	0.015 (I) + 0.011 (CEC) + 0.033	66	0.684**

C. Quartz (Q)

	Groupings	Equations	n	R^2
1.	Texture			
	C	-4.354 (K) + 0.529 (I) - 0.441 (V) + 3.557	29	0.672**
2.	Horizons			
	C & R	5.665 (K) + 0.280 (I) + 0.372	66	0.575**

Table 9 (Continued)

	Groupings	Equations	n	R^2
D.	Vermiculite (V)			
1.	Texture			
	C	-13.347 (K) - 0.718 (Q) + 0.607 (I) + 6.364	29	0.564**
2.	Families			
	>61% Clay	-30.087 K) + 20.835	12	0.674**
	36-60% Clay	-7.380 (K) + 0.348 (I) + 1.792	43	0.500**
E.	Montmorillonite (M)			
1.	Texture			
	SiC, SiCL	-9.657 (K) + 1.311 (CEC) - 0.976 (V) - 5.195	37	0.513**
2.	Horizons			
	A	-3.451 (K) + 0.827 (CEC) - 4.397	39	0.548**
3.	Parent Material			
	Alluvium	-13.756 (K) + 1.409 (CEC) - 0.989 (V) - 4.442	66	0.743**
4.	Families			
	18-35% Clay	1.138 (CEC) - 8.072	78	0.582**
F.	Kaolinite (Ka)			
1.	Texture			
	C	-31.965 (K) - 1.038 (Q) + 0.932 (I) + 21.426	29	0.528**
2.	Parent Material			
	Sandstone - Siltstone	-15.230 (K) + 1.019 (I) + 0.436 (CEC) - 1.280	52	0.681**
G.	Illite (I)			
1.	Texture			
	C	14.561 (K) + 1.154 (Q) + 0.813 (V) - 5.155	29	0.768**
	SiC, SiCL	14.036 (K) + 1.349 (V) + 0.853	37	0.612**
2.	Horizon			
	A	5.395 (K) + 0.487 (CEC) - 2.449	39	0.672**

Table 9 (Continued)

	Groupings	Equations	n	R^2
G.	(Continued)			
3.	Non-Plastic	3.781 (K) + 0.740 (V) + 0.280 (M) + 0.556	41	0.606**
4.	Parent Material			
	Alluvium	19.655 (K) + 0.432 (Ka) - 0.754	66	0.671**
	Sandstone and Siltstone	12.537 (K) + 0.505 (Ka) + 0.098	52	0.642**

as dependent variables. The results for single comparisons show that only (CEC) and (C) are related to soil engineering properties. The best relationships occurred for (C) vs (LL) and (C) vs (PI); $R^2 = 0.817$ and 0.803, respectively. The data were then subdivided into groups according to texture, horizons, plastic soils, non-plastic soils, parent material, and families to determine if higher R^2 values could be determined. It occurred only for the parent material subgroups. In all cases except one, (CEC) vs (PI), the higher values were obtained for (C) vs (LL) and (C) vs (PI). The data were next analyzed with multiple linear regression analyses by treating the engineering variables in separate analysis as the dependent variable. The data were also subdivided into soil groupings as previously described. In both cases R^2 values were no better than those where single comparisons were made.

Separate relationships for mineralogy {illite (I), amorphous material (A), quartz (Q), vermiculite (V), montmorillonite (M), and kaolinite (Ka)} and exchangeable potassium (K) vs (CEC) were determined when the data from all locations were combined. The best R^2 values occurred for (CEC) vs (K) and (CEC) vs (M); 0.521 and 0.576, respectively. The other R^2 values were less than 0.200. The data were subdivided as previously described and again analyzed. The only R^2 values that were increased were those for (CEC) vs (K) or (M) in the alluvium and alluvium-loess and (CEC) vs (M) in the (C & R) horizon (0.607, 0.699, and 0.743, respectively).

Multiple linear regression analysis was then used as previously described to determine if the R^2 values could be increased. The best relationship occurred when (CEC) was the dependent variable. The independent variables were (K), (M), and (V). When (K) was discarded and the analysis conducted a second time, (I) replaced (V) and R^2 decreased from 0.714 to 0.606. The only other expressions of importance were those for the dependent variables (K), (M), and (I). Their respective R^2 values were 0.646, 0.649, and 0.551. Subdivisions, as previously described, were made and R^2 for the dependent variable (CEC) in the family of soils with more than 60% clay was 0.816. The other R^2 values were less than 0.714. When the other variables were separately treated as the dependent variable, R^2 values were increased where the soil had a clay texture or belonged to the family that contains more than 60% clay.

Thus, in conclusion, data for (CEC) and (C) from all 15 counties can be combined and used to predict (LL), (PI), (GI), (MD), and (OM) and mineralogical data can be used to predict (CEC) of these respective soils. There was very little advantage obtained when the data were divided into soil subgroupings.

A P P E N D I X

Appendix Table 1 - Summary for the number of soil samples collected from each county and their respective series and parent material.

Tech. Rpt. No.	County	No. Samples	No. Soil Series	Parent Material
1.	Cleveland	13	5	Coastal Plain
2.	Cross	8	3	Loess
3.	Woodruff	9	3	Alluvium
4.	Washington	21	7	S.S., Si.S - Alluvium
5.	Franklin	20	8	S.S., Si.S
6.	Chicot	17	8	Alluvium
7.	Mississippi	23	10	Alluvium
8.	Greene	5	3	Alluvium
9.	Arkansas	20	7	Alluvium, loess
10.	Desha	9	3	Alluvium
11.	Ouachita	16	6	Coastal Plain
12.	Jackson	9	3	Alluvium
13.	Benton	14	5	Chert, Si.S, Alluvium
14.	Howard	14	6	Calcareous marl, Alluvium
15.	Johnson	15	5	S.S., Si.S. - Alluvium
		213	82	

Appendix Table 2 - List of soil series and the counties where they were sampled.

	Series	County		Series	County
1.	Alaga	Ouachita	35.	Houston	Howard
2.	Allen	Washington	36.	Jay	Washington
3.	Alligator (2)†	Mississippi, Green	37.	Johnsburg (2)	Washington
4.	Amagon (3)	Arkansas, Jackson	38.	Kaufman	Howard
5.	Amy	Ouachita	39.	Kirvin (2)	Ouachita
6.	Arklaburla	Cross	40.	Lafe	Cross
7.	Bosket	Woodruff	41.	Leadvale (2)	Franklin, Johnson
8.	Brandon	Greene	42.	Linker	Franklin
9.	Bruno	Mississippi	43.	Miller	Arkansas
10.	Calloway	Chicot	44.	Montevallo	Franklin
11.	Caspiana	Johnson	45.	Morganfield (2)	Mississippi, Johnson
12.	Clarksville	Benton	46.	Muskogee	Johnson
13.	Cleora	Franklin	47.	Nacogdoches	Cleveland
14.	Colbert	Benton	48.	Newellton	Desha
15.	Collins	Greene	49.	Nixa	Benton
16.	Commerce	Desha	50.	Norwood	Arkansas
17.	Convent	Mississippi	51.	Norfolk	Ouachita
18.	Crevasse	Mississippi	52.	Ouachita	Ouachita
19.	Crowley (2)	Arkansas	53.	Oktibbeha	Howard
20.	Dubbs	Franklin	54.	Pembroke	Benton
21.	Dundee	Chicot	55.	Pickwick	Johnson
22.	Earle	Mississippi	56.	Portland	Chicot
23.	Enders	Franklin	57.	Razort	Benton
24.	Falkner	Franklin	58.	Saffell	Cleveland
25.	Fayetteville	Washington	59.	Sallisaw	Howard
26.	Foley	Woodruff	60.	Savannah (2)	Washington
27.	Forestdale	Mississippi	61.	Sharkey (2)	Chicot, Mississippi
28.	Gallion	Chicot	62.	Shubuta	Cleveland
29.	Grenada (2)	Chicot, Arkansas	63.	Steele	Mississippi
30.	Hartsells	Howard	64.	Stuttgart	Arkansas
31.	Hebert	Chicot	65.	Sumter	Howard
32.	Henry (2)	Chicot, Cross	66.	Susquehana	Cleveland
33.	Hillemann	Jackson	67.	Tippah	Cleveland
34.	Holston	Greene	68.	Tuckerman	Jackson
			69.	Tunica (2)	Desha, Mississippi

† The number in parenthesis indicates number of profiles sampled from that particular series.

Appendix Table 3 - List of samples by series and county that were analyzed to determine the engineering and mineralogical properties.

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
CLEVELAND COUNTY - TECH. RPT. NO. 1			
Tippah very fine sand loam			
B21t	10-17	S-62-Ark-13-3-4	2282
IIC2	32-62	S-62-Ark-13-2-7	2285
Saffell gravelly fine sandy loam			
B2t	7-36	S-62-Ark-13-4-3	2288
C	36-65+	S-62-Ark-13-4-4	2289
Shubuta fine sandy loam			
A2	2-7	S-62-Ark-13-5-2	2291
B22t	14-27	S-62-Ark-13-5-4	2293
C1	25-60	S-62-Ark-13-5-5	2294
Susquehanna silty clay loam			
B21t	3-10	S-62-Ark-13-6-2	2296
B22t	10-20	S-62-Ark-13-6-3	2297
C	20-72+	S-62-Ark-13-6-4	2298
Nacogdoches gravelly loam			
B21t	8-14	S-62-Ark-13-7-3	2301
C1	25-41	S-62-Ark-13-7-5	2303
IIC2	41-72	S-62-Ark-13-7-6	2304
CROSS COUNTY - TECH. RPT. NO.2			
Arklabutla silt loam			
C1g	13-20	UA-62-Ark-19-23-3	2897
C3g	36-72	UA-62-Ark-19-23-5	2899
Henry silt loam			
A2	4-17	UA-63-Ark-19-22-2	2891
B21tg	17-24	UA-63-Ark-19-22-3	2892
Bx	31-72	UA-63-Ark-19-22-5	2894
Lafe silt loam			
A2	6-13	UA-63-Ark-19-21-2	2886
B21t	13-29	UA-63-Ark-19-21-3	2887
Cg	38-72	UA-63-Ark-19-21-5	2889

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
WOODRUFF COUNTY - TECH. RPT. NO. 3			
Bosket fine sandy loam			
Ap	0-8	S-63-Ark-74-2-1	2571
B2	14-34	S-63-Ark-74-2-3	2573
C1	34-72	S-63-Ark-74-2-4	2574
Foley silt loam			
A1	0-5	S-63-Ark-74-4-1	2581
B22tg	22-42	S-63-Ark-74-4-5	2585
C	42-72+	S-63-Ark-74-4-6	2586
Amagon silt loam			
A1p	0-7	S-63-Ark-74-6-1	2593
B1	16-28	S-63-Ark-74-6-4	2596
B21	28-40	S-63-Ark-74-6-5	2597
WASHINGTON COUNTY - TECH. RPT. NO.4			
Johnsburg silt loam			
Ap2	5-8	S-63-Ark-72-1-2	2349
B2t	16-23	S-63-Ark-72-1-4	2351
Bxtg	23-58	S-63-Ark-72-1-5	2352
Savannah silt loam			
A3	5-13	S-63-Ark-72-2-2	2355
B22t	17-25	S-63-Ark-72-2-4	2357
Bx2t	30-57	S-63-Ark-72-2-6	2359
Savannah fine sandy loam			
Ap	0-5	S-63-Ark-72-3-1	2361
B2t	11-22	S-63-Ark-72-3-3	2363
Bx2t	29-70	S-63-Ark-72-3-5	2365
Fayetteville fine sandy loam			
Ap	0-9	S-63-Ark-72-7-1	2384
B1	16-25	S-63-Ark-72-7-3	2386
B22t	36-67	S-63-Ark-72-7-5	2388
			2390
Allen loam			
Ap	0-8	S-63-Ark-72-12-1	2411
B22t	29-39	S-63-Ark-72-12-4	2414
C	39-45+	S-63-Ark-72-12-5	2415

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
Johnsburg loam			
Ap	0-6	S-63-Ark-72-16-1	2616
Btg	9-20	S-63-Ark-72-16-3	2618
Bxtg	20-40	S-63-Ark-72-16-4	2619
Jay silt loam			
Ap	0-99	S-63-Ark-72-4-1	2366
B2t	16-25	S-63-Ark-72-4-3	2368
Bx2t	29-56	S-63-Ark-72-4-5	2370
			2371
FRANKLIN COUNTY - TECH. RPT. NO. 5			
Linker fine sandy loam			
Ap1	0-5	S-64-Ark-24-2-1	3402
B2t	14-23	S-64-Ark-23-2-4	3405
Falkner silt loam			
Ap	0-7	S-64-Ark-24-6-1	3428
B22t	19-32	S-64-Ark-24-6-4	3431
B23t	32-68	S-64-Ark-24-6-5	3432
Dubbs fine sandy loam			
Ap2	3-7	S-64-Ark-24-8-2	3439
B2t	7-27	S-64-Ark-24-8-3	3440
B32	37-44	S-64-Ark-24-8-5	3442
Montevallo gravelly fine sandy loam			
B2t	7-11	S-64-Ark-24-9-3	3445
R	11+	S-64-Ark-24-9-4	3446
Leadvale fine sandy loam			
B1t	5-10	S-64-Ark-24-10-3	3449
B22t	13-23	S-64-Ark-24-10-5	3451
B23tx	23-39	S-64-Ark-24-10-6	3452
Holston gravelly loam			
A22	4-8	S-64-Ark-24-11-3	3456
B21t	8-25	S-64-Ark-24-11-4	3457
			3458
IIC	31-37+	S-64-Ark-24-11-6	3460
Cleora fine sandy loam			
C3	17-30	S-64-Ark-24-12-4	3464
C5	46-72	S-64-Ark-24-12-6	3466
Enders gravelly fine sandy loam			
B22t	16-24	S-64-Ark-24-4-4	3417
C	36-72+	S-64-Ark-24-4-7	3420

Appendix Table 3 (continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
	CHICOT COUNTY - TECH. RPT. NO. 6		
Calloway silt loam			
Ap	0-8	S-62-Ark-9-11-1	2191
B22tx	29-72	S-62-Ark-9-11-5	2195
Dundee silt loam			
A12	6-12	S-62-Ark-9-5-2	2172
C1	20-49	S-62-Ark-9-5-4	2174
IIC2	49-72+	S-62-Ark-9-5-5	2175
Gallion silt loam			
A2	8-19	S-62-Ark-9-4-2	2167
B2	26-39	S-62-Ark-9-4-4	2169
C	39-72	S-62-Ark-9-4-5	2170
Grenada silt loam			
A2	3-10	S-62-Ark-9-10-2	2187
B21tx	25-41	S-62-Ark-9-10-4	2189
B22tx	41-58	S-62-Ark-9-10-5	2190
Hebert silt loam			
Ap1	0-4	S-62-Ark-9-1-1	2159
B2	16-27	S-62-Ark-9-1-4	2162
C2	51-72	S-62-Ark-9-1-7	2165
Henry silt loam			
B21tx	13-29	S-62-Ark-9-9-3	2183
Portland clay			
C	17-72	S-62-Ark-9-7-3	2178
Sharkey clay			
C	4-9+	S-62-Ark-9-8-2	2180
	MISSISSIPPI COUNTY - TECH. RPT. NO. 7		
Crevasse loamy sand			
C1	12-28	S-64-Ark-47-2-3	3616
IIC3g	47-73	S-65-Ark-47-2-5	3618
Forestdale silty clay loam			
Ap	0-8	S-65-Ark-47-3-1	3619
B22tg	20-34	S-65-Ark-47-3-3	3621
C1g	34-62	S-65-Ark-47-3-4	3622
IIC4	78-88+	S-65-Ark-47-3-7	3625

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
Earle clay			
B21	5-34	S-65-Ark-47-4-2	3627
B22	34-55	S-65-Ark-47-4-3	3628
IIC1	55-76	S-65-Ark-47-4-4	3629
Alligator clay			
C2g	20-51	S-65-Ark-47-5-3	3632
IIC3g	51-74	S-65-Ark-47-5-4	3633
Bruno fine sandy loam			
C1	17-48	S-65-Ark-47-6-3	3636
Sharkey clay			
C1	6-34	S-65-Ark-47-7-2	3638
Tunica clay			
B21g	8-24	S-65-Ark-47-8-2	3641
C	45-72	S-65-Ark-47-8-4	3643
Morganfield fine sandy loam			
C1	11-32	S-65-Ark-47-9-3	3646
C3	62-80	S-65-Ark-47-9-5	3648
Commerce fine sandy loam			
Ap	0-7	S-65-Ark-47-10-1	3649
B21g	11-23	S-65-Ark-47-10-3	3651
C1	39-61	S-65-Ark-47-10-5	3653
Steele silt loam			
C2	12-20	S-65-Ark-47-11-2	3657
C4g	22-31	S-65-Ark-47-11-5	3659
C6g	38-72	S-65-Ark-47-11-7	3661
GREENE COUNTY - TECH. RPT. NO. 8			
Brandon silt loam			
A2	2-7	S-64-Ark-28-10-2	3173
B3	15-35	S-64-Ark-28-10-5	3176
Collins silt loam			
A1	6-15	S-64-Ark-28-11-2	3179
C2	25-74	S-64-Ark-28-11-4	3181
Alligator silt loam			
C1g	11-32	S-64-Ark-28-12-3	3184

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
	ARKANSAS COUNTY - TECH. RPT. NO. 9		
Miller silty clay loam			
C1	7-39	S-65-Ark-1-1-2	4064
C2	39-51	S-65-Ark-1-1-3	4065
IIC3	51-72	S-65-Ark-1-1-4	4066
Norwood silt loam			
C1	8-33	S-65-Ark-2-2-2	4068
C2	33-52	S-65-Ark-1-2-3	4069
C3	52-72	S-65-Ark-1-2-4	4070
Crowley silt loam			
A12g	6-13	S-65-Ark-1-3-2	4072
IIB21tg	17-32	S-65-Ark-1-3-4	4074
IIB23t	44-55	S-65-Ark-1-3-6	4076
Amagon silt loam			
A12g	6-17	S-65-Ark-1-4-2	4079
B22tg	30-72	S-65-Ark-1-4-4	4081
Crowley silt loam			
B1tg	9-15	S-65-Ark-1-5-3	4084
IIB21tg	15-30	S-65-Ark-1-5-4	4085
IIB22tg	30-72	S-65-Ark-1-5-5	4086
Stuttgart silt loam			
Ap	0-6	S-65-Ark-1-6-1	4087
B22t	15-24	S-65-Ark-1-6-4	4090
B24tg	33-72	S-65-Ark-1-6-6	4092
Grenada silt loam			
B1	7-20	S-65-Ark-1-7-2	4094
B22xt	33-60	S-65-Ark-1-7-5	4097
IIC	60-72	S-65-Ark-1-7-6	4098
	DESHA COUNTY- TECH. RPT. NO. 10		
Commerce silt loam			
B21	14-22	S-66-Ark-21-1-3	4499
C1	39-55	S-66-Ark-21-1-6	4502
C3g	68-72	S-66-Ark-21-1-8	4504

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
Newellton silty clay			
B2	5-15	S-66-Ark-21-3-2	4511
IIB3	15-22	S-66-Ark-21-3-3	4512
IIC2	36-86	S-66-Ark-21-3-5	4514
Tunican silty clay			
B2g	5-24	S-66-Ark-21-2-2	4506
IIC1	24-38	S-66-Ark-21-2-3	4507
IIIC3	45-72	S-66-Ark-21-2-5	4509
OUACHITA COUNTY - TECH. RPT. NO. 11			
Alaga loamy sand			
C1	7-24	S-67-Ark-52-2-2	4713
C2	24-46	S-67-Ark-52-2-3	4714
Norfolk sandy loam			
A2	7-21	S-67-Ark-52-5-2	4731
B21t	21-36	S-67-Ark-52-5-3	4732
B23t	49-63	S-67-Ark-52-5-5	4734
Amy silt loam			
A2	4-18	S-67-Ark-52-1-2	4708
B21tg	18-41	S-67-Ark-52-1-3	4709
B22t	41-52	S-67-Ark-52-1-4	4710
Kirvin fine sandy loam			
B2t	5-18	S-67-Ark-52-3-2	4718
C1	18-35	S-67-Ark-52-3-3	4719
C2	35-55	S-67-Ark-52-3-4	4720
Ouachita very fine sandy loam			
B21t	19-34	S-67-Ark-52-6-3	4738
Bbt	42-69	S-67-Ark-52-6-5	4740
Kirvin fine sandy loam			
B21t	9-24	S-67-Ark-52-4-3	4725
B22t	24-38	S-67-Ark-52-4-4	4726
B3t	38-55	S-67-Ark-52-4-5	4727
JACKSON COUNTY - TECH. RPT. NO. 12			
Amagon silt loam			
B21tg	13-21	S-67-Ark-34-2-3	4779
C1	28-41	S-67-Ark-34-2-5	4781
Bb	41-60	S-67-Ark-34-2-6	4782

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
Hillemann silt loam			
B21t	5-13	S-67-Ark-34-1-2	4785
B23tg	18-27	S-67-Ark-34-1-4	4787
B24tg	27-46	S-67-Ark-34-1-5	4788
Tuckerman silt loam			
B21tg	21-41	S-67-Ark-34-3-4	4793
B22tg	41-62	S-67-Ark-34-3-5	4794
B23tg	62-62	S-67-Ark-34-3-6	4795
BENTON COUNTY - TECH. RPT. NO. 13			
Pembroke silt loam			
Ap	0-9	S-67-Ark-4-9-1	4796
B21t	9-26	S-67-Ark-4-9-2	4797
B22t	26-42	S-67-Ark-4-9-3	4798
Clarksville cherty silt loam			
A2	1-10	S-67-Ark-4-7-1	3065
B21t	24-40	S-67-Ark-4-7-3	3067
Colbert stony silt loam			
A1	0-7	S-67-Ark-4-6-1	4756
B21t	7-14	S-67-Ark-4-6-2	4757
B22t	14-31	S-67-Ark-4-6-3	4758
Nixa cherty silt loam			
A2	3-17	S-67-Ark-4-3-2	4704
Bx	17-32	S-67-Ark-4-3-3	4705
Razort gravelly silt loam			
A1	0-10	S-67-Ark-4-8-1	4802
B22t	24-44	S-67-Ark-4-8-3	4804
B21	12-22	S-68-Ark-31-7-3	4940
B22	22-41	S-68-Ark-31-7-4	4941
HOWARD COUNTY - TECH. RPT. NO. 14			
Hartsells fine sandy loam			
B21t	11-16	S-68-Ark-31-3-3	4916
B22t	16-30	S-68-Ark-31-3-4	4917
B23t	30-36	S-68-Ark-31-3-5	4918

Appendix Table 3 (Continued)

Horizon	Depth Inches	SCS No.	U. of A. Lab. No.
Houston clay			
C1	5-16	S-68-Ark-31-5-2	4925
C2	16-29	S-68-Ark-31-5-3	4926
C3	29-46	S-68-Ark-31-5-4	4927
Kaufman clay			
B21	12-22	S-68-Ark-31-71-3	4940
B22	22-41	S-68-Ark-31-71-4	4941
Oktibbeha clay			
B22t	12-19	S-68-Ark-31-6-3	4932
B23t	19-29	S-68-Ark-31-6-4	4933
Sallisaw fine sandy loam			
B21t	22-37	S-68-Ark-31-2-4	4910
B22t	37-52	S-68-Ark-31-2-5	4911
Sumter clay			
B21	4-9	S-68-Ark-31-4-2	4920
B22	9-16	S-68-Ark-31-4-3	4921
JOHNSON COUNTY - TECH. RPT. NO. 15			
Caspiana silt loam			
B21t	10-24	S-68-Ark-36-2-2	5381
B23t	30-40	S-68-Ark-36-2-4	5382
C1	40-52	S-68-Ark-36-2-5	5383
Pickwick silt loam			
Ap	0-6	S-68-Ark-36-6-1	5384
B21t	12-22	S-68-Ark-36-6-3	5385
B23t	35-52	S-68-Ark-36-6-5	5386
Muskogee silt loam			
A2	4-9	S-68-Ark-36-13-2	5387
B22t	23-39	S-68-Ark-36-13-4	5388
B23t	39-50	S-68-Ark-36-13-5	5389
Leadvale silt loam			
A2	5-10	S-68-Ark-36-15-2	5390
B21t	18-23	S-68-Ark-36-15-4	5391
Bx1	23-49	S-68-Ark-36-15-5	5392
Morganfield silt loam			
A12	7-14	S-68-Ark-36-16-2	5393
C1	14-30	S-68-Ark-36-16-3	5394
C2	30-41	S-68-Ark-36-16-4	5395

Appendix Table 4 - Multiple linear regression equations for chemical and engineering properties

A. Clay Textured Soils (n=29)

Equation[a/]	R^2 [b/]
CL = 0.787 (LL) + 9.151	0.800**
CEC = 1.234 (GI) + 8.256	0.434**
M2M = 1.023 (OM) - 0.802 (MD) + 0.499 (PI) + 174.143	0.446**
LL = 1.175 (OM) + 0.877 (PI) + 4.694	0.938**
PI = 0.664 (MD) + 0.858 (LL) + 0.438 (GI) - 94.435	0.949**
GI = 0.504 (PI) + 5.957	0.592**
MD = -1.406 (OM) + 130.410	0.759**
OM = -0.540 (MD) + 77.010	0.759**
PE = 0.788 (CEC) + 1.294	0.316*

a/ Cl - % Clay, CEC - cation exchange capacity (me/100g), M2M - <200 mesh, LL - liquid limit, PI - plasticity index, GI - group index, MD - maximum density, OM - optimum moisture, PE - percent expandable.

b/ (**) and (*) denote R^2 values are significantly different at 0.01P and 0.05P, respectively.

B. Silt and Silt Loam Textured Soils (n=76)

Equation	R^2
CL = 0.866 (PI) + 1.269 (OM) + 0.660 (MD) - 0.579 (GI) - 77.021	0.687**
CEC = 0.390 (CL) + 0.354 (GI) - 0.380 (MD) + 36.040	0.638**
M2M = -2.341 (PI) + 5.043 (GI) + 0.597 (LL) + 48.304	0.614**
LL = 3.310 (OM) - 0.384 (GI) + 1.215 (MD) + 1.892 (PI) - 0.248 (PE) - 171.891	0.830**
PI = 0.185 (CL) + 0.115 (PE) - 0.285 (MD) + 0.232 (LL) + 0.817 (GI) - 0.177 (MD) - 0.008 (M2M) + 21.250	0.915**
GI = 0.281 (PI) + 0.109 (M2M) - 3.366	0.750**
MD = -1.990 (OM) + 0.235 (CL) + 136.681	0.799**
OM = 0.052 (CL) - 0.376 (MD) + 0.045 (LL) + 55.251	0.877**
PE = 0.992 (CEC) - 2.593	0.362**

C. Loam and Clay Loam Textured Soils (n=27)

Equation	R^2
CL = 3.987 (OM) + 1.702 (MD) - 229.098	0.452**
CEC = 0.585 (GI) + 6.341	0.482**
M2M = 2.396 (GI) + 51.813	0.538**
LL = 1.458 (MD) + 3.733 (OM) + 1.085 (PI) - 204.218	0.855**
PI = 0.977 (GI) - 0.315 (CEC) + 0.310 (LL) - 2.584	0.916**
GI = 0.547 (PI) + 1.920	0.784**
MD = -1.640 (OM) + 1.379	0.833**
OM = -0.382 (MD) + 0.093 (LL) + 55.777	0.927**
PE = No significant terms appear at 0.05P or 0.01P	______

Appendix Table 4 (Continued)

D. Sandy Loam, Loamy Sand, Sand, Sandy Clay, and Sandy Clay Loam Textured Soils (n=37)	R^2
CL = 0.420 (CEC) + 1.964 (OM) + 0.871 (MD) + 0.411 (LL) - 121.044	0.911**
CEC = 0.532 (OM) + 0.236 (CL) - 2.658	0.649**
M2M = 7.046 (GI) + 25.932	0.759**
LL = 2.656 (PI) + 1.517	0.914**
PI = 0.344 (LL) - 0.210	0.914**
MD = -2.345 (OM) + 0.311 (CL) + 1.422	0.921**
GI = 0.150 (PL) + 0.104 (M2M) - 2.686	0.853**
OM = -0.392 (MD) + 0.129 (CL) + 56.846	0.927**
PE = 0.768 (CEC) - 0.124	0.336**

E. Silty Clay and Silty Clay Loam Textured Soils (n=36)	R^2
CL = -0.830 (OM) + 0.731 (LL) + 22.200	0.558**
CEC = 0.441 (LL) + 0.604	0.624**
M2M = -0.565 (MD) + 148.349	0.191**
LL = 1.145 (PI) + 1.369 (OM) - 0.414 (GI) -1.787	0.979**
PI = 0.665 (LL) - 0.922 (OM) + 0.583 (GI) + 1.891	0.981**
GI = 0.725 (PI) - 0.071	0.919**
MD = -1.733 (OM) + 138.459	0.949**
OM = -0.548 (MD) + 77.001	0.949**
PE = 1.162 (GI) + 0.547	0.530**

F. Horizon A (n=39)	R^2
CL = 1.549 (CEC) - 2.685	0.717**
CEC = 0.463 (CL) + 4.355	0.717**
M2M = 4.742 (GI) + 44.855	0.623**
LL = 2.248 (OM) + 0.574 (GI) + 0.926 (MD) + 2.795 (PI) - 0.538 (PE) - 132.308	0.930**
PI = -0.218 (MD) + 0.194 (PE) - 0.432 (OM) + 0.255 (LL) - 0.189 (GI) + 0.112 (CL) + 29.074	0.948**
GI = 0.156 (CL) - 0.160 (MD) - 0.276 (OM) + 0.101 (M2M) + 17.962	0.800**
MD = -1.932 (OM) + 138.231	0.846**
OM = -0.367 (MD) + 0.136 (PI) + 54.756	0.879**
PE = 0.823 (CEC) - 2.752	0.561**

Appendix Table 4 (Continued)

G. Horizon B (n=100)	R^2
CL = 0.595 (CEC) + 2.591 (OM) + 0.987 (MD) + 0.754 (PI) - 0.546 (GI) - 138.019	0.814**
CEC = -0.468 (OM) - 0.516 (MD) + 0.340 (GI) + 0.219 (CL) + 67.495	0.798**
M2M = 1.816 (MD) - 4.033 (OM) + 3.144 (GI) - 1.969 (PI) + 0.754 (LL) + 313.620	0.557**
LL = 1.181 (OM) + 0.945 (PI) + 0.592	0.934**
PI = -0.166 (MD) - 0.691 (OM) + 0.782 (GI) + 0.421 (LL) - 0.066 (M2M) + 26.776	0.945**
GI = 0.456 (OM) + 0.094 (MD) + 0.671 (PI) - 0.104 (LL) + 0.090 (M2M) - 20.911	0.924**
MD = -1.731 (OM) + 139.013	0.953**
OM = 0.077 (LL) - 0.072 (PI) - 0.447 (MD) + 0.045 (CL) + 63.205	0.966**
PE = 0.802 (CEC) + 1.514	0.356**

H. Horizons C and R (n=66)	R^2
CL = 0.922 (PI) + 1.109 (MD) + 3.563 (OM) - 0.421 (GI) - 167.423	0.913**
CEC = 0.373 (PE) + 0.358 (GI) + 0.230 (CL) + 2.269	0.849**
M2M = 4.266 (GI) - 1.435 (PI) + 49.301	0.530**
LL = -0.273 (PE) + 0.231 (CEC) + 2.481 (OM) + 1.742 (PI) - 0.790 (GI) + 0.977 (MD) + 0.143 (M2M) - 1449.66	0.954**
PI = 0.154 (CL) - 0.170 (CEC) - 0.267 (OM) + 0.270 (LL) + 0.728 (GI) + 0.217 (PE) - 0.073 (M2M) + 4.335	0.974**
GI = -0.119 (CL) + 0.216 (CEC) + 0.413 (OM) - 0.110 (LL) + 0.632 (PI) - 0.131 (PE) + 0.086 (M2M) - 8.071	0.938**
MD = -2.066 (OM) + 0.129 (LL) + 139.780	0.932**
OM = -0.399 (MD) + 0.105 (CL) + 58.173	0.963**
PE = 0.786 (PI) + 0.677 (CEC) + 0.894 (OM) - 0.493 (GI) - 0.402 (CL) - 10.448	0.806**

I. Plastic Soils (n=163)	R^2
CL = 1.481 (OM) + 0.756 (MD) + 0.587 (LL) + 0.401 (CEC) - 106.854	0.833**
CEC = 0.373 (PE) + 0.358 (GI) + 0.230 (CL) + 2.269	0.849**
M2M = -1.112 (MD) - 2.263 (OM) + 0.854 (LL) - 1.604 (PI) + 2.848 (GI) - 0.413 (CL) + 212.717	0.511**
LL = -0.179 (GI) + 1.635 (OM) + 0.281 (MD) + 0.910 (PI) + 0.134 (CL) - 38.745	0.954**
PI = -0.640 (OM) - 0.082 (MD) + 0.681 (GI) + 0.531 (LL) - 0.064 (M2M) + 13.481	0.947**

Appendix Table 4 (Continued)

I. (Continued)	R^2
GI = 0.387 (OM) + 0.652 (PI) - 0.169 (LL) + 0.101 (M2M) - 7.923	0.897**
MO = 0.086 (CL) - 0.111 (CEC) - 1.905 (OM) - 0.073 (LL) + 138.183	0.939**
OM = 0.128 (LL) - 0.078 (PI) - 0.388 (MD) + 0.033 (CL) + 55.336	0.963**
PE = 0.856 (CEC) - 0.028	0.511**

J. Non-Plastic Soils (n=42)	R^2
CL = 6.791 (LL) - 20.091 (PI) + 1.316 (CEC) - 2.052	0.724**
CEC = -1.061 (LL) + 3.152 (PI) + 0.363 (CL) + 4.808	0.577**
M2M = 7.617 (GI) + 30.739	0.811**
LL = 3.145 (PI) - 0.001	0.999**
PI = 0.318 (LL) + 0.0004	0.999**
GI = -0.146 (PE) + 0.134 (CEC) + 1.093 (PI) - 0.325 (LL) + 0.104 (M2M) - 2.805	0.855**
MD = -9.281 (PI) + 3.132 (LL) - 2.449 (OM) + 1.459	0.819**
OM = -6.233 (PI) + 2.061 (LL) -0.332 (MD) + 51.274	0.838**
PE = 0.764 (OM) + 0.558 (CEC) + 0.151 (MD) -3.462 (LL) + 10.629 (PI) -1.420 (GI) + 0.146 (M2M) - 30.858	0.339**

K. Alluvial Soils (n=65)	R^2
CL = 1.192 (PI) + 7.574	0.862**
CEC = 0.597 (PI) + 8.579	0.852**
M2M = 3.305 (GI) - 3.101 (PI) + 1.299 (LL) + 43.313	0.649**
LL == -0.838 (GI) + 0.474 (OM) + 1.774 (PI) + 0.226 (M2M) - 10.402	0.938**
PI = 0.145 (CL) + 0.144 (CEC) + 0.120 (PE) + 0.217 (LL) + 0.592 (GI) - 0.079 (M2M) - 1.269	0.975**
GI = 0.631 (PI) + 0.319 (OM) - 0.151 (LL) + 0.104 (M2M) -7.158	0.914**
MD = -1.903 (OM) + 0.176 (PE) + 137.149	0.914**
OM = -0.455 (MD) + 0.120 (PE) + 64.447	0.944**
PE = 1.041 (MD) + 1.893 (OM) + 0.642 (PI) - 137.394	0.782**

Appendix Table 4 (Continued)

L. Alluvium - Loess Soils (n=98)	R^2
CL = 0.769 (PI) + 0.711 (CEC) + 2.088	0.863**
CEC = 0.245 (CL) + 0.491 (OM) + 0.194 (PE) - 2.099	0.856**
M2M = -3.183 (PI) + 3.418 (GI) + 1.254 (LL) + 48.932	0.573**
LL = -1.013 (GI) + 0.547 (OM) + 1.859 (PI) + 0.223 (M2M) - 11.169	0.932**
PI = 0.111 (CL) + 0.100 (PE) + 0.699 (GI) + 0.265 (LL) - 0.082 (M2M) + 0.029	0.968**
GI = -0.101 (MD) + 0.140 (OM) + 0.648 (PI) - 0.158 (LL) + 0.099 (M2M) + 6.831	0.912**
MD = -1.899 (OM) + 0.161 (PE) + 137.641	0.920**
OM = -0.407 (MD) + 0.100 (GI) + 0.083 (PE) + 59.051	0.953**
PE = 1.157 (MD) + 2.665 (OM) + 0.676 (CEC) - 166.926	0.735**

M. Coastal Plains Soils (n=27)	R^2
CL = 0.961 (OM) + 0.494 (LL) - 7.932	0.966**
CEC = 0.548 (GI) + 0.310 (CL) + 2.261	0.897**
M2M = 3.506 (GI) + 32.451	0.662**
LL = 0.941 (PI) + 0.784 (CL) + 0.201	0.955**
PI = 0.705 (GI) - 0.584 (OM) + 0.366 (LL) + 5.952	0.944**
GI = -0.135 (CL) + 0.105 (CEC) + 0.326 (OM) - 0.085 (LL) + 0.557 (PI) - 0.115 (MD) + 0.074 (M2M) + 7.279	0.960**
MD = -1.478 (OM) + 133.958	0.906**
OM = -0.397 (MD) + 0.165 (CL) + 56.790	0.958**
PE = No significant terms appears at 0.05 P or 0.01 P	———

N. Sandstone and Siltstone Soils (n=54)	R^2
CL = 1.025 (PI) + 2.772 (OM) + 1.011 (MD) - 142.244	0.903**
CEC = 0.646 (OM) + 0.352 (GI) - 1.368	0.803**
M2M = -3.584 (MD) - 6.551 (OM) + 2.280 (GI) - 1.590 (PI) + 0.955 (LL) + 545.533	0.667**
LL = 1.769 (MD) + 3.642 (OM) - 0.773 (GI) + 1.674 (PI) + 0.247 (M2M) - 256.269	0.929**
PI = 0.208 (CL) + 0.368 +0.205 (LL) - 3.480	0.946**
GI = -0.103 (CL) + 0.398 (CEC) + 0.129 (M2M) - 0.152 (LL) + 0.656 (PI) + 0.259 (MD) + 0.617 (OM) - 0.148 (PE) - 43.646	0.877**
MD = 0.085 (CL) - 2.145 (OM) + 0.157 (GI) + 0.151 (LL) - 0.122 (PI) - 0.084 (M2M) + 145.095	0.953**
OM = 0.051 (CL) + 0.075 (CEC) - 0.373 (MD) + 0.041 (LL) + 54.234	0.969**
PE = 0.590 (OM) - 2.223	0.142**

Appendix Table 4 (Continued)

O. Soils containing 61% or more Clay (n=12)	R^2
CL = 0.855 (CEC) + 2.000 (M2M) - 0.829 (LL) + 11.459 (OM) + 6.817 (MD) - 0.363 (PE) - 1016.501	0.913*
CEC = -4.260 (MD) - 1.659 (M2M) + 568.952	0.579**
M2M = 0.406 (CL) - 0.405 (CEC) + 0.435 (LL) - 5.522 (OM) - 3.308 (MD) + 0.172 (PE) - 497.570	0.969**
LL = 4.136 (OM) - 48.765	0.587**
PI = 0.959 (LL) - 33.164	0.920**
GI = No significant terms appear at 0.05 P or 0.01 P	
MD = -1.387 (OM) + 129.059	0.675**
OM = -0.487 (MD) + 72.611	0.675**
PE = -2.198 (CL) + 30.009 (OM) + 5.144 (M2M) - 2.382 (LL) + 17.500 (MD) + 2.147 (CEC) - 2629.857	0.928*

P. Soils Containing 36 to 60% Clay (n=43)	R^2
CL = 0.518 (GI) + 36.921	0.200*
CEC = 0.482 (LL) + 0.004	0.312**
M2M = 0.817 (PI) - 66.722	0.374**
LL = 0.731 (PI) + 0.609 (OM) - 0.494 (MD) + 68.276	0.937**
PI = 0.745 (GI) - 0.441 (OM) + 0.575 (LL) + 0.315 (MD) - 39.157	0.951**
GI = 0.746 (PI) - 0.360	0.884**
MD = -1.479 (OM) + 132.705	0.806**
OM = -0.545 (MD) + 77.097	0.806**
PE = 0.913 (PI) - 1.756	0.330**

Q. Soils containing 18 to 35% Clay (n=80)	R^2
CL = 2.044 (OM) + 0.763 (MD) - 92.688	0.264**
CEC = -0.435 (MD) + 0.321 (PI) + 57.103	0.680**
M2M = 4.822 (GI) - 1.845 (PI) + 58.445	0.646**
LL = 0.943 (PI) + 0.894 (OM) + 6.001	0.834**
PI = -0.560 (OM) + 0.129 (CEC) - 0.145 (MD) + 0.432 (LL) + 0.763 (GI) - 0.094 (M2M) + 22.403	0.883**
GI = 0.200 (MD) + 0.491 (OM) + 0.600 (PI) - 0.130 (LL) + 0.128 (M2M) - 34.655	0.860**
MD = -2.055 (OM) + 0.168 (CL) + 139.910	0.926**
OM = -0.397 (MD) + 0.081 (LL) + 57.807	0.943**
PE = 1.084 (CEC) - 3.111	0.400**

Appendix Table 4 (Continued)

R. Soils Containing Less Than 18% Clay (n=70)	R^2
CL = 0.795 (CEC) + 1.347 (OM) + 0.724 (MD) - 96.661	0.647**
CEC = 0.542 (OM) + 0.450 (CL) - 3.936	0.593**
M2M = 7.609 (GI) + 29.599	0.841**
LL = 3.360 (PI) + 1.571	0.880**
PI = 0.262 (LL) - 0.087	0.880**
GI = 0.126 (PI) + 0.104 (M2M) - 2.437	0.858**
MD = -2.326 (OM) + 0.391 (CL) + 140.880	0.874**
OM = 0.374 (MD) + 0.155 (CL) + 54.572	0.872**
PE = 0.697 (CEC) - 0.080	0.223**

Appendix Table 5 - Multiple Linear regression equations for mineralogy.

A. Clay Textured Soils (n=29)

Equation [a]	R^2 [b]
K = -0.015 (V) + 0.014 (I) + 0.009 (CEC) + 0.039	0.748**
CEC = 40.864 (K) + 15.494	0.403**
I = 14.561 (K) + 1.154 (Q) + 0.813 (V) - 5.155	0.768**
A = No significant terms appear at 0.05P Or 0.01P.	______
Q = -4.354 (K) + 0.529 (I) - 0.441 (V) + 3.557	0.672**
V = -13.347 (K) - 0.718 (Q) + 0.607 (I) + 6.364	0.564**
M = -1.630 (V) + 29.503	0.172**
Ka = -31.965 (K) - 1.038 (Q) + 0.932 (I) + 21.426	0.528**

a/ K - total potassium (%), CEC - cation exchange capacity (me/100g), I - illite, A - amorphous material, Q - quartz, V - vermiculite, M - montmorillonite, Ka - kaolinite.

b/ (**) and (*) denote R^2 values are significantly different at 0.01P and 0.05P, respectively.

B. Silt and Silt Loam Textured Soils (n=75)

Equation	R^2
K = 0.014 (CEC) + 0.024 (I) -0.012 (Ka) - 0.025	0.458**
CEC = 14.451 (K) + 0.330 (M) + 7.447	0.604**
I = 7.705 (K) + 0.332 (V) + 1.729	0.438**
A = No significant terms appear at 0.05P or 0.01P.	______
Q = No significant terms appear at 0.05P or 0.01P.	______
V = -5.248 (K) + 0.793 (I) + 0.420	0.266**
M = -12.927 (K) + 1.208 (CEC) - 5.655	0.416**
Ka = -6.537 (K) + 0.525 (I) + 3.140	0.204**

C. Loam and Clay Loam Textured Soils (n=27)

Equation	R^2
K = No significant terms appear at 0.05P or 0.01P.	______
CEC = " " " " " " " " "	______
I = " " " " " " " " "	______
A = No significant terms appear at 0.05P or 0.01P.	______
Q = " " " " " " " " "	______
V = " " " " " " " " "	______
M = 25.549 (K) + 0.478	0.112**
Ka = No significant terms appear at 0.05P or 0.01P.	______

Appendix Table 5 (Continued)

D. Sandy loam, Loamy Sand, Sand, Sandy Clay, and Sandy Clay Loam Textured Soils. (n=36)

	Equation	R^2
K	= 0.016 (A) + 0.135	0.262*
CEC	= 19.417 (K) + 4.869	0.149**
I	= -2.354 (K) + 0.355 (V) + 2.256	0.135*
A	= 15.979 (K) - 0.723	0.262**
Q	= -2.002 (K) + 0.589 (V) + 1.543	0.325*
V	= 2.476 (K) + 0.550 (Q) - 0.059	0.329**
M	= -11.590 (K) + 1.115 (A) + 1.048 (I) + 1.803	0.360**
Ka	= No significant terms appear at 0.05P or 0.01P.	———

E. Silty Clay and Silty Clay Loam Textured Soils (n=37)

	Equation	R^2
K	= -0.027 (V) + 0.017 (I) + 0.016 (CEC) - 0.105	0.622**
CEC	= 22.842 (K) - 0.444 (I) + 0.929 (V) + 0.317 (M) + 10.665	0.719**
I	= 14.036 (K) + 1.349 (V) + 0.853	0.612**
A	= No significant terms appear at 0.05P or 0.01P.	———
Q	= " " " " " " " " "	———
V	= -9.733 (K) + 0.254 (CEC) + 0.425 (I) + 0.140 (A) - 0.136 (M) - 1.638	0.726**
M	= -9.657 (K) + 1.311 (CEC) - 0.976 (V) - 5.195	0.513**
Ka	= No significant terms appear at 5 or 1 percent level of probability.	———

F. Horizon A (n=39)

	Equation	R^2
K	= 0.029 (I) + 0.095	0.443**
CEC	= 7.640 (K) + 0.483 (I) + 0.519 (V) + 0.438 (M) + 4.609	0.814**
I	= 5.395 (K) + 0.487 (CEC) - 2.449	0.672**
A	= No significant terms appear at 0.05P or 0.01P.	———
Q	= " " " " " " " " "	———
V	= " " " " " " " " "	———
M	= -3.451 (K) + 0.827 (CEC) - 4.397	0.548**
Ka	= No significant terms appear at 0.05P or 0.01P.	———

G. Horizon B (n=99)

	Equation	R^2
K	= 0.011 (CEC) + 0.043	0.474**
CEC	= 31.002 (K) + 0.282 (M) + 6.650	0.598**
I	= 12.840 (K) + 0.642 (V) + 0.271 (A) - 0.383	0.417**
A	= 1.059 (K) - 0.341 (V) + 0.317 (I) + 2.582	0.145**
Q	= No significant terms appear at 0.05P or 0.01P.	———

Appendix Table 5 (Continued)

G. (Continued)		R^2
V	= -10.375 (K) - 0.221 (A) + 0.528 (I) - 0.121 (Q) + 4.403	0.402**
M	= 0.813 (CEC) - 0.745 (V) + 0.313	0.455**
Ka	= -2.433 (K) + 0.369 (V) + 5.773	0.095*

H. Horizon C and R (n=66)		R^2
K	= 0.015 (Q) + 0.010 (I) - 0.010 (V) + 0.009 (CEC) + 0.028	0.776**
CEC	= 29.052 (K) + 0.642 (M) + 0.997 (V) - 0.604 (I) + 2.931	0.840**
I	= 11.802 (K) - 0.194 (CEC) + 0.867 (V) + 0.595 (Q) + 0.192 (M) + 0.012	0.704**
A	= 3.472 (K) + 1.348	0.089*
Q	= 5.665 (K) + 0.280 (I) + 0.372	0.575**
V	= -4.054 (K) + 0.248 (I) + 1.391	0.202**
M	= -9.314 (K) + 0.888 (CEC) - 1.379 (V) + 0.753 (I) - 2.060	0.805**
Ka	= 3.099 (K) + 0.917 (V) + 2.611	0.144**

I. Plastic Soils (n=163)		R^2
K	= -0.011 (V) + 0.013 (I) + 0.009 (CEC) + 0.070	0.580**
CEC	= 23.048 (K) + 0.417 (M) + 6.786	0.671**
I	= 13.433 (K) + 0.651 (V) + 0.157 (Ka) + 0.213 (Q) + 0.094 (M) - 2.898	0.514**
A	= -2.376 (K) + 0.141 (CEC) + 1.172	0.101**
Q	= 0.243 (I) + 4.639	0.058**
V	= -5.894 (K) - 0.123 (Q) + 0.411 (I) - 0.096 (M) + 4.019	0.369**
M	= -7.736 (K) + 0.876 (CEC) + 0.486 (I) - 0.844 (V) - 0.395 (Ka) + 0.668	0.633**
Ka	= -7.948 (K) + 0.179 (CEC) + 0.321 (I) - 0.178 (M) + 5.543	0.158**

J. Non-Plastic Soils (n=41)		R^2
K	= No significant terms appear at 0.05P or 0.01P.	______
CEC	= 15.545 (K) + 5.654	0.149*
I	= 3.781 (K) + 0.740 (V) + 0.280 (M) + 0.556	0.606**
A	= No significant terms appear at 0.05P or 0.01P.	______
Q	= " " " " " " " " "	______
V	= 1.821 (K) + 0.296 (I) + 0.157	0.0227**
M	= -8.289 (K) + 1.316 (I) + 0.660	0.350**
Ka	= No significant terms appear at 0.05P or 0.01P.	______

Appendix Table 5 (Continued)

K. Alluvial Soils (n=66)	R^2
K = 0.015 (I) + 0.011 (CEC) + 0.033	0.684**
CEC = 17.133 (K) + 0.418 (M) + 0.507 (V) + 0.385 (Ka) + 3.959	0.879**
I = 19.655 (K) + 0.432 (Ka) - 0.754	0.671**
A = 2.911 (K) + 0.762	0.092**
Q = 9.732 (K) + 0.751 (A) + 0.659	0.379**
V = No significant terms appear at 0.05P or 0.01P.	______
M = -13.756 (K) + 1.409 (CEC) - 0.989 (V) - 4.442	0.743**
Ka = -3.219 (K) + 0.418 (I) + 1.503	0.265**

L. Alluvium - Loess Soils (n=99)	R^2
K = 0.020 (CEC) + 0.018 (I) - 0.011 (Ka) - 0.011 (V) - 0.007 (M) - 0.005	0.779**
CEC = 19.930 (K) + 0.610 (V) + 0.409 (M) + 0.329 (Ka) + 3.251	0.873**
I = 14.074 (K) + 0.283 (Ka) - 0.237 (A) + 0.282 (Q) + 0.096 (M) - 1.286	0.705**
A = 0.606 (K) + 0.125 (Ka) - 0.137 (I) + 0.149 (Q) + 0.084 (M) + 0.322	0.231**
Q = 0.433 (I) + 2.523	0.306**
V = -2.912 (K) + 0.185 (CEC) - 0.096 (M) + 1.087	0.140*
M = -21.860 (K) + 1.292 (CEC) - 1.166 (V) + 0.560 (A) + 0.414 (I) - 3.540	0.759**
Ka = -8.086 (K) + 0.174 (A) + 0.297 (I) + 0.163 (CEC) + 1.375	0.261**

M. Coastal Plains Soil (n=28)	R^2
K = -0.062 (V) + 0.029 (I) + 0.171	0.235*
CEC = 5.725 (K) + 1.868 (I) - 0.825 (Q) + 0.635 (M) + 7.107	0.714**
I = 5.375 (K) + 0.887 (V) + 0.457	0.254**
A = No significant terms appear at 0.05P or 0.01P.	______
Q = -11.707 (K) + 0.924 (V) + 0.399 (I) + 0.219 (M) + 2.595	0.542**
V = -2.909 (K) + 0.227 (I) + 0.759	0.274*
M = 14.743 (K) + 1.630 (Q) - 1.309 (I) - 1.826 (V) + 0.698 (CEC) - 5.834	0.751**
Ka = No significant terms appear at 0.05P or 0.01P.	______

Appendix Table 5 (Continued)

N. Sandstone and Siltstone Soils (n=52)	R^2
K = 0.008 (I) + 0.122	0.167**
CEC = 17.792 (K) + 0.344 (Ka) + 6.482	0.364**
I = 12.537 (K) + 0.505 (Ka) + 0.098	0.642**
A = No significant terms appear at 0.05P or 0.01P.	———
Q = No significant terms appear at 0.05P or 0.01P.	———
V = -7.891 (K) + 0.745 (I) + 1.602	0.348**
M = 0.851 (K) + 0.800 (A) + 1.032	0.186**
Ka = -15.230 (K) + 1.019 (I) + 0.436 (CEC) - 1.280	0.681**

O. Soils containing 61% or more Clay (n=12)	R^2
K = -0.017 (V) + 0.017 (I) - 0.012 (A) + 0.009 (CEC) + 0.059	0.990**
CEC = 48.610 (K) - 1.376 (I) + 32.257	0.816**
I = 57.347 (K) + 0.950 (V) + 0.669 (A) - 0.547 (CEC) - 2.237	0.978**
A = -65.654 (K) - 1.101 (V) + 1.091 (I) + 0.623 (CEC) + 4.191	0.804*
Q = No significant terms appear at 0.05P or 0.01P.	———
V = -30.087 (K) + 20.835	0.674**
M = No significant terms appear at 0.05P or 0.01P.	———
Ka = No significant terms appear at 0.05P or 0.01P.	———

P. Soils containing 36 to 60% Clay (n=43)	R^2
K = -0.020 (V) + 0.013 (I) + 0.011 (CEC) + 0.030	0.484**
CEC = 28.354 (K) + 0.461 (A) - 0.376 (Q) + 15.709	0.466**
I = 16.607 (K) + 1.395 (V) - 0.176	0.539**
A = No significant terms appear at 0.05P or 0.01P.	———
Q = 8.359 (K) + 4.167	0.113*
V = -7.380 (K) + 0.348 (I) + 1.792	0.500**
M = 1.054 (CEC) - 7.468	0.428**
Ka = -17.346 (K) + 15.546	0.177*

Q. Soils Containing 18 to 35% Clay (n=78)	R^2
K = 0.013 (I) + 0.011 (CEC) - 0.011	0.362**
CEC = 9.151 (K) + 0.444 (M) + 8.632	0.635**
I = 11.803 (K) + 0.321 (V) + 1.283	0.340**
A = No significant terms appears at 0.05P or 0.01P.	———
Q = No significant terms appears at 0.05P or 0.01P.	———

Appendix Table 5 (Continued)

Q. (Continued)	R^2
V = -7.940 (K) + 0.511 (I) + 2.756	0.170**
M = 1.138 (CEC) - 8.072	0.582**
Ka = -4.176 (K) + 0.2411 (A) + 0.315 (I) - 0.208 (M) + 5.795	0.276**

R. Soils Containing Less than 18% Clay (n=71)	R^2
K = 0.014 (CEC) + 0.039	0.192**
CEC = 13.501 (K) + 0.635 (V) + 0.292 (M) + 4.423	0.516**
I = 2.789 (K) + 0.361 (V) + 2.069	0.155**
A = 3.109((K) - 0.167 (CEC) + 0.133 (M) + 1.796	0.136*
Q = No significant terms appear as 0.05P or 0.01P.	———
V = -2.933 (K) + 0.218 (CEC) + 0.341 (I) - 0.136 (M) - 0.299	0.321**
M = -17.744 (K) - 1.255 (V) + 1.250 (CEC) - 1.475	0.391**
Ka = No significant terms appear at 0.05P or 0.01P.	———

3529