VOLUME III
GEOTECHNICAL INTERPRETIVE REPORT
ISLES DERNIERES STABILIZATION PROJECT
STATE PROJECT NO. 750-55-01
TERREBONNE PARISH, LOUISIANA

REPORT TO

J. WAYNE PLAISANCE, INC./T. BAKER SMITH & SON, INC.
HOUMA, LOUISIANA

McClelland engineers

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GEOTECHNICAL INTERPRETIVE REPORT
ISLES DERNIERES STABILIZATION PROJECT
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Report

to

J. WAYNE PLAISANCE, INC./T. BAKER SMITH & SON, INC.

Houma, Louisiana

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McCLELLAND ENGINEERS, INC.
Geoscience Consultants
Westlake, Louisiana

December 1987

McClelland engineers

Report No. 1087-1328
Volume III
December 23, 1987

J. WAYNE PLAISANCE, INC./T. BAKER SMITH & SON, INC.
550 South Van
Houma, Louisiana 70361

Attention: Mr. Marc Rogers, P.E., Project Manager

Geotechnical Interpretive Report
Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Mr. Rogers, we are pleased to submit Volume III, of a three-volume report, for the geotechnical services performed for the proposed Isles Dernieres Beach Stabilization Project. This work was authorized in writing by Mr. Rogers on April 7, 1987, and our services were performed in general accordance with the signed agreement dated February 16, 1987. During the project, minor changes to the scope of work and method of data presentation were made in order to address the concerns of the design professionals involved with this project and as a result of the encountered soil conditions.

Volume III is our Geotechnical Interpretive Report and it presents the results of our geotechnical engineering studies for the proposed stabilization program. Volume I, submitted under separate cover, describes field and laboratory testing procedures and explains our method of data presentation for the three island segments. Volume II describes the laboratory testing procedures and explains our method of data presentation for the proposed borrow areas. This document will also be submitted as a separate document. At various times during this project, we provided preliminary findings to the design team members. The information in the above referenced reports supersedes and replaces all previous data.

Mr. Rogers, we appreciate the opportunity to be of service to you and the design team on this initial phase of this very important study. We look forward to working with you on later phases of the study. After you receive this report, we will call you to answer your questions.

Sincerely,
McCLELLAND ENGINEERS, INC.

Andrew L. Shafer
Project Engineer

David E. Lourie, P.E.
Division Manager

ALS/DEL/me(R14.32)
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EXECUTIVE SUMMARY

A reconnaissance study was conducted as part of a comprehensive study for the proposed beach stabilization project for Isles Dernieres. McClelland Engineers performed field and laboratory studies on the three-island segments. Our field operations consisted of more than 3300 lin ft of cone penetrometer testing at 180 locations on the islands. A field investigation program was performed by Ocean Surveys, Inc., in the proposed borrow source areas north of Isles Dernieres. They used vibracoring methods to explore seafloor conditions at 256 locations to penetrations of about 20 ft. The samples obtained from the vibracoring were submitted to McClelland for laboratory testing.

The results of our involvement in this study are presented in three volumes, all submitted under separate cover. Volume III, the Geotechnical Interpretive Report, is presented here. This volume provides geotechnical recommendations for preliminary design of the beach restoration program. Volume I contains information from the islands including a description of our involvement, cone penetrometer data, and laboratory test results. Volume II contains a description of our laboratory testing program, the vibracore logs, and laboratory test results from the borrow area soils.

This report presents our interpretation of the geotechnical aspects of the data developed during this study. Specifically, the engineering properties that were characterized during the field and laboratory investigations have allowed us to select five subsurface design soil profiles for the three islands. Site-specific data together with our experience have been used to conduct analyses for: 1) foundation bearing capacity, 2) retention dike slope stability, and 3) long-term foundation settlement. A complete description of our methods of interpretation and analyses is presented in this report. The Illustrations section of this report contains the results our interpretations and of most of our analyses in an easy-to-use tabular format.

INTRODUCTION

Background

The Isles Dernieres is a low profile barrier island chain located along the Gulf Coast of Louisiana in Terrebonne Parish. The islands are about 4 to 6.5 mi south of the mainland and are separated from the mainland by lakes and bays. Currently, the island chain is relatively undeveloped and consists of three island segments: East Island, Middle Island, and West Island. These three island segments contain about 16 mi of coastline along the Gulf side, and the width of the islands varies between about 200 and 5000 ft. The islands are separated from each other by breaches and passes. Plan views of the islands are shown in Volumes I and II.

Reportedly, the entire island system is both migrating landward and eroding. Historical records indicate that in the mid-1800s the islands were separated from the mainland by only a quarter of a mile. The islands were also less fragmented and had a greater area. Currently, the island area is less than about one third of the area believed to present in the late 1800s. Since about 1850, Lake Pelto has increased significantly in size due to a number of factors including relative sea level rise and subsidence. It is estimated that the islands have migrated landward by about 0.6 mi since the mid-1800s. Furthermore, Isles Dernieres is estimated to be retreating at a rate of 30 to 90 ft per year. Although erosion is occurring due to a number of factors, erosion of the islands is caused primarily by hurricanes. The information presented here concerning the background of Isles Dernieres was provided by The Traverse Group during this study.

Project Description

In response to concerns about the loss of Isles Dernieres, a comprehensive study has been undertaken for a proposed beach stabilization project. The proposed beach stabilization project conceptually consists of nourishing the islands using dredged materials obtained from north of the islands. Other aspects of the project may include the construction of coastal structures. The locations of the proposed borrow areas are shown in Volume II.

During the course of this project, we have communicated with various members of the project team through meetings, phone conversations, and written correspondence. This interaction has been with representatives from T. Baker Smith & Son, Inc.; The Traverse Group, Inc.; and Ocean Surveys, Inc. We have also discussed key aspects of our field and laboratory programs with the Louisiana Department of Transportation and Development. Furthermore, we have supplied unused portions of the vibracore samples to the Louisiana Geological Survey and Louisiana State University.

Report Format

The initial sections of this report describe our involvement with this project and provide an overview of the various documents that support the interpretations and findings presented here. Next, we describe the geotechnical engineering aspects of the foundation soils on the islands. Our methods of analysis together with our findings and recommendations complete the text. Illustrations developed for this study follow the text and complete Volume III.

Purposes and Scope of Services

In order for the other members of the project team to identify and select appropriate beach stabilization alternatives within the framework of the concepts planned for Isles Dernieres, it was necessary to investigate subsurface conditions on the islands and in the proposed borrow areas. The purposes of our involvement on the islands and in the borrow areas were to:

- o Develop site-specific information on subsurface conditions on the islands and in the proposed borrow areas,
- o Evaluate the data collected on the islands, and
- o Provide preliminary geotechnical design recommendations for the proposed beach stabilization project.

To accomplish these purposes, the components of the reconnaissance study on the islands and in the borrow areas included the following:

- o Conducting shallow cone penetrometer soundings on the three islands at locations specified by T. Baker Smith & Son, Inc.,
- o Obtaining bag samples of the surficial soils at each cone sounding location,
- o Interpreting the cone data using well-established correlations with the aid of our in-house computer program,

- Transporting the vibracore samples obtained from the proposed borrow areas by Ocean Surveys, Inc. (OSI), from the dock in Cocodrie, Louisiana to our laboratory,
- Performing laboratory tests to verify visual classification, and to determine water content, remolded shear strength, moisture-density-shear strength relationships, and maximum-minimum densities,
- Summarizing the field and laboratory data we developed during the study and preparing Geotechnical Data Reports presenting the results of our field and laboratory testing programs,
- Analyzing the field and laboratory data, and developing preliminary recommendations to guide planning and construction of beach stabilization concepts, and
- Preparing a Geotechnical Interpretive Report presenting our evaluation of the data, results of our engineering analyses, and the recommendations we developed.

Relevant McClelland Reports

In 1959, McClelland Engineers conducted a subsurface investigation for the State of Louisiana Department of Public Works as part of a beach erosion control study from Belle Pass to Raccoon Point. As part of that study, a total of five borings penetrating from 20 to 50 ft were drilled and sampled on Isles Dernieres. The results of that study are presented in McClelland Engineers Report No. N5905, dated January 13, 1960.

The data and recommendations developed during this reconnaissance study are presented in three volumes for the islands and the borrow areas and are reported as follows:

- Volume I consists of Volumes I, Ia, Ib, and Ic. Volume I provides an overview of our methods and procedures for our field and laboratory investigations on the islands. Volumes Ia through Ic contain field and laboratory data from the islands.
- Volume II consists of Volumes II, IIa, IIb, and IIc. These volumes discuss our involvement and present data from the proposed borrow areas.
- Volume III, the Geotechnical Interpretive Report, is presented here and it contains the results of our engineering analyses.

Limitations

Subsurface Conditions. Our conclusions about subsurface conditions presented in this report are based on the information disclosed by the widely spaced, shallow cone penetrometer soundings we performed and the vibracore samples obtained by OSI for this study. Although we have allowed for minor variations in subsurface conditions, our recommendations may not be appropriate for other soil conditions. If project design concepts change, or if different soil conditions are encountered during construction, we should be advised and retained so that we may review our recommendations and, if necessary, revise our conclusions.

Use of Data. We have prepared this report for the exclusive use of the Owner and Engineer for evaluating the design of the project as it relates to our interpretation of the geotechnical aspects discussed here. It should be made available to prospective contractors for information only and not as a warranty of subsurface conditions described in this report. The data presented here should be used in conjunction with the information presented in Volumes I, Ia through Ic, II, and IIa through IIc developed for this project.

GENERALIZED SITE CONDITIONS

Island Areas

One hundred and eighty cone penetrometer tests (CPTs) were performed to penetrations between 10 and 43 ft on the three islands. With a total of about 3330 lin ft of cone soundings conducted for this study, the average sounding penetration was about 18 ft. Since most of the beach stabilization concepts involve placing dredge materials or coastal structures on the islands, it was necessary to identify the near-surface soil conditions as well as the properties of the foundation soils for our geotechnical engineering analyses.

Surface Conditions. The three islands typically have very little vertical relief and have surface elevations on the order of 3 to 6 ft above the Gulf level. On the Gulf of Mexico side of the islands, a fine sand beach area is generally present. Behind the beach, dunes in various stages of development are sometimes present. A mangrove marsh occasionally occurs on the back side of the island that borders the back bays. At the locations where we conducted our CPTs, clean fine sand with a few shells was often present at the ground surface. In the marsh areas, highly plastic and organic clays were encountered.

Subsurface Conditions. Using our interpretation of the CPT data, we developed the five generalized design profiles presented on Plates 1 through 5. Because of the relatively complex and variable subsurface conditions on the islands, it was not possible to select only one profile for an island nor was it possible to identify the precise location of the transition from one design profile to another. The primary criteria we used in selecting the various design profiles was the similarity in geotechnical engineering properties of the different strata. This included stratum thickness, the depth at which the stratum was encountered, and strength properties of the soils. Since sample borings were beyond the scope of this project, the different strata selected for each design profile are based on published cone penetrometer correlations rather than site-specific correlations. Therefore, we did not attempt to differentiate between minor changes in soil classification; rather, we separated the soils into profiles consisting primarily sands and clays. Below about 20-ft penetration, we assumed that clays were present.

Borrow Areas

A stratigraphic interpretation or profiling of the borrow areas is beyond our scope of work on this project. However, we understand that OSI will characterize the proposed borrow locations using the laboratory data presented in Volumes II and IIa through IIc together with other information. For use in our engineering analyses, we considered the borrow soils to be either highly plastic clays or silty fine sands to sandy silts.

GEOTECHNICAL ENGINEERING SOIL PROPERTIES

General

The geotechnical engineering soil properties of the near-surface island soils and the borrow area soils were determined using the laboratory tests outlined in Volumes I and II. A summary of the types and numbers of tests performed for this study is presented below.

Test Type	Number of Tests
Mechanical grain size analysis	498
Hydrometer analysis	180
Liquid and plastic limit tests	87

Test Type	Number of Tests
Water content measurements	157
Remolded miniature vane tests	81
Standard Proctor tests	4
Minimum-maximum density determinations	4

As noted previously, well-established published correlations of cone penetrometer data were used to obtain the primary engineering properties of the subsurface soils on the islands. Other sources of information include our general Company experience and published data for similar onshore and offshore Gulf Coast soils. Plate 6 presents a summary of the design soil parameters we used in our various analyses. Additional information concerning the selection of these parameters is presented below.

Classification and Strength Parameters

Cohesive Soils. For the cohesive soils on the islands, we relied primarily on our interpretation of the CPT data. Correlations of friction ratio (FR) and cone bearing resistance (q_c) indicate that most of the cohesive soils exhibit characteristics of highly plastic or organic soils. Sensitive fine grained soils are also encountered and these may consist of plastic silts or sensitive clays.

Based on our interpretation of the CPT data, CPT-determined undrained shear strengths range from less than about 20 psf to greater than about 1500 psf. However, for the typical subsurface conditions present on the islands, values on the order of 200 psf are common. In general, shear strengths appear to be relatively constant with depth. Occasionally, slightly stronger soils appear to be present near the surface, but these increases are minor and may be due seasonally occurring desiccation.

For the borrow area clays, classification and water content tests indicate they are highly plastic and often their water contents are near or above their liquid limits. In general, this implies these soils are weak and are capable of experiencing significant volume changes. Remolded miniature vane tests performed at the natural water contents indicated undrained shear strengths ranging from about 25 to 200 psf, with values of about 40 psf being common. We estimate that the sensitivity of these soils (the ratio of the peak undrained shear strength to remolded undrained shear strength) is about 2 to 3.

<u>Granular Soils</u>. The CPT data suggest that the granular soils are primarily fine sands or silty fine sands. Sandy silts and clayey silts are also encountered. Although gravelly sands are occasionally indicated, we believe that these are probably shell deposits. The granular soils are typically present in a medium-dense to dense condition; however, loose and very dense materials also are encountered. CPT-interpreted friction angles for these soils usually range between about 30 and 44 degrees. Typically, for soils along the Gulf Coast, medium-dense fine sands are assumed to have a friction angle of 35 degrees while friction angles in medium-dense silty fine sands are taken to be 30 degrees.

The borrow area granular soils appear to be somewhat finer grained than the island soils, and sandy silts to silty fine sands are more common. In addition, clayey silts were also encountered. Information is not available to us to estimate the in-place density of these soils, but we believe they are likely to be in a loose to medium-dense condition. Typically, an internal friction angle of 25 degrees is used for sandy silts.

One of our observations in the laboratory that may be indicative of field performance during dredging, is that these fine grained soils remained in suspension during the hydrometer tests for significant periods of time. This implies that since clays and silts settle from suspension at a much slower rate than sand, effluent problems may be encountered in the discharge water because of the greater turbidity. In addition, the resulting dredge material is likely to have high water content, low density, low strength, and high compressibility.

<u>Other Parameters</u>

<u>Compressibility Characteristics</u>. To estimate the stress history of the clay soils within the upper 20 ft, we compared our interpreted shear strength of 200 psf with the shear strength value that would be expected in a normally consolidated deposit with similar plasticity characteristics (liquid limit of about 70 and a plasticity index of about 43). For our analyses, we selected a ratio of undrained shear strength (s_u) to effective overburden pressure (p') of 0.27 to be representative of the normally consolidated clay. The comparisons of expected shear strength in a normally consolidated deposit with that used for design (200 psf), indicate that the

soils are moderately overconsolidated near the surface and are approximately normally consolidated at 20-ft penetration. Below 20 ft, we assumed normally consolidated clays were present.

To estimate the value of the virgin compression index (C_c), we used a relationship developed by McClelland, B.[1] for Mississippi River clays that relates the liquid limit to C_c. For the overconsolidated clays above 20-ft penetration, we estimated that the value of the recompression index (C_r) would be on the order of 15 percent of C_c.

Total Unit Weight. Our estimated values for total unit weight are based on our experience with similar soils as well as the laboratory tests performed for this project.

Specific Gravity. Although we did not conduct specific gravity tests for this project, our experience suggests that typical values for silty fine and fine sands from the Gulf of Mexico are about 2.65 to 2.67. Clays are typically on the order of 2.70 to 2.75.

ENGINEERING ANALYSES, RECOMMENDATIONS, AND CONCLUSIONS

General

The design concepts for this project entail placing dredged soils over portions of the island and/or constructing coastal structures. Therefore, our engineering analyses were focused on determining the bearing capacity of the foundation soils, the stability of possible retention dikes, and the magnitude of settlement of the foundation soils.

Bearing Capacity

We calculated the ultimate bearing capacity of the foundation soils for each of the five design profiles described on Plates 1 through 5. Using the design soil parameters presented on Plate 6, we have summarized the results of our bearing capacity computations as shown on Plate 7. In general, these equations are appropriate for vertical loads applied at the ground surface. For our analyses, the weakest soil at or near the ground surface was assumed

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(1) McClelland, B. (1967), "Progress of Consolidation in Delta Front and Prodelta Clays of the Mississippi River", University of Illinois Press, pg 22-40.

to be 200 psf, and this is the condition assumed to prevail at locations represented by Design Profile IV. At locations where sands are present over the clays, we have assumed that the load would be transmitted to the underlying weaker clay using a load spread of 4-vertical on 1-horizontal.

Slope Stability

General. We understand that retention dikes may be constructed on the islands to assist with dredging operations. Discussions with personnel from T. Baker Smith & Son, Inc., indicate that on-island soils will be used to construct the dikes. Therefore, the primary construction materials are likely to be fine sands and very soft clays. In general, two primary failure modes were considered to be significant. First the external stability of the constructed embankment, i.e., deep-seated failure of the foundation soils. The second mode of failure is within the embankment itself. The stability of fill slopes built on soft and very soft subsoils depends on:

- The strength of the fill,
- The unit weight of the fill,
- The height of the fill,
- The slope angle, and
- The strength of the foundation.

The critical failure mechanism is usually sliding on a deep surface tangent to the top of a firm layer within the foundation. A large part of the failure surface lies within the foundation, especially when the weak soils are present to significant depths. Embankment failures on weak clay foundations often occur progressively because of differences in the stress-strain characteristics of the embankment and the foundation.

Design Approach. For our analyses, we considered embankments constructed on the five design profiles together with the soil parameters presented on Plate 6. We selected two fill heights, two fill materials, and at least two slope angles for each case that we analyzed. The design conditions are summarized on Plate 8. Since the clay soils that will be used within the embankment and that are present in the foundation are very soft to soft, undrained analyses were considered to be appropriate and representative of conditions during and shortly after construction. We believe this approach will be somewhat conservative for long-term conditions because strength gains in the soil are likely to occur with time due to consolidation of the foundation soils.

Theoretical Method of Analysis. For this study, we evaluated slope stability with our computer program (STABL) that uses the Modified Bishop Method of Slices for circular shaped failure surfaces. This method assumes that interslice forces on each side of the wedge are equal and act at the same point. Potential circular shaped failure surfaces are pseudo-randomly generated from a specified number of initiation points along the ground surface. From each initiation point, a specified number of trial surfaces are generated. Using this technique, the computer searches for the circular surface having the lowest calculated factor of safety (the "critical circle").

For the slope geometries and the soil profiles analyzed in this study, hundreds of failure surfaces were analyzed for each case. The computer analyzes these surfaces in its search and the factor of safety for the ten most critical of the trial failure surfaces examined are printed out for each run. Plate 8 summarizes the results of our analyses. The coordinates and radii of the critical circle are also shown on Plate 8.

Settlement of the Foundation Soils

General. We performed settlement analyses for various sizes of flexible foundations and two values of sustained bearing pressures applied at the ground surface. For the five design profiles, we used the compressibility parameters that are discussed above for the clays and are shown on Plate 6. In addition, we assumed that clays having similar compressibility characteristics were present between 20- and 175-ft penetration. Since the clays are expected to be the source of most of the foundation settlement, we assumed that the sands would be relatively incompressible.

Theoretical Method of Analysis. Using estimated values of soil unit weights and assuming the water table to be at the ground surface, we were able to compute the existing stresses in the foundation soils. Computation of the distribution of the applied pressure is based on the Boussinesq equation for vertical stress in an elastic, isotropic, homogeneous, semi-infinite mass due to a load. This equation is incorporated into our computer program GENSET and allows us to develop settlement estimates. Our ranges of computed settlements for various sizes of loaded areas and sustained pressures are summarized on Plate 9. These values are for the center of the loaded areas and edge settlements will likely be about 50 to 75 percent of the computed center settlement.

To obtain the total amount of settlement for an embankment or for dredged soils requires adding the settlement within the embankment or dredge soils to the values presented on Plate 9. Calculation of these additional settlements are beyond our scope of work on this project.

Rate of Settlement. Although we have assumed that clays are present below 20-ft penetration for determining magnitudes of settlements, it is reasonable to assume that granular seams and layers are present. The presence of these strata together with the seams and layers present within the upper 20 ft indicate that consolidation settlements should occur fairly rapidly. Based on our experience, we expect that about 30 to 50 percent of the ultimate computed settlement of the foundation soils will occur during material placement and within about 1 yr after construction. After about 5 yr, we estimate that about 80 to 95 percent of the ultimate settlement will have occurred.

Factors of Safety

Factors of safety in foundation design are selected based on engineering judgment and experience to provide an acceptably small likelihood of failure. The selection process must consider the magnitude and probability of the loading, the accuracy of the soil information, the uncertainty inherent on the analytical procedures, and the consequences of a failure.

Continuing application of theory to foundation design over the years has eliminated some of the uncertainties with respect to the selection of an appropriate factor of safety. The major uncertainty in the selection of the factor of safety is therefore the accuracy of the soil data developed. When soil data are sparse, as from a preliminary program with widely-spaced shallow cone penetrometer soundings, it is our usual practice to select preliminary design soil parameters in the range between the lower bound and mean values. With additional soil data, these design soil parameters may be increased.

Tabulated below are typical ranges for factors of safety for various design cases.

Design Case	Range in Acceptable Factors of Safety
Bearing capacity	1.5 to 3.0
Slope stability	1.2 to 1.5

In general, with the selection of lower factors of safety, the likelihood of failure will increase. Furthermore, variations in soil conditions from those used in our analyses may reduce the computed factors of safety.

CONSTRUCTION MONITORING

Prior to beginning construction, we recommend that a performance monitoring program be developed. The primary purposes of this program are to:

- o Verify design approach,
- o Provide construction control,
- o Control rate and placement of fill, and
- o Maintain safety of the embankment against failure.

Some of the variables that should be monitored and evaluated during construction of the beach stabilization project include:

- o Embankment strength,
- o Pore pressure of the foundation soils, and
- o Settlement and heave of the foundation soils.

Through proper monitoring and evaluation of significant variables, a properly planned and implemented program will monitor actual behavior during construction so that procedures and/or schedules can be determined or revised. Therefore, we recommend that we be retained to develop an adequate monitoring program prior to construction. During construction, our personnel should be onsite to observe and monitor actual construction performance, and if necessary, recommend modifications to the construction procedures.

I L L U S T R A T I O N S

Subsurface conditions for this design soil profile are based on cone penetration data compiled from cone soundings 46 N, M, and S through 53 N, M, and S; and 11 M through 19 M.

Stratum I: Stratum I occurs from the ground surface to a depth of about 2 ft. The material consists of loose to medium-dense fine sand.

Stratum II: Stratum II occurs from about 2 ft below the surface and extends to about 7 ft below the surface. The Stratum II material consists of very soft to soft, highly plastic, organic and inorganic clays.

Stratum III: Stratum III occurs from about 7 ft below the ground surface to the bottom of the cone soundings, which was generally about 20 ft below the surface. The Stratum III material consists of medium-dense to dense fine sand.

Note: The approximate depths of Strata referenced above were found at the time of the investigation. Recent erosion and deposition may cause referenced depths to vary.

DESIGN PROFILE I

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Subsurface conditions for this design profile are based on cone penetration data compiled from cone soundings 53 M through 57 M; 32 N, M, and S through 45 N, M, and S; 19 N and M through 27 N and M; and 19 S through 31 S.

Stratum I: Stratum I occurs from the ground surface to about 5 ft below the surface. The Stratum I material consists of loose to dense fine sands. The sand at the surface is loose, but increases in density with an increase in depth.

Stratum II: Stratum II occurs from about 5 ft to 17 ft below the surface. The Stratum II material consists of very soft to soft, highly plastic, organic and inorganic clays.

Stratum III: Stratum III occurs about 17 ft below the ground surface to the bottom of the cone soundings, which generally was about 20 ft. The Stratum III material typically consists of medium-dense to dense fine sands.

Note: The approximate depths of Strata referenced above were found at the time of the investigation. Recent erosion and deposition may cause referenced depths to vary.

DESIGN PROFILE II

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Subsurface conditions for this design soil profile are based on cone penetration data compiled from cone soundings, 1 S through 19 S; 1 M through 11 M; and 53 N through 57 N.

Stratum I: Stratum I occurs from the ground surface to a depth of about 2 ft. The material which makes up Stratum I generally consists of loose to medium-dense sand.

Stratum II: Stratum II occurs about 2 ft below the ground surface and extends to the bottom of the cone soundings, which typically was about 20 ft. The Stratum II material generally consists of very soft to soft, highly plastic, organic and inorganic clays.

Note: The approximate depths of Strata referenced above were found at the time of the investigation. Recent erosion and deposition may cause referenced depths to vary.

DESIGN PROFILE III

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Subsurface conditions for this design soil profile are based on cone penetration data compiled from cone soundings 1 N through 19 N.

Stratum I: Stratum I occurs from the ground surface to a depth of about 7 ft. The Stratum consists of very soft to soft, highly plastic, organic and inorganic clays.

Stratum II: Stratum II occurs from about 7 ft below the ground surface to the bottom of the cone soundings, which generally was about 20 ft below the surface. The Stratum II material consists of medium-dense to dense fine sands.

Note: The approximate depths of Strata referenced above were found at the time of the investigation. Recent erosion and deposition may cause referenced depths to vary.

DESIGN PROFILE IV

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Subsurface conditions for this design soil profile are base on cone penetration data compiled from cone soundings 27 N through 31 N and 53 S through 57 S.

Stratum I: Stratum I occurs from the ground surface to a depth of about 15 ft. The Stratum typically consists of loose to dense fine sand. The surficial sand is loose, but its' density increases with an increase in depth.

Stratum II: Stratum II occurs from about 15 ft below the ground surface to the bottom of the cone soundings, which generally was about 20 ft below the surface. The Stratum II material typically consists of very soft to soft, highly plastic, organic and inorganic clays.

Note: The approximate depths of Strata referenced above were found at the time of the investigation. Recent erosion and deposition may cause referenced depths to vary.

DESIGN PROFILE V

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Design Profile	Stratum	Depth, ft From	To	Primary Soil Type	Total Unit Weight, pcf	Undrained Shear Strength, psf	Internal Friction Angle, deg	Virgin Compression Index
Dike	---	---	--	Clay	94	80	0	N.A.
Dike	---	---	--	Sand	110	0	30	N.A.
I	I	0	2	Sand	120	0	30	N.A.
	II	2	7	Clay	94	200	0	0.583
	III	7	20	Sand	125	0	35	N.A.
II	I	0	5	Sand	120	0	30	N.A.
	II	5	17	Clay	94	200	0	0.583
	III	17	20	Sand	125	0	35	N.A.
III	I	0	2	Sand	120	0	30	N.A.
	II	2	20	Clay	94	200	0	0.583
IV	I	0	7	Clay	94	200	0	0.583
	II	7	20	Sand	125	0	35	N.A.
V	I	0	15	Sand	120	0	30	N.A.
	II	15	20	Clay	94	200	0	0.583

Notes:

1) Profiles I through V are based on our interpretation of the cone penetrometer data obtained during this study and our experience with similar soils.
2) The profiles and conditions described above are based on shallow, widely spaced data points and locallized variations are likely.
3) Depths presented above are referenced to the ground surface present at the time of our study.
4) Below 20-ft depth, normally consolidated clays are assumed to be present.

DESIGN SOIL PARAMETERS

Isles Dernieres Stabilization Project--Island Areas
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Foundation Design Profile	Ultimate Bearing Capacity Equations
I	$Q_{ultimate} = 1000\ [1+0.2\ \frac{B+1}{L+1}]$
II	$Q_{ultimate} = 1000\ [1+0.2\ \frac{B+2.5}{L+2.5}]$
III	$Q_{ultimate} = 1000\ [1+0.2\ \frac{B+1}{L+1}]$
IV	$Q_{ultimate} = 1000\ [1+0.2\ \frac{B}{L}]$
V	$Q_{ultimate} = 1000\ [1+0.2\ \frac{B+7.5}{L+7.5}]$

Notes:

1) See Plate 6 for a description of the soil design profiles and paramenters.

2) The ultimate bearing capacity equations presented above are based on vertical loads applied at the ground surface. At locations where weak and/or organic clays are present near the surface, ultimate bearing capacities will be significantly less and failures are likely.

3) In the above, the ultimate bearing capacity, $Q_{ultimate}$, is in psf and:

   B = Footing width, ft

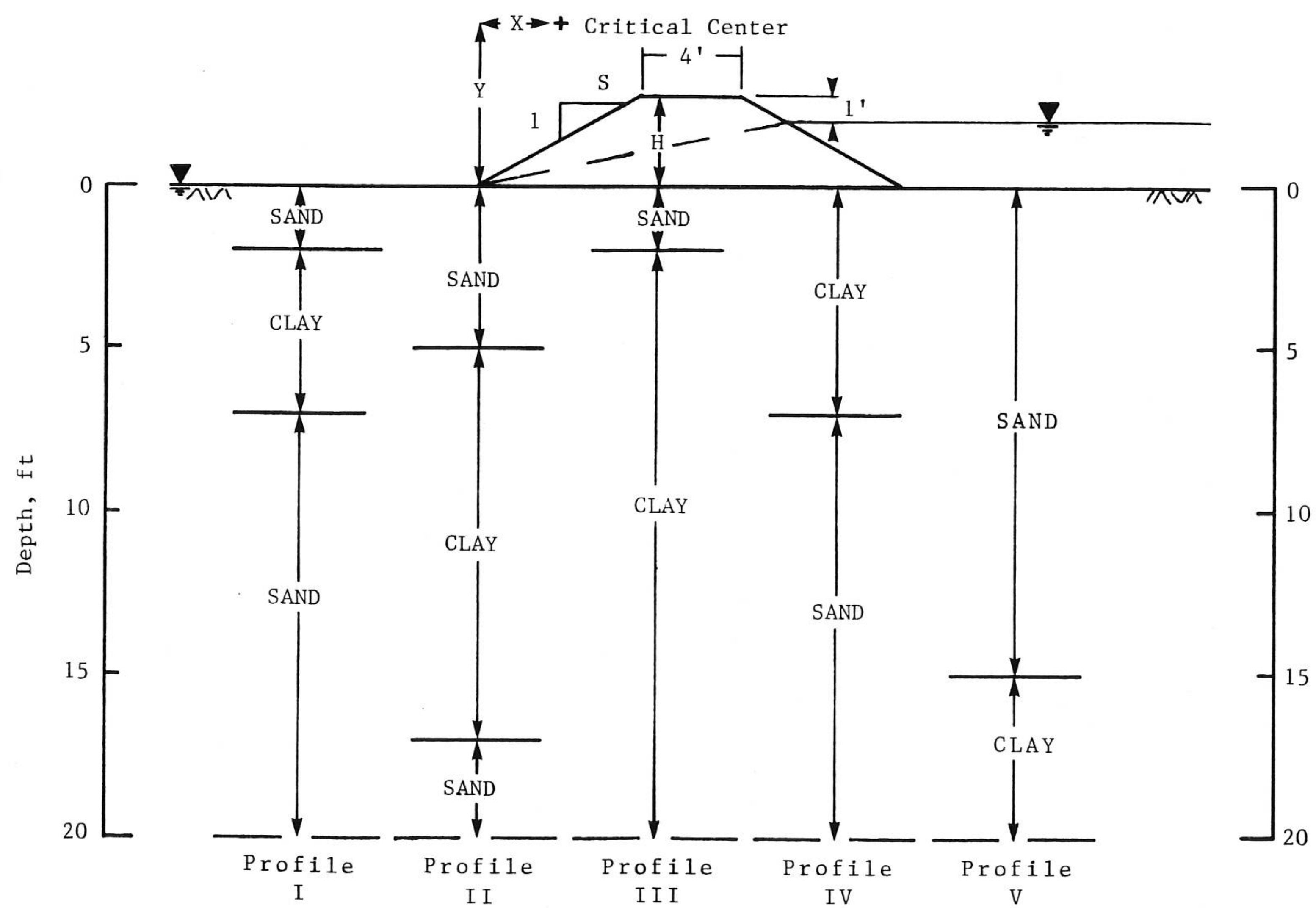
   L = Footing length, ft

4) See text for discussion of factors of safety.

DESIGN PROFILE BEARING CAPACITY EQUATIONS

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Notes: 1) See Plate 6 for a description of the soil design profiles and parameters.
2) At locations where weak and/or organic clays are present near the surface, computed factors of safety will be less.
3) See text for discussion of factors of safety.



H, Dike Height, ft	Foundation Profile	Dike Material	S, Dike Side Slope	Minimum Factor of Safety	Coordinates and Radii of Critical Circles X, ft	Y, ft	Radius, ft
3	I	Clay	1.5	1.57	2.7	4.7	6.0
"	II	"	"	1.57	2.7	4.7	6.0
"	III	"	"	1.57	2.7	4.7	6.0
"	IV	"	"	1.96	1.8	6.0	6.1
"	V	"	"	1.57	2.7	4.7	6.0
3	I	Clay	3	1.89	3.8	9.9	11.5
"	II	"	"	1.81	3.7	6.4	8.6
"	III	"	"	1.89	3.8	9.9	11.5
"	IV	"	"	2.03	6.3	6.1	9.0
"	V	"	"	1.81	3.7	6.4	8.6
3	I	Sand	1.5	0.87	0.0	4.8	5.0
"	II	"	"	0.87	0.0	4.8	5.0
"	III	"	"	0.87	0.0	4.8	5.0
"	IV	"	"	0.91	0.2	5.1	5.0
"	V	"	"	0.87	0.0	4.8	5.0
3	I	Sand	3	1.55	2.6	10.4	11.3
"	II	"	"	1.55	2.6	10.4	11.3
"	III	"	"	1.55	2.6	10.4	11.3
"	IV	"	"	1.76	3.2	11.5	10.1
"	V	"	"	1.55	2.6	10.4	11.3
10	I	Clay	3	0.83	19.7	22.5	23.6
"	II	"	"	0.62	13.7	26.0	30.2
"	III	"	"	0.82	19.8	20.7	22.2
"	IV	"	"	0.65	13.6	16.9	22.8
"	V	"	"	0.62	13.7	26.0	30.2
10	I	Clay	5	1.12	32.4	20.1	21.6
"	II	"	"	0.81	20.7	53.1	57.6
"	III	"	"	1.12	32.4	20.1	21.6
"	IV	"	"	0.85	30.6	19.3	25.4
"	V	"	"	0.70	28.3	22.6	31.8
10	II	Clay	7	1.18	28.9	90.4	93.7
"	IV	"	"	1.00	44.4	32.0	37.6
"	V	"	"	0.72	39.2	43.4	56.3
10	V	Clay	10	0.84	46.4	80.7	100.2
10	I	Sand	3	1.13	13.6	16.9	22.8
"	II	"	"	1.14	12.1	25.0	36.9
"	III	"	"	1.06	14.0	23.6	34.0
"	IV	"	"	1.30	10.4	26.7	29.2
"	V	"	"	1.24	10.4	26.7	29.2
10	I	Sand	5	1.57	28.0	29.8	36.8
"	II	"	"	1.24	26.3	35.5	49.6
"	III	"	"	1.19	26.1	39.0	56.6
"	IV	"	"	1.89	20.7	53.1	57.6
"	V	"	"	1.82	9.3	81.3	83.2

SLOPE STABILITY SUMMARY

End-of-Construction Conditions
Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne Parish, Louisiana

Design Profiles	Sustained Bearing Pressure, psf	Footing Width, ft	Range of Estimated Settlements, ft
		<50	<0.5
I, II, III, IV, V	330	50-150	0.5-1.0
		>150	1.0-1.5
		<50	0.5-1.5
I, IV, V	1110	50-150	1.5-2.5
		>150	2.5-4.5
		<50	1.0-2.0
II, III	1110	50-150	2.0-3.0
		>150	3.0-4.5

Notes:
1) See Plate 6 for a description of the soil design profiles and parameters.
2) Estimated settlements presented above reflect settlements of the foundation soils only.
3) At locations where weak and/or organic clays are present, settlements may be significantly greater.
4) Sustained bearing pressures should not exceed the ultimate bearing pressure reduced by an appropriate factor of safety.

SETTLEMENT ESTIMATES

Isles Dernieres Stabilization Project
State Project No. 750-55-01
Terrebonne, Louisiana