- GEOTECHNICAL ENGINEERING
- CONSTRUCTION MATERIALS ENGINEERING & TESTING
- SOILS • ASPHALT • CONCRETE

May 28, 2019

Frankfurt-Short-Bruza Associates, P.C. (FSB)
5801 Broadway Extension, Suite 500
Oklahoma City, OK 73118

Attention: Linda Phillips

SUBJECT: **SUBSURFACE EXPLORATION, LABORATORY TESTING PROGRAM, AND FOUNDATION AND PAVEMENT RECOMMENDATIONS FOR THE PROPOSED AIRCRAFT CORROSION CONTROL FACILITY JBSA LACKLAND - KELLY FIELD ANNEX SAN ANTONIO, TEXAS**
RETL Project Number: 219147

Dear Ms. Phillips,

In accordance with our agreement, Rock Engineering & Testing Laboratory, Inc. (RETL) performed a subsurface exploration and foundation and pavement evaluation for the referenced project. The results of this exploration, together with our recommendations, are presented in the accompanying report, an electronic copy of which is being transmitted herewith. RETL will provide up to two (2) versions of this report in hard copy at the request of the client.

Often, because of design and construction details that occur on a project, questions arise concerning soil conditions. RETL would be pleased to continue its role as the Geotechnical Engineer during project implementation.

RETL also has great interest in providing materials testing and special inspection services during the construction phase of this project. If you will advise us of the appropriate time to discuss these engineering services, we will be pleased to meet with you at your convenience.

Sincerely,

Kyle D. Hammock, P.E.
Vice President - San Antonio

ROCK ENGINEERING & TESTING LABORATORY, INC.
10856 VANDALE STREET • SAN ANTONIO, TEXAS, 78216
OFFICE: (210) 495-8000 • FAX: (210) 495-8015 • www.rocktesting.com

SUBSURFACE EXPLORATION, LABORATORY TESTING PROGRAM, AND FOUNDATION AND PAVEMENT RECOMMENDATIONS FOR THE PROPOSED AIRCRAFT CORROSION CONTROL FACILITY JBSA LACKLAND – KELLY FIELD ANNEX SAN ANTONIO, TEXAS

RETL PROJECT NUMBER: 219147

PREPARED FOR:

FRANKFURT-SHORT-BRUZA ASSOCIATES, P.C. (FSB)
5801 BROADWAY EXTENSION, SUITE 500
OKLAHOMA CITY, OK 73118

MAY 28, 2019

PREPARED BY:

ROCK ENGINEERING AND TESTING LABORATORY, INC.
10856 VANDALE STREET
SAN ANTONIO, TEXAS 78216
PHONE: (210) 495-8000; FAX: (210) 495-8015

TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NUMBER 2101

Kyle D. Hammock, P.E.
Vice President - San Antonio

TABLE OF CONTENTS

INTRODUCTION

This report presents the results of a subsurface exploration and foundation and pavement evaluation for the proposed Aircraft Corrosion Control Hangar to be located at JBSA Lackland - Kelly Field Annex in San Antonio, Texas. This study was conducted for Frankfurt-Short-Bruza Associates, P.C. (FSB).

Authorization

The work for this project was performed in accordance with RETL Proposal No. P042219B dated April 22, 2019. The proposal contained a scope of work, fee, and limitations. The proposal contained a scope of work, fee, and limitations. RETL's proposal was approved and AIA Document C401-2017 Standard Form of Agreement between Architect and Consultant was issued to RETL on April 26, 2019 and executed on April 30, 2019. RETL's proposal was attached as Exhibit C.

Purpose and Scope

The purpose of this study was to provide applicable foundation and pavement design recommendations for the proposed project. The scope of this study included the subsurface exploration, field and laboratory testing, engineering analysis and evaluation of the subsurface soils, development of foundation and pavement recommendations suitable for the proposed project, and preparation of this report.

The scope of services did not include an environmental assessment. Any statements in this report, or on the Logs of Boring, regarding odors, colors, unusual or suspicious items or conditions are strictly for the information of the client.

General

The exploration and analysis of the subsurface conditions reported herein are considered sufficient in detail and scope to form a reasonable basis for foundation and pavement designs. The recommendations submitted for the proposed project are based on the available soil information and the preliminary design details provided to RETL by Linda Phillips of Frankfurt-Short-Bruza Associates, P.C. (FSB). If other design criteria are required for the structural and civil engineers to complete the foundation and pavement designs, and the requested information can be obtained from the agreed upon scope of work, RETL will provide the requested information as a supplement to this report.

The Geotechnical Engineer states that the findings, recommendations, specifications or professional advice contained herein, have been presented after being prepared in a manner consistent with the level of care and skill ordinarily exercised by reputable members of the Geotechnical Engineer's profession practicing contemporaneously under similar conditions in the locality of the project.

RETL operates in accordance with "*Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction*", (ASTM D3740). No other representations are expressed or implied, and no warranty or guarantee is included or intended.

This report has been prepared for the exclusive use of Frankfurt-Short-Bruza Associates, P.C. (FSB) for the specific application for the proposed Aircraft Corrosion Control Facility to be located at JBSA Lackland - Kelly Field Annex in San Antonio, Texas.

FIELD EXPLORATION

Scope

The field exploration, completed in order to evaluate the engineering characteristics of the foundation and pavement materials, included a reconnaissance of the project site, drilling test borings and recovering relatively undisturbed and disturbed samples of the subsurface materials encountered at the test boring locations. RETL performed a total of three (3) test borings at the site, two (2) drilled to a depth of 30-feet in the hangar area and one (1) drilled to a depth of 10-feet in the pavement area.

During the sample recovery operations, the soils encountered were classified and recorded on Logs of Boring in accordance with "*Standard Guide for Field Logging of Subsurface Exploration of Soil and Rock*", (ASTM D5434). Upon completion of the drilling operations and obtaining the groundwater observations, the drill holes were backfilled with excavated soil.

Frankfurt-Short-Bruza Associates, P.C. (FSB) determined the number and location of the borings and RETL determined the depth of the borings. The borings were located in the field by RETL and RETL completed the drilling operations. A Boring Location Plan is provided in the Appendix of this report.

Drilling and Sampling Procedures

The test borings were performed using a drilling rig equipped with a rotary head turning solid flight augers to advance the boreholes to the termination depths. Disturbed samples were obtained employing split-barrel sampling procedures in general accordance with the procedures for "*Penetration Test and Split-Barrel Sampling of Soils*" (ASTM D1586). Relatively undisturbed soil samples were obtained using thin-wall tube sampling procedures in accordance with the procedures for "*Thin Walled Tube Sampling of Soils*" (ASTM D1587). The samples obtained by this procedure were extruded by a hydraulic ram in the field.

The samples obtained from the test borings were classified in the field, placed in plastic bags, marked according to boring number, depth and any other pertinent field data, and stored in special containers. The samples were delivered to the laboratory for testing at the completion of the drilling operations.

Field Tests and Measurements

Penetration Tests - During the sampling procedures, standard penetration tests (SPT) were performed to obtain the standard penetration value of the soil. The standard penetration value (N) is defined as the number of blows of a 140-pound hammer, falling 30-inches, required to advance the split-barrel sampler 1-foot into the soil. The sampler is lowered to the bottom of the previously cleaned drill hole and advanced by blows from the hammer. The number of blows is recorded for each of three successive 6-inch penetrations.

The “N” value is obtained by adding the second and third 6-inch increment number of blows from the hammer. The results of standard penetration tests indicate the relative density of cohesionless soils and comparative consistency of cohesive soils, thereby providing a basis for estimating the relative strength and compressibility of the soil profile components.

Groundwater Observations - Groundwater observations were made during the test boring operations and are noted on the Logs of Boring provided in the Appendix. The amount of water in an open borehole largely depends on the permeability of the soils encountered at the boring location. In relatively pervious soils, such as sandy soils, the indicated depth is usually a reliable groundwater levels. In relatively impervious soils, a suitable estimate of the groundwater depth may not be possible, even after several days of observation. Seasonal variations, temperature, land-use, proximity to a creek, river or lake and recent rainfall conditions may influence the depth to groundwater.

Ground Surface Elevations - The ground surface elevations at the test borings were not provided. The depths referred to in this report are reported from the actual ground surface at the boring locations during the time of our field investigation.

Soil Resistivity Testing - The testing conducted to identify the resistivity properties of the soils included a reconnaissance of the project site and employment of the Wenner Four-Electrode Method. During the testing process, the in-situ resistivity values were measured and recorded on resistivity logs in general accordance with “Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method” (ASTM G57).

Soil Resistivity Testing was conducted at one (1) location in two (2) perpendicular directions. The soil resistivity test locations were located in the field by RETL personnel where on-site obstructions and conditions would allow. The test locations are annotated on the attached Boring Location Plan provided in the Appendix of this report.

The tests included measuring the in-situ soil resistivity values of the subsurface soil in north-south and east-west directions at separation distances (i.e. "a spacings") of 5-feet, 7-feet, 10-feet, 15-feet, and 20-feet. Electrodes were inserted into the ground surface at depths not exceeding 5-percent of electrode separation distance, and a voltage was impressed between the two outer electrodes, inducing a current flow. The drop-in voltage, or resistance, of the soil between the outer current-inducing electrodes and the two inner electrodes was measured in ohms and recorded on resistivity logs. A measure of the subsurface soil's ability to resist current flow by unit length, a property known as electrical resistivity, was calculated and reported in units of ohm-feet. The apparent resistivity values of the subsurface soils at this site are provided on the Soil Resistivity Testing Graphs included in the Appendix of this report.

Dynamic Cone Penetrometer (DCP) Tests - Dynamic Cone Penetrometer (DCP) tests were performed on the subgrade below the base at each pavement boring location. The Kessler Dynamic Cone Penetrometer is a device used to estimate the strength characteristics of fine-grained soils, granular construction material, and weak stabilized or modified material. The device is driven into the soil by dropping a sliding 17.6-pound hammer from a height of 22.6-inches.

The depth of cone penetration is measured at selected penetration or hammer drop intervals and the soil shear strength is reported in terms of DCP index. The DCP index is based on the average penetration depth resulting from one blow of the 17.6-pound hammer.

The California Bearing Ratio (CBR) can be estimated using the DCP index. The penetration per blow, or penetration rate (PR), is then used to estimate the in-situ CBR, or shear strength, using the appropriate correlation depending on the soil type. The following correlations were provided by the DCP manufacturer, Kessler Soils Engineering Products, Inc., and have been recommended by the US Army Corps of Engineers:

1. $CBR = 292 / PR^{1.12}$ (All soils except those listed in #2 and #3)
2. $CBR = 1 / (0.017019 * PR)^{2}$ (CL soils w/ CBR less than 10)
3. $CBR = 1 / (0.002871 * PR)$ (CH Soils)

PR= DCP Penetration Rate, mm per blow

It should be noted that a field DCP measurement results in a field, or in-situ, CBR and will not normally correlate with the laboratory, or soaked, CBR of the same material. The test is thus intended to evaluate the in-situ strength of a material under existing field conditions compared to controlled conditions in a lab. The DCP test results are included in the Appendix.

LABORATORY TESTING PROGRAM

A laboratory-testing program was conducted to supplement the information obtained during the field investigation. The results of the laboratory-testing program provide additional pertinent engineering characteristics of the subsurface materials necessary in analyzing the behavior of the foundation and pavement systems for the proposed project.

The laboratory-testing program included performing supplementary visual classification (ASTM D2487) and moisture content tests (ASTM D2216). In addition, selected samples were subjected to Atterberg limits tests (ASTM D4318), percent material finer than the #200 sieve tests (ASTM D1140), and one-dimensional swell tests (ASTM D4546). Estimated soil strengths were obtained using a hand penetrometer.

The laboratory-testing program was conducted in general accordance with applicable ASTM Specifications. The results of these tests are presented on the accompanying Logs of Boring provided in the Appendix.

SUBSURFACE CONDITIONS

General

The types of materials encountered in the test borings have been visually classified and are described in detail on the Logs of Boring. The results of the standard penetration tests, strength tests, water level observations and other laboratory tests are presented on the Logs of Boring in numerical form. Representative samples of the soils were placed in polyethylene bags and are now stored in the laboratory for further analysis, if desired. Unless notified to the contrary, the samples will be disposed of three months after issuance of this report.

The stratification of the soil, as shown on the Logs of Boring, represents the conditions at the actual boring locations. Variations may occur between, or beyond, the boring locations. Lines of demarcation represent the approximate boundary between different soil types, but the transition may be gradual, or not clearly defined.

It should be noted that, whereas the test borings were drilled and sampled by experienced drillers, it is sometimes difficult to record changes in stratification within narrow limits. In the absence of foreign substances, it is also difficult to distinguish between discolored soils and clean soil fill.

Soil Conditions

The generalized soil conditions encountered in the borings performed at the site have been summarized and soil properties including soil classification, strength, grain size, and plasticity are provided in the following tables:

BORING B-1

D	Description	LL	PI	C	θ	γ_e	-#200	N or P
0-4	Fat **CLAY**	59	43	2,000	0	120	90	P= 3.0-4.5+
4-17	Lean **CLAY**	40-43	29	3,500	0	120	80-81	N= 28-47 P= 4.5+
17-23	Clayey **GRAVEL**	37	26	0	36	125	22	N= 74
23-30	Fat **CLAY**	---	---	4,000	0	60	---	N= 35-47

BORING B-2

D	Description	LL	PI	C	θ	γ_e	-#200	N or P
0-4	Fat **CLAY**	60	45	2,000	0	120	90	P= 2.5-4.5+
4-8	Fat **CLAY** w/**SAND**	53	39	3,000	0	120	84	N= 30 P= 4.5+
8-17	Lean **CLAY**	42	30	3,500	0	120	88	P= 4.5+
17-23	Clayey **GRAVEL**	---	---	0	36	125	---	N= 30/50/5"
23-30	Fat **CLAY**	54	40	4,000	0	120	72	N= 34-52

BORING B-3

D	Description	LL	PI	C	θ	γ_e	-#200	N or P
0-4	Fat **CLAY**	64	49	2,500	0	120	79	N= 33 P= 4.5+
4-10	Lean **CLAY**	---	---	4,000	0	120	---	N= 41-50

Where:
D = Depth in feet below existing grade
LL = Liquid Limit (%)
PI = Plasticity Index
C = Average Soil Cohesion, psf (undrained)
θ = Angle of Internal Friction, deg. (undrained)
γ_e = Effective Soil Unit Weight, pcf
-#200 = Percent Material Finer than a #200 Sieve
N = Standard Penetration Value range, blows per foot
P = Pocket penetrometer value range, tsf

Detailed descriptions of the materials encountered at the boring locations are provided on the Logs of Boring included in the Appendix.

Seismic Site Class

The field investigation did not include a 100-foot deep soil boring, therefore, the soil properties are not known in sufficient detail to determine the Site Class per IBC. This site generally has very stiff to hard clay soils extending to the 30-foot depth. In accordance with IBC Section 1613.3.2-Site Class Definitions and Chapter 20 of ASCE 7, Site Class D materials should have soil undrained shear strengths between 1,000 and 2,000 psf and standard penetration resistances between 15 and 50 blows per foot. The on-site soils extending to the 30-foot depth have strengths similar to Site Class D materials; therefore, RETL recommends that Site Class D, "stiff soil" profile be assumed.

Groundwater Observations

Groundwater was encountered at a depth of 23-feet during the drilling operations and measured at a depth of 23-feet upon completion of the drilling. It should be noted that water levels in open boreholes may require several hours to several days to stabilize depending on the permeability of the subsurface materials and that groundwater levels or zones of seepage may be subject to seasonal conditions, recent rainfall, drought or temperature effects.

FOUNDATION DISCUSSION AND RECOMMENDATIONS

Project Description

Based on the information provided to RETL, it is understood that the project will consist of the construction of a new pre-engineered metal hangar building with an approximate footprint of 12,200 SF. Loads were not provided; however, our experience with similar type metal building structures would indicate maximum concentrated loads on the order of 150-kips and wall loads will be in the range of 1.0 to 2.0-kips per linear feet. A slab-on-grade type foundation is typically used in the project area for buildings similar to the one proposed. In addition, automobile parking areas and an aircraft apron adjacent to the new building are planned.

PVR Discussion

Differential vertical movements associated with the shrinking and swelling of high plasticity clay soils can adversely affect the performance of a shallow slab-on-grade foundation. The materials within the active zone at the site generally consist of high plasticity fat clays underlain by moderate plasticity lean clays. **Based on the subsurface conditions encountered at the boring locations, the calculated potential vertical rise (PVR) for a slab-on-grade construction at this site is approximately 3½-inches.**

The PVR was calculated using the Texas Department of Transportation Method TEX-124E and into account the depth of active zone, estimated to extend to a depth of approximately 15-feet, and the Atterberg limits test results of the soils encountered within the active zone.

The estimated PVR value, calculated using the Texas Department of Transportation Method TEX-124E, is based on a floor system applying a sustained surcharge load of approximately 1.0 pound per square inch on the subgrade soils. The value represents the vertical rise that can be experienced by dry subsoils if they are subjected to conditions that allow them to become saturated, such as poor drainage. The actual movement of the subsoils is dependent upon their change in moisture content. Differential vertical movements associated with the soils at this site may occur over a distance of 15-feet, or approximately the depth of the active zone, within the footprint of a slab-on-grade.

Based on our calculations, in order to consistently reduce the PVR to approximately 1-inch for slab on grade foundation construction, the natural clay soils should be undercut to a minimum depth of 6-feet and the excavation replaced with a minimum of 6-feet of properly compacted, non-expansive select fill.

Foundation Selection Criteria

The type and depth of a foundation suitable for a given structure depends on several factors including the subsurface conditions, the function of the structure and the loads it will carry. Ultimately the acceptable performance criteria with respect to allowable vertical and differential movements should be agreed upon between the Owner, the Structural Engineer and the Architect.

The soil and groundwater design considerations affecting the choice of foundation type for the proposed structure at this site, based on a review of the soil boring information and engineering characteristics determined by the field testing and laboratory test results, are outlined below:

- The strengths of the subsurface materials encountered at this site are suitable to support both a shallow slab-on-grade foundation and a deep-drilled pier foundation.
- The clay soils encountered within the active zone at this site are moderate to high in plasticity, resulting in a calculated PVR value of approximately 3½-inches.
- To reduce the PVR to approximately 1-inch in the building area, it will be necessary to remove the expansive soils to a minimum depth of 6-feet, moisture condition and compact the exposed subgrade soils, and place a minimum 6-feet of properly compacted, non-expansive select fill soils into the excavation.

- Groundwater, at the time of our field investigation, was measured at a depth of approximately 23-feet.

Two foundation types have been considered for the support of the proposed building structure. The foundation types considered for this project include a shallow, conventionally reinforced slab-on-grade foundation system and drilled piers utilized in conjunction with a structurally suspended floor slab.

A conventionally reinforced slab-on-grade foundation system is typically the most economical foundation system utilized to support a relatively light structure that can withstand some soil movements. Movements experienced by a shallow foundation at this site could be related to soil swelling (heave) conditions resulting in differential movements. Differential movements, even as small as 1-inch, can result in unsightly cracking of interior and exterior architectural facades and rigid brick, block or concrete walls.

The soils at this site are moderate to highly expansive within the active zone. Therefore, changes in moisture content of the supporting soils will result in significant changes in volume of the soils, which in turn will likely result in unacceptable differential foundation movements. A shallow slab-on-grade foundation may be utilized at this site provided the site improvement earthwork recommendations included in the "**PVR Discussion**" section of this report to reduce the PVR to approximately 1-inch are performed, and it is understood by the Owner and Design Team that foundation movements will likely occur.

RETL assumes that the Owner and Design Team desire the highest level of performance from the foundation system for the structure with little to no movement. **RETL therefore recommends that a drilled pier foundation system be used to support the structural loads of the new structure. The piers should be used in conjunction with a structurally suspended floor slab system. Considering the presence of gravel and groundwater, deep straight shaft piers may be difficult to install. Therefore, intermediate depth underreamed piers shall be utilized.**

Underreamed Drilled Piers

Underreamed drilled piers used in conjunction with structurally suspended floor slabs are recommended to be used to support the proposed structure planned for construction at this site. Grade beams should be supported on the underreamed piers where required to support wall loads. In addition, RETL recommends that exterior doorway stoops and any covered entry areas also be supported on underreamed drilled piers used in conjunction with structurally suspended floor slabs.

Underreamed drilled piers should be founded at a minimum depth of 17-feet below the existing grades. The underreamed drilled piers can be sized to exert a net allowable unit end bearing pressure of **12,000 psf**. The net allowable unit end bearing pressure for underreamed drilled piers includes a factor of safety of 3.0 against bearing failure and can be increased 33-percent for maximum transient loads.

If the underreamed drilled piers are designed using the recommended net allowable unit end bearing pressure provided above, the piers should experience total settlements on the order of ¼-percent of the diameter of the belled portion of the underreamed drilled pier.

The underreamed piers should have a minimum bell diameter to shaft diameter ratio of two. This is necessary to resist uplift forces, associated with shrinking and swelling of the in-situ soils that may be created by soil-to-pier adhesion in the zone of expansive clays. The maximum recommended bell diameter to shaft diameter ratio is three. Underreamed drilled piers should be spaced a minimum distance of 2-times the diameter of the belled portion of the underreamed drilled pier measured center to center.

The piers will be subject to tension loading as a result of the upper clay soils swelling with an increase in the soil moisture content. The uplift force acting on the piers is a function of the soil shear strength, soil-pier adhesion factor, pier circumference and the length of the pier that is subjected to swelling soils. An uplift force in kips equal to 50-times the diameter of the pier shaft (in feet) can be used to estimate the force on the pier created by the expansive clay soils. The uplift forces created due to the expansive soils can be resisted according to the following equation:

$$Ur = 8 \cdot (D^2 - d^2) + Wp + DLp$$

Where:	Ur	=	allowable uplift resistance of pier (kips)
	d	=	diameter of pier shaft (feet)
	D	=	diameter of bell (feet)
	Wp	=	weight of pier (kips)
	DLp	=	dead load on pier (kips)

The manual *Drilled Shafts: Construction Procedures and Design Methods* suggests that piers be reinforced throughout their length with a minimum of 1-percent longitudinal reinforcing steel by cross sectional area of the pier. The referenced document states that some reduction in the percentage of longitudinal reinforcing steel may be acceptable if the cross-sectional area of the pier is larger than required due to loading conditions. However, a minimum ¾-percent reinforcing steel by cross sectional area is suggested in the manual even if the cross-sectional area of the pier is more than twice that required due to loading conditions.

A minimum 12-inch void space should be constructed beneath the grade beams spanning between the piers and beneath any pier caps. Grade beams spanning between piers and pier caps should be structurally connected to the piers. It is also recommended that the structural slab be constructed with a minimum 12-inch void space between the slab and the soil at the site. For the highest level of performance, a crawl space should be constructed beneath the floor slab. Provisions to collect and remove water in the crawl space should be incorporated into the final design.

Free fall of concrete into the pier excavation is permitted provided the concrete can be placed into the pier excavation without striking the sides of the excavation or hitting the rebar. In situations where it is impossible for the concrete to fall freely without striking the rebar cage or sides of the pier excavation, the free fall should be limited to 10-feet or placed with a tremie. Pier excavations should not be allowed to stay open overnight.

The successful installation of a drilled pier foundation system is dependent on the expertise of the drilled pier foundation contractor. A test pier excavation should be performed at the site to verify the contractor's construction methods and to identify any potential groundwater infiltration and soil sloughing problems. The Geotechnical Engineer, or his designated representative, should be present to witness the installation of all the drilled piers, including the test pier excavation.

Detailed inspection of pier construction should be made by the Geotechnical Engineer or his designated representative to verify that the piers are vertical and founded in the proper bearing stratum, and to verify that all loose materials have been removed prior to concrete placement. Temporary casing must be used where necessary to stabilize pier holes and to reduce water inflow and caving. Any accumulated water must be removed prior to the placement of concrete.

If the pier hole has been cased, sufficient concrete should remain in the casing as the casing is withdrawn to prevent any discontinuities from forming within the concrete section. Furthermore, concrete placed in drilled piers should not be placed at slumps less than 6-inches unless it is consolidated with a vibrator or by other means. Concrete placed in piers at a slump less than 6-inches increases the potential for honeycombing. Concrete used in piers should be designed to achieve the required strength at the higher slump as referenced above.

For any given pier excavation, placement of steel and concreting should be completed within the same workday. Where water inflow or caving soils are encountered, excavation of piers and placement of concrete within a very short time frame will frequently aid in proper pier construction.

Slab-on-Grade Recommendations

The proposed structure may be supported on a stiffened slab-on-grade foundation at this site provided the foundation is designed to account for the 1-inch PVR condition noted previously. Typically, a PVR of approximately 1-inch is considered acceptable for structures similar to the one proposed, provided a stiffened foundation is used.

Grade beams and footings shall be founded in properly compacted select fill at a minimum depth of 2-feet below the finished floor slab elevation. The exterior grade beams and footings should also have a minimum embedment depth of 2-feet below the final exterior grades. Grade beams and spread footings founded in properly compacted general fill or select fill can be designed for a net allowable unit soil bearing pressure of **3,000 psf**.

The net allowable unit soil bearing pressure provided utilizes a safety factor of at least 3 and can be increased by 50-percent for total loads. Properly constructed grade beams and footings at this site could expect total and differential settlement of up to 1-inch.

The grade beams should be a minimum of 12-inches wide to reduce the potential for localized shear failure. The Structural Engineer may vary beam depths and spacing based experience designing and constructing similar type structures on sites with similar clay soil conditions.

The *"Design of Slab-On-Ground Foundations"* published by the Wire Reinforcement Institute, Inc. (August 1981) utilizes the design criteria provided in the table below for design of a stiffened slab-on-grade foundation with a PVR value of approximately 1-inch:

WRI DESIGN CRITERIA	
PVR Condition (in)	**+/- 1**
Minimum Undercut Depth/Select Fill Thickness (ft)	6
Climatic Rating (Cw)	17
Effective Plasticity Index	25
Soil/Climatic Rating Factor (1-C)	0.10
Maximum Beam Spacing (ft)	20

Laboratory test results and VOLFLO Version 1.5 software have been used to develop soil parameters based on the Post-Tensioning Institute 3rd Edition, *"Design and Construction of Post-Tensioned Slabs-On-Ground"* as indicated in the following table for this site with a PVR of approximately 1 -inch:

3rd EDITION POST TENSION DESIGN PARAMETERS	
Minimum Undercut Depth/Select Fill Thickness (ft)	6
Moisture Penetration Distance; Em (center lift) (ft)	9.0
Moisture Penetration Distance; Em (edge lift) (ft)	5.1
Differential Movement; Ym (shrink) (center) (in)	-0.95
Differential Movement; Ym (swell) (edge) (in)	1.34

As an alternate to designing a stiffened slab-on-grade foundation, the site may be classified as "Not Considered Expansive" in accordance with the IBC provided the natural clay soils are undercut to a minimum depth of 9-feet and the excavation replaced with a minimum of 9-feet of properly compacted, non-expansive select fill. Interior stiffening beams will not be required for this type foundation system.

Soil supported floor slabs are subject to vertical movements, as discussed earlier in this report. Even slight differential movements may cause distress to interior wall partitions and rigid exterior facades supported by a shallow slab-on-grade foundation resulting in cosmetic damage. This amount of movement should be understood and addressed during the design phase of the proposed structure planned for construction at this site.

The foundation excavations should be observed by a representative of RETL prior to steel or concrete placement to assess that the foundation materials are capable of supporting the design loads and to identify the acceptability of the bearing materials under the beams and footings.

Soft or loose zones encountered at the bottom of the beam or footing excavations should be removed to the level of competent materials as directed by the Geotechnical Engineer. Cavities formed as a result of excavation of soft or loose zones should be backfilled with properly compacted select fill.

After opening, beam and footing excavations should be observed, and concrete placed as quickly as possible to avoid exposure of the beam and footing bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If it is required that beam and footing excavations be left open an extended period, they should be protected to reduce evaporation or entry of moisture.

PAVEMENT RECOMMEDNATIONS

In designing the proposed automobile parking areas, driveways and aprons, the existing subgrade conditions must be considered together with the expected traffic use and loading conditions.

The conditions that influence pavement design can be summarized as follows:

1. Bearing values of the subgrade. These values can be represented by a California Bearing Ratio (CBR) for the design of flexible asphalt pavements, or a Modulus of Subgrade Reaction (K) for rigid concrete pavements.

2. Vehicular traffic, in terms of the number and frequency of vehicles and their range of axle loads.

3. Probable increase in vehicular use over the life of the pavement.
4. The availability of suitable materials to be used in the construction of the pavement and their relative costs.

Specific laboratory testing to define the subgrade strength (i.e. CBR/K values) have not been performed for this analysis. Based upon local experience and the plasticity indices of the in-situ subgrade soils, the CBR and K value for design has been selected as 3 and 100 pci, respectively.

Since automobile traffic counts have not been provided, it is possible to provide a non-engineered pavement section suitable for light and heavy-duty service based on pavement sections that have provided adequate serviceability for similar type applications.

Allowances for proper drainage and proper material selection of base materials are most important for performance of asphaltic pavements. Ruts and birdbaths in asphalt pavements allow for quick deterioration of the pavement primarily due to saturation of the underlying base materials and subgrade soils.

Parking areas and driveways and can be designed with either a flexible or rigid pavement. It is important that the exposed subgrade is properly prepared prior to pavement installation.

Flexible Asphalt Pavements

The recommended light and heavy-duty flexible pavement section options, using the locally available base material, are provided in the following tables:

Light Duty Flexible Pavement (Automobile Parking Areas)	
Pavement Constituent	Thickness
HMAC Type D	2"
Crushed Limestone Base Material	8"
Tensar Geogrid	TX-5
Compacted Subgrade	6"

Heavy Duty Flexible Pavement (Main Driveways)	
Pavement Constituent	Thickness
HMAC Type D	3"
Crushed Limestone Base Material	12"
Tensar Geogrid	TX-5
Compacted Subgrade	6"

Rigid Concrete Pavements

The use of concrete for paving has become more prevalent in recent years due to the long-term maintenance cost benefits of concrete pavement compared to asphalt pavements. Concrete pavement is recommended in areas that receive continuous repetitive traffic such as the main driveway entrances, loading areas and trash dump approach areas. The recommended light and heavy-duty rigid concrete pavement sections are provided in the following table:

Rigid Pavement	**Light Duty Parking**	**Heavy Duty Driveways**
Reinforced Concrete	5½"	7"
Crushed Limestone Base	6"	6"
Compacted Subgrade	6"	6"

Apron Concrete Pavements

The concrete apron adjacent to the new Corrosion Control Facility will be required to support loads from F-16 aircraft and the tow tractor. Approximately 15 F-16 aircraft will be serviced at the facility per month. The typical tow tractor is an MB-4 built by Entwistle, weighs 20,000 pounds and has a drawbar pull capacity of 14,000 pounds. The recommended rigid concrete pavement section for the apron at this facility is provided in the following table:

Rigid Pavement	**Apron**
Reinforced Concrete	12"
Crushed Limestone Base	6"
Compacted Subgrade	6"

Pavement Material Recommendations

Compacted Subgrade - The upper 6-inches of exposed subgrade soils should be compacted to a minimum density of 95-percent of the maximum dry unit weight of the subgrade soils as determined by a standard Proctor test (ASTM D698). The moisture content of the subgrade soils should be maintained at or above the optimum moisture content.

Compacted General Fill - After subgrade preparation is complete, the placement of properly compacted general fill soils may begin in the paved areas to raise the grades, where required. General fill soils could consist of on-site soils free of organics and other deleterious materials or imported soils with a maximum plasticity index (PI) of 25.

The general fill used to raise the grade where required in the proposed parking, driveway and apron areas should be placed in no greater than 8-inch thick loose lifts and compacted to at least 95-percent of the maximum dry density as determined by the Standard Proctor test (ASTM D-698). The moisture content of the soils should be at or above the optimum moisture content.

Geogrid - Geogrid should be placed beneath the base material and on top of the compacted subgrade in flexible pavement areas. Geogrid should be Tensar TX-5 and should be placed and overlapped in accordance with the manufacturer's recommendations. Geogrid will significantly improve the long-term performance of the flexible pavements and reduce cracking.

Base Material - Base materials should meet the requirements set forth in the Texas Department of Transportation (TxDOT) 2014 Standard Specifications for Construction of Highways, Streets and Bridges; Item 247, Type A, Grade 1-2. The base material should be placed in maximum 8-inch thick loose lifts and compacted to a minimum density of 95-percent of the maximum dry density as determined by the modified Proctor test (ASTM D1557). The moisture content of the base materials should be maintained within 2-percent of the optimum moisture content.

Hot Mix Asphaltic Concrete - Hot mix asphaltic concrete should meet the requirements set forth in TxDOT Item 340 or 341; Type D surface course. The asphaltic concrete should be compacted to between 92 and 97-percent of the theoretical density.

Rigid Concrete - The concrete pavement should be properly reinforced and jointed, as per ACI 330R, and should have a minimum 28-day compressive strength of 4,000 psi.

Contraction joint spacing should not exceed 15-feet and preferably less to adequately control cracking. The joints should be thoroughly cleaned, and sealant should be installed without overfilling before the pavement is opened to traffic.

Based on past experience with concrete pavements supported on similar subgrade soils, RETL recommends that reinforcement for concrete pavement consist of #4 bars (1/2-inch diameter) spaced at 18 and 12-inches on center each way for light and heavy-duty options, respectively. The reinforcement for the concrete apron should consist of two (2) layers of #4 bars spaced at 12-inches on center each way.

SITE IMPROVEMENT METHODS

General Considerations

A majority of foundation related problems are attributable, at least in part, to poor drainage. Cohesive soils can swell or shrink by absorbing or losing water, respectively. Reducing the variation in moisture content can reduce the variation in volume. A number of measures may be used to attain a reduction in subsoil moisture content variations, thus reducing the soil's volume change potential. Some of these measures are outlined below:

- During construction, a positive drainage scheme should be implemented to prevent ponding of water on the subgrade in the foundation area.
- Positive drainage should be maintained around the structure through a roof/gutter system connected to piping or directed to paved surfaces, transmitting water away from the foundation perimeters. In addition, positive grades sloping away from the foundation should be designed and implemented for the area extending at least 10-feet away from the foundation perimeters.
- Utility trenches should not be backfilled with sand or gravel to assure the trenches do not serve as aqueducts that could transport water beneath the structure due to excessive surface water infiltration. The upper 12-inches of backfill adjacent to the foundation should consist of properly compacted fat clay. Clay collars or plugs should be installed within the trench just outside of the building pad to prevent horizontal migration of water into the building pad.
- Vegetation placed in landscape beds that are adjacent to the structure should be limited to plants and shrubs that will not exceed a mature height of 3-feet. Large bushes and trees should be planted away from the foundations at a distance that will exceed their full mature height and canopy width.

Project features beyond the scope of those discussed above should be planned and designed similarly to attain a region of relatively uniform moisture content within the foundation area. Poor drainage schemes resulting in soil moisture and volume changes are generally the primary cause of slab-on-grade foundation problems.

Concrete Flatwork

Concrete site flatwork such as sidewalks and driveways will be subject to PVR movements when constructed over the clay soils. Changes in the moisture content of the supporting plastic clay soil causes volumetric changes, likely resulting in differential movements of the flatwork. Provisions in the site development should be made in order to maintain relative uniform moisture contents of the supporting soils.

Individual panels of concrete flatwork should be dowelled together to minimize trip hazards as a result of differential movements within the flatwork. Efforts should be made to avoid having situations where site flatwork panels are partially supported on compacted select fill soils and partially supported on natural in-situ expansive clay soils. This may result in differential movement and may also result in a negative slope back to the building causing ponding of water next to the structure. If it is desired to increase the performance level and reduce the PVR for concrete flatwork adjacent to the building, the select fill building pad should be extended to a distance of 12-inches beyond the flatwork.

CONSTRUCTION CONSIDERATIONS

Subgrade Preparation

In the slab-on-grade foundation footprint areas (structure and any appurtenances including porches, patios and stoops), vegetation, roots, objectionable materials, fill materials, and the clay subgrade soils should be undercut to a minimum depth of 6-feet below the existing grade and replaced with a minimum of 6-feet of select fill to reduce the PVR to approximately 1-inch. An undercut and replacement depth of 9-feet will be required for the "Not Considered Expansive" site condition.

The stripping and undercutting should extend approximately 3-feet beyond the perimeter of the foundation. If any soft pockets or pumping areas are identified at the subgrade level, the soil should be removed to expose firm materials and the excavation replaced with compacted select fill. The RETL Geotechnical Engineer must approve the subgrade condition prior to select fill placement.

Prior to compaction, the exposed subgrade in the building area should be proof-rolled with a minimum 20-ton rubber-tired vehicle under the supervision of RETL. If any soft or loose areas are identified, the soils should be removed and replaced with compacted select fill. The upper 6-inches of exposed subgrade soil in the building areas should then be moisture conditioned and compacted to at least 95-percent of the standard Proctor (ASTM D698) maximum dry density with a moisture content at or above of the optimum moisture content.

Upon completion of the subgrade preparation, compacted select fill soils should be placed to fill the undercut excavation. The select fill building pad should extend a minimum of 5-feet outside the perimeter of the proposed structure. Excavation of beams, footings and utility trenches may proceed after placement of select fill is complete.

Engineered Fill Materials

After subgrade preparation is complete, properly compacted fill soils should be used to the raise the site to the design subgrade elevations where engineered improvements are planned. Fill soils placed to raise the site to the design subgrade elevations should consist of select fill for the building structure and general fill soils for the remainder if the site.

Building Area (Select Fill) - Select fill used for the building pad should consist of imported crushed limestone. Imported limestone select fill should meet the plasticity and gradation requirements set forth in Texas Department of Transportation (TxDOT) Standard Specifications 2014; Item 247, Type A, Grade 1-2, or better.

Select fill soils should be placed in no greater than 8-inch thick loose lifts and shall be compacted to at least 95-percent of the maximum dry density as determined by the modified Proctor (ASTM D1557). The moisture content of the select fill soils should be maintained within 2-percentage points of the optimum moisture content. The Geotechnical Engineer shall approve select fill utilized at this site.

General Fill - On-site excavated soils free of organics and deleterious materials or imported soils can be used to raise the site grades as necessary. Imported general fill soils should have a maximum plasticity index (PI) of 25.

General fill soils should be compacted to at least 95-percent of the maximum dry density as determined by the standard Proctor (ASTM D698). The moisture content of the general fill soils should be maintained at or above the optimum moisture content.

Earthwork and Foundation Acceptance

Exposure to the environment may weaken the soils at the foundation bearing level if excavations remain open for long periods of time. Therefore, it is recommended that the foundation excavations be extended to the design subgrade elevation and the foundation be constructed as soon as possible to minimize potential damage to the bearing soils.

The foundation bearing level should be free of loose or soft soil, ponded water or debris and should be observed prior to concreting by the Geotechnical Engineer, or his designated representative. Foundation concrete should not be placed on soils that have been disturbed by seepage. If the bearing soils are softened by water intrusion, the unsuitable soils must be removed from the foundation excavations and be replaced with properly compacted select fill prior to placement of concrete.

The Geotechnical Engineer, or his designated representative, should approve the condition of the exposed subgrade and monitor the placement of all select fill. As a guideline, a minimum of one in-place density test should be performed on the subgrade and each lift of select fill for each 3,000 SF or a minimum of three in-place densities per testing interval, whichever results in the greater number of tests. Any areas not meeting the required compaction should be recompacted and retested until compliance is met.

Vapor Retarder

A vapor retarder with a permeance of less than 0.3 US perms (ASTM E96) should be placed under the concrete floor slab on the ground to reduce the transmission of water vapor from the supporting soil through the concrete slab and to function as a slip sheet to reduce subgrade drag friction.

Polyethylene film with a minimum thickness of 10 mils (0.25 mm) is typically used for reduced vapor transmission and durability during and after its installation. The vapor retarder should be installed according to ASTM E1643, "Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs."

Penetrations through the vapor retarder should be sealed to ensure its integrity. The vapor retarder should be taped around all openings to ensure the effectiveness of the barrier. Grade stakes should not be driven through the barrier and care should be taken to avoid punctures during reinforcement and concrete placement. Placement of slab concrete directly on the vapor retarder increases the risks of surface dusting, blistering and slab curling making good concrete practice critical. A low water to cement ratio concrete mix design combined with proper and adequate curing procedures will help ensure a good quality slab.

Utilities

Utilities that project through slab-on-grade floors should be designed with either some degree of flexibility, or with sleeves, in order to prevent damage to these lines should movement occur.

Expansion Joints

Expansion or control joints should be designed and placed in various portions of the structure, especially rigid exterior masonry walls. Properly planned placement of these joints will assist in controlling the degree and location of material cracking that normally occurs due to material shrinkage, thermal affects, soil movements and other related structural conditions.

GENERAL COMMENTS

If significant changes are made in the character or location of the proposed structure, a consultation should be arranged to review any changes with respect to the prevailing soil conditions. At that time, it may be necessary to submit supplementary recommendations.

It is recommended that the services of RETL be engaged to test and evaluate the soils in the undercut excavation prior to placing select fill and in the foundation excavation and in the footing excavations prior to concreting in order to verify that the bearing soils are consistent with those encountered in the borings. RETL cannot accept any responsibility for any conditions that deviate from those described in this report, nor for the performance of the foundation and pavements if not engaged to also provide construction observation and testing for this project. If it is required for RETL to accept any liability, then RETL must agree with the plans and perform such observation during construction as we recommend.

Sheeting, shoring and bracing of trenches, pits and excavations should be made the responsibility of the contractor and should comply with all current and applicable local, state and federal safety codes, regulations and practices, including the Occupational Safety and Health Administration.

APPENDIX

BORING LOCATION PLAN

NO SCALE
BORING LOCATIONS ARE APPROXIMATE

May 28, 2019
Frankfurt-Short-Bruza Associates, P.C. (FSB)
RETL Project No.: 219147

AIRCRAFT CORROSION CONTROL FACILITY
JBSA Lackland - Kelly Field Annex
San Antonio, Texas

ROCK ENGINEERING AND TESTING LABORATORY, INC.
10856 VANDALE STREET
SAN ANTONIO, TEXAS 78216
(210) 495-8000

LOG OF BORING B-1

SHEET 1 of 1

Rock Engineering & Testing Laboratory, Inc.
10856 Vandale Street
San Antonio, Texas 78216
Telephone: 210-495-8000
Fax: 210-495-8015

CLIENT: Frankfurt-Short-Bruza Assoc., P.C. (FSB)
PROJECT: Aircraft Corrosion Control Facility
LOCATION: JBSA Lackland - San Antonio, Texas
NUMBER: 219147
DATE(S) DRILLED: 05/15/19

DRILLING METHOD(S):
Solid Flight Auger

GROUNDWATER INFORMATION:
Groundwater (GW) was encountered at 23-feet during drilling. GW measured at 23-feet upon the completion of the drilling.

SURFACE ELEVATION: N/A

DEPTH (FT)	SAMPLE NUMBER	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	COMPRESSIVE STRENGTH (TONS/SQ FT)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
	SH S-1	P= 3.0	19	59	16	43			90	**FAT CLAY**, dark brown, moist, very stiff. (CH)
	SH S-2	P= 4.5+	16							Same as above. (swell= 0.9%, final moisture= 24%)
5	SH S-3	P= 4.5+	15	43	14	29			80	**LEAN CLAY**, with sand and calcareous material, brown, moist, very stiff. (CL)
	SH S-4	P= 4.5+	15							Same as above.
10	SPT S-5	N= 47	13	40	11	29			81	Same as above, hard. (CL)
15	SPT S-6	N= 28	16							**LEAN CLAY**, light brown, moist, very stiff.
20	SPT S-7	N= 74	7	37	11	26			22	**CLAYEY GRAVEL** with sand, light brown, dry, very dense. (GC)
25	SPT S-8	N= 35	19							**FAT CLAY**, brown and gray, moist, hard.
30	SPT S-9	N= 47	18							Same as above.
										Boring terminated at a depth of 30-feet.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - POCKET TORVANE SHEAR STRENGTH

REMARKS:
Boring location determined by client. Drilling operations performed by RETL.
GPS Coordinates: N 29.386907°, W 98.596619°

LOG OF BORING B-2

Rock Engineering & Testing Laboratory, Inc.
10856 Vandale Street
San Antonio, Texas 78216
Telephone: 210-495-8000
Fax: 210-495-8015

CLIENT: Frankfurt-Short-Bruza Assoc., P.C. (FSB)
PROJECT: Aircraft Corrosion Control Facility
LOCATION: JBSA Lackland - San Antonio, Texas
NUMBER: 219147

DATE(S) DRILLED: 05/15/19

DRILLING METHOD(S):
Solid Flight Auger

GROUNDWATER INFORMATION:
Groundwater (GW) was encountered at 23-feet during drilling. GW measured at 23-feet upon the completion of the drilling.

SURFACE ELEVATION: N/A

SOIL SYMBOL	DEPTH (FT)	SAMPLE NUMBER	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	COMPRESSIVE STRENGTH (TONS/SQ FT)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
		SH S-1		P= 2.5	22							**FAT CLAY**, dark brown, moist, very stiff.
		SH S-2		P= 4.5+	22	60	15	45			90	Same as above. (CH)
	5	SH S-3		P= 4.5+	16							**FAT CLAY**, with sand and calcareous material, brown, moist, very stiff. (swell= 18%, final moisture= 20%)
		SPT S-4		N= 30	15	53	14	39			84	Same as above, hard. (CH)
		SH S-5		P= 4.5+	12							**LEAN CLAY**, with calcareous material, light brown, moist, hard.
	10											
		SH S-6		P= 4.5+	17	42	12	30			88	Same as above. (CL)
	15											
		SPT S-7		N= 30-50/5"	7							**CLAYEY GRAVEL** with sand, light brown, dry, very dense.
	20											
		SPT S-8		N= 52	27	54	14	40			72	**FAT CLAY**, with sand, brown and gray, very moist, very hard. (CH)
	25											
		SPT S-9		N= 34	26							Same as above, hard.
	30											Boring terminated at a depth of 30-feet.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - POCKET TORVANE SHEAR STRENGTH

REMARKS:
Boring location determined by client. Drilling operations performed by RETL.
GPS Coordinates: N 29.386899°, W 98.596397°

LOG_OF_BORING 219147 LOGS.GPJ ROCK_ETL.GDT 5/31/19

LOG OF BORING B-3

Rock Engineering & Testing Laboratory, Inc.
10856 Vandale Street
San Antonio, Texas 78216
Telephone: 210-495-8000
Fax: 210-495-8015

CLIENT: Frankfurt-Short-Bruza Assoc., P.C. (FSB)
PROJECT: Aircraft Corrosion Control Facility
LOCATION: JBSA Lackland - San Antonio, Texas
NUMBER: 219147

DATE(S) DRILLED: 05/15/19

DRILLING METHOD(S):
Solid Flight Auger

GROUNDWATER INFORMATION:
Groundwater was not encountered during drilling, nor measured upon the completion of the drilling.

SURFACE ELEVATION: N/A

FIELD DATA				LABORATORY DATA							
DEPTH (FT)	SAMPLE NUMBER	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: TONS/SQ FT PERCENT RECOVERY/ ROCK QUALITY DESIGNATION	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	ATTERBERG LIMITS PLASTIC LIMIT PL	ATTERBERG LIMITS PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	COMPRESSIVE STRENGTH (TONS/SQ FT)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
1	SH S-1		P= 4.5+	13	64	15	49			79	**FAT CLAY**, with sand, dark brown, slightly moist, hard. (CH)
3	SPT S-2		N= 33	15							Same as above.
5	SPT S-3		N= 41	12							**LEAN CLAY**, with calcareous material, light brown, slightly moist, hard.
7	SPT S-4		N= 45	9							Same as above, slightly moist.
9	SPT S-5		N= 50	9							Same as above, very hard.
10											Boring terminated at a depth of 10-feet.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - POCKET TORVANE SHEAR STRENGTH

REMARKS:
Boring location determined by client. Drilling operations performed by RETL.
GPS Coordinates: N 29.386679°, W 98.596573°

Engineering & Testing Laboratory, Inc.

Rock Engineering & Testing Laboratory
10856 Vandale
San Antonio, TX 78216
Telephone: 210-495-8000
Fax: 210-495-8015

KEY TO SOIL CLASSIFICATION AND SYMBOLS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		SYMBOL	NAME
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well Graded Gravels or Gravel-Sand mixtures, little or no fines
		GP	Poorly Graded Gravels or Gravel-Sand mixtures, little or no fines
		GM	Silty Gravels, Gravel-Sand-Silt mixtures
		GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SAND AND SANDY SOILS	SW	Well Graded Sands or Gravelly Sands, little or no fines
		SP	Poorly Graded Sands or Gravelly Sands, little or no fines
		SM	Silty Sands, Sand-Silt Mixtures
		SC	Clayey Sands, Sand-Clay mixtures
FINE GRAINED SOILS	SILTS AND CLAYS LL < 50	ML	Inorganic Silts and very fine Sands, Rock Flour, Silty or Clayey fine Sands or Clayey Silts
		CL	Inorganic Clays of low to medium plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
		OL	Organic Silts and Organic Silt-Clays of low plasticity
	SILTS AND CLAYS LL > 50	MH	Inorganic Silts, Micaceous or Diatomaceous fine Sandy or Silty soils, Elastic Silts
		CH	Inorganic Clays of high plasticity, Fat Clays
		OH	Organic Clays of medium to high plasticity, Organic Silts
HIGHLY ORGANIC SOILS		PT	Peat and other Highly Organic soils

TERMS CHARACTERIZING SOIL STRUCTURE

SLICKENSIDED - having inclined planes of weakness that are slick and glossy in appearance

FISSURED - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical

LAMINATED (VARVED) - composed of thin layers of varying color and texture, usually grading from sand or silt at the bottom to clay at the top

CRUMBLY - cohesive soils which break into small blocks or crumbs on drying

CALCAREOUS - containing appreciable quantities of calcium carbonate, generally nodular

WELL GRADED - having wide range in grain sizes and substantial amounts of all intermediate particle sizes

POORLY GRADED - predominantly of one grain size uniformly graded) or having a range of sizes with some intermediate size missing (gap or skip graded)

SYMBOLS FOR TEST DATA

- ▽ — Groundwater Level (Initial Reading)
- ▼ — Groundwater Level (Final Reading)
- ■ — Shelby Tube Sample
- ☒ — SPT Samples
- — Auger Sample
- — Rock Core

TERMS DESCRIBING CONSISTENCY OF SOIL

COARSE GRAINED SOILS		FINE GRAINED SOILS		
DESCRIPTIVE TERM	NO. BLOWS/FT. STANDARD PEN. TEST	DESCRIPTIVE TERM	NO. BLOWS/FT. STANDARD PEN. TEST	UNCONFINED COMPRESSION TONS PER SQ. FT.
Very Loose	0 - 4	Very Soft	< 2	< 0.25
Loose	4 - 10	Soft	2 - 4	0.25 - 0.50
Medium	10 - 30	Firm	4 - 8	0.50 - 1.00
Dense	30 - 50	Stiff	8 - 15	1.00 - 2.00
Very Dense	over 50	Very Stiff	15 - 30	2.00 - 4.00
		Hard	over 30	over 4.00

Field Classification for "Consistency" is determined with a 0.25" diameter penetrometer

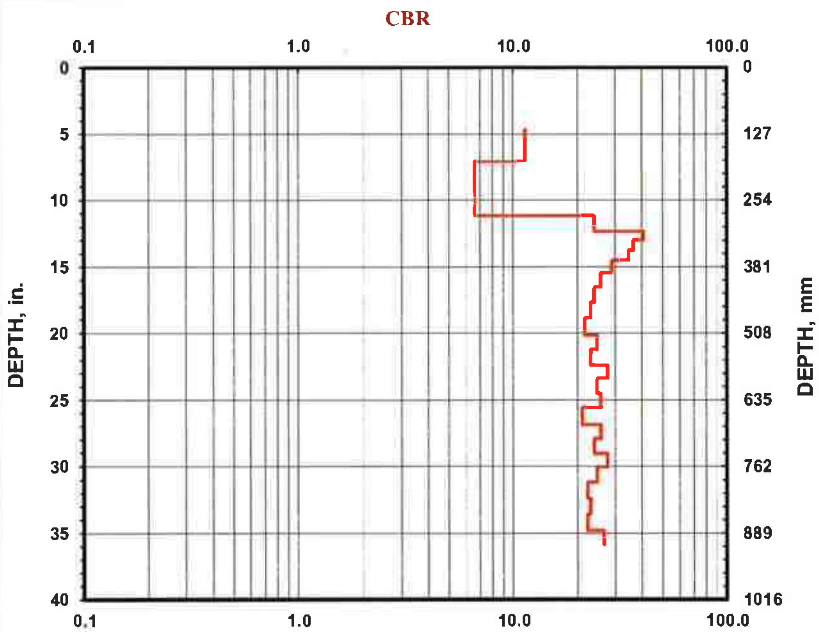
DCP TEST DATA

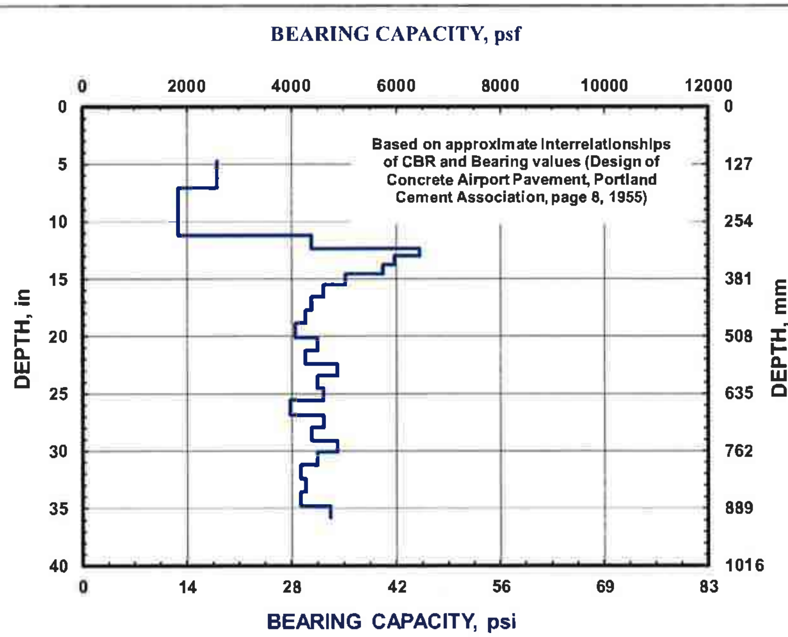
Project: *219147*
Location: B-3
Date: 15-May-19
Soil Type(s): High plasticity Clay

Hammer
- ○ 10.1 lbs.
- ● 17.6 lbs.
- ○ Both hammers used

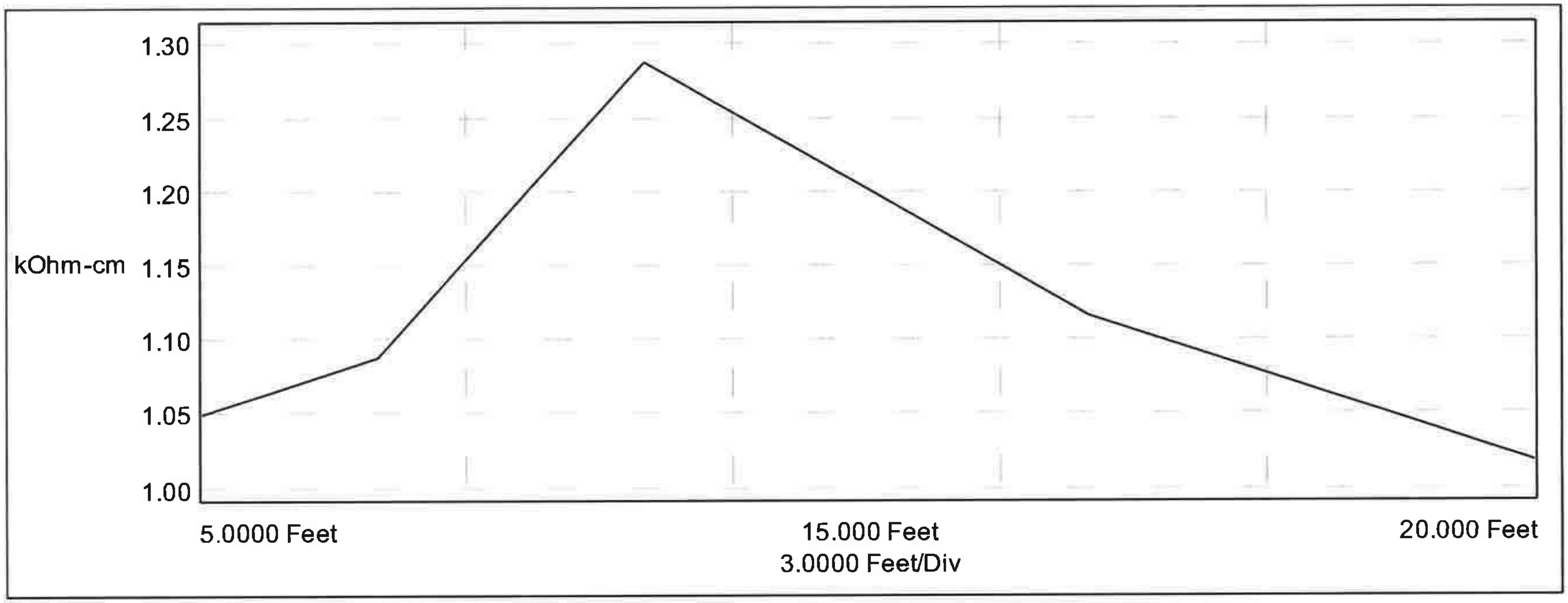
Soil Type
- ● CH
- ○ CL
- ○ All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	119	1
2	180	1
2	285	1
2	314	1
2	331	1
2	350	1
2	370	1
2	394	1
2	421	1
2	450	1
2	480	1
2	512	1
2	540	1
2	570	1
2	595	1
2	623	1
2	650	1
2	683	1
2	710	1
2	739	1
2	764	1
2	792	1
2	823	1
2	853	1
2	884	1
2	910	1





RESISTIVITY RESULTS
NORTH-SOUTH

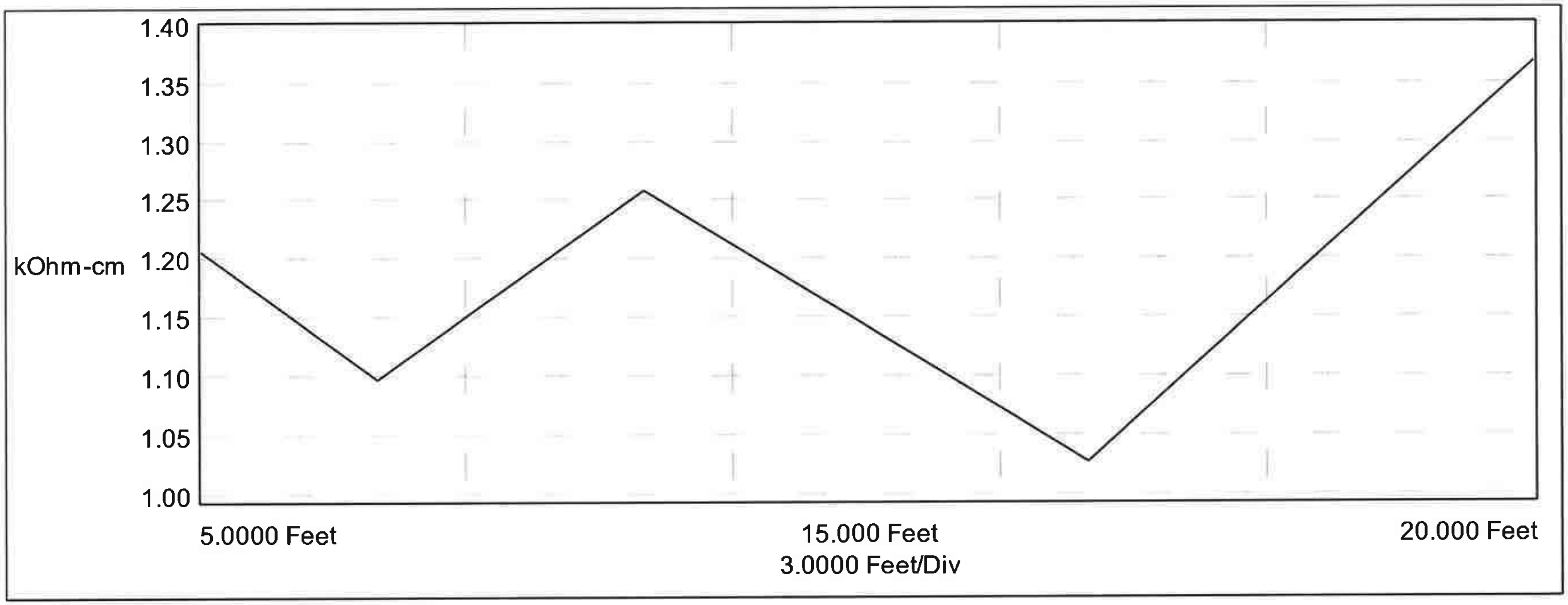


May 28, 2019
Frankfurt-Short-Bruza Associates, P.C.
RETL Project No.: 219147

AIRCRAFT CORROSION CONTROL FACILITY
JBSA Lackland – Kelly Field Annex
San Antonio, Texas

ROCK ENGINEERING AND TESTING LABORATORY, INC.
10856 VANDALE STREET
SAN ANTONIO, TEXAS 78216
(210) 495-8000

RESISTIVITY RESULTS
EAST-WEST



May 28, 2019
Frankfurt-Short-Bruza Associates, P.C.
RETL Project No.: 219147

AIRCRAFT CORROSION CONTROL FACILITY
JBSA Lackland – Kelly Field Annex
San Antonio, Texas

ROCK ENGINEERING AND TESTING LABORATORY, INC.
10856 VANDALE STREET
SAN ANTONIO, TEXAS 78216
(210) 495-8000